UTILIZATION OF JACK FRUIT (*Artocarpus heterophyllus* Lam.) FOR PRODUCT DEVELOPMENT AND BY-PRODUCT RECOVERY

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for the degree of

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DECLARATION

I hereby declare that this thesis entitled '**Utilization of jack fruit (*Artocarpus heterophyllus* Lam.) for product development and by-product recovery**' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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With Profound Gratitude to
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LIST OF ABBREVIATIONS

%	–	Per cent
β	–	Beta
α	–	Alpha
AOAC	–	Association of the Official Agriculture Chemists
BIS	–	Bureau of Indian Standards
CCP	–	Critical Control Point
CD	–	Critical difference
CFTRI	–	Central Food Technology Research Institute
cfu/g	–	Colony forming unit per gram
Fig.	–	Figure
FPO	–	Fruit Product Order
g	–	Gram
GDP	–	Gross domestic product
GNP	–	Gross national product
ha	–	Hectare
HACCP	–	Hazard Analysis Critical Control Point
i.e.		That is
kg	–	Kilogram
l	–	Litre
mg	–	Milligram
ml	–	Millilitre
MT	–	Million Tonnes
RTS	–	Ready to serve
TSS	–	Total Soluble Solids
viz	–	Namely

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Introduction

1. INTRODUCTION

Providing food for the subsistence of the ever-growing population has always been a formidable challenge facing the global community. More discoveries regarding food and its processing are emerging due to emination and spread of information on a global basis, bringing the food of every culture and every region closer to each other.

India with its wide range of soil and agro-climatic conditions, grows different kinds of horticultural crops, and is considered as one of the horticulturally rich countries of the world (Sharma, 2004).

It is stepping towards Golden revolution and has made remarkable achievements in the production of horticultural crops, ranking second in fruit (45.4 MT) and vegetable (90.8 MT) production in the world during the year 2001. Despite this huge production approximately 50 per cent of this wealth is being lost due to wastage and value destruction accounting to be Rs. 23,000 crores (Parpia, 2000). Per capita availability of fruits in India is 85 g and that of vegetable is 75 g which is still lower than the recommended levels (Kapoor and Kaur, 2004).

India has turned out to be a good producer of fruits and vegetables, though India's processed food industry is less developed when compared to other countries (Indian News and Notes, 2001).

Kapoor and Kaur (2002) are of the opinion that fresh foods which are in excess supply during season and shortage during the rest of the year is a phenomenon, which invites attention to the development of technologies for appropriate processing and packaging.

Anand (2000) pointed out that a strong and vibrant food processing sector plays a significant role in economic growth, as it provides vital linkages and synergies between the two pillars of the economy namely, industry and agriculture. Processing industry improves value addition of agriculture produce, generates mass employment, enhances income of farmers and rural poor and creates surplus for export growth.

The fruit and vegetable processing industry has made major strides in advancing its competitive scenario and its future success depends on adequate and regular availability of uniform and quality raw materials (Kapoor and Kaur, 2004).

The changing socio economic scenario in the country with hectic life styles and rise in disposable incomes, the 'ready to eat food market' is growing at a rate 35 per cent every year (Parpia, 2000).

Fruits and vegetables play a significant role in the human diet through its supply of vitamins and minerals. They have become star nutrients as they contain antioxidants and various phytochemicals which help to protect the body against chronic diseases (Rajeshwari, 2003). Currently they are coined as functional foods since they not only fulfill the physiological needs, but also have prophylactic effect (Kapoor and Kaur, 2004). Increased awareness about sound health and quality life and increased problems of nutritional insecurity, brought about a sudden shift from food grain production and consumption pattern to diversified and value added food production and consumption (Premnath *et al*., 2004).

Kapoor and Kaur (2004) reported that the underutilized fruits have an important role to play in satisfying the demand of nutritionally rich natural foods of high therapeutic value. Huge variety of underutilized fruits available are not easily marketed in the fresh form hence should be processed into value added products so that the consumers all over the world get an opportunity to enjoy the fruit at least in the processed form (Roy, 2001).

The **jackfruit** (*Artocarpus heterophyllus* Lam) a member of Moraceae family is an excellent example of under-exploited fruit which is grown sporadically in India as well as in other parts of the tropics mostly as dooryard tree. The jackfruit indigenous to India is the single largest edible fruit and is a heavy yielder than any other fruit trees (Singh, 1990). The fruit is unusual as it is borne on the main branches of the trunks occasionally even from surface roots of the tree.

Haque (2005) reported, that jackfruit originated in India, is extensively cultivated in low lying areas of the country and also in various other countries like Burma, Malaysia, Brazil, Philippines and Thailand. In India this fruit tree is distributed over Assam, Bihar, South India and foot hills of Himalayas in Northern India.

The annual production of jackfruit in India is 1.07 MT and area under production is around 0.51 million hectare (Rajeshwari, 2003). The production of jackfruit in Kerala is 320 numbers is million and area under production is 92,651 hectares. Kannur district leads in production (46 million) followed by Thiruvananthapuram (31 million), Malappuram (30 million), Idukki (28 million) and Wayanad (21 million) (FIB, 2001).

Among the fruits grown in Kerala, jackfruit tops the list in terms of production. The fruit is of premium price and relished well in the raw as well as ripe form. The fruit is highly nutritious with a pack of various nutrients such as protein, calcium, phosphorus, iron, thiamine etc. and is considered as a poor man's food (Haque, 2005).

Jackfruits possess excellent processing qualities, with good sensory appeal and hence highly suitable for value addition and processing. According to agricultural experts of Kerala, market glut and waste accumulation is a major setback in jackfruit processing. Jackfruit peels, cores and seeds are left as waste during the processing of jackfruit. These wastes are reported to be a rich source of pectin, fibre and starch which finds its application in several industries including food processing and pharmaceuticals.

Inspite of the above facts, processing potential of fruit is not fully exploited at commercial level so far, and this plentiful resource is being wasted. Taking into account of the above, the present investigation was taken up with the following objectives.

1) To develop value added and diversified products utilizing jackfruit bulbs and seeds.
2) Assessing the chemical, nutritional, organoleptic and shelf-life characteristics of the developed products along with consumer acceptance and preference.
3) Exploring the feasibility of byproduct recovery from the jackfruit waste and its quality evaluation.

Review of Literature

2. REVIEW OF LITERATURE

The review of literature is an essential prerequisite of any research endeavor. The groundwork of any scientific enquiry is studies conducted in the past. The literature pertaining to the present investigation is reviewed under the following heads.

2.1 Significance of fruits and vegetables
2.1.1 Fruit Production in India
2.1.2 Post Harvest Technology of fruits and need for processing
2.1.3 Jackfruit – An under exploited fruit for processing
2.2 Jackfruit – Origin, geographical distribution and varietal differences
2.3 Jackfruit – Production and harvesting
2.4 Physiochemical characteristics of Jackfruit
2.4.1 Nutritional composition of Jackfruit
2.5 Scope of Jackfruit for processing and its Product profile
2.6 By product recovery from Jackfruit waste

2.1 SIGNIFICANCE OF FRUITS AND VEGETABLES

"Let your food be your medicine and Let your medicine be your food" (Hypocrates). Sohrab (1993) opined that food has a wide connotation but it could be summed up as any plant or animal material which is consumed for nutrition and sustenance.

Indra (2004) stated that modern life style demands a consistent food supply with high quality that is convenient as well as affordable. The food consumed may vary among the population but the basic structure and composition remains same; mainly comprising of pulses, cereals, fruits and vegetables, milk and milk products, oils and seeds, eggs and poultry. Kumar *et al.* (2003) stated that fruit has been a major food for mankind from time immemorial. Fruit constitute an important item in our diet. George (1994) stated that fruits are no longer a luxury, since they belong to an important class of protective foods, which provide adequate vitamins and minerals needed for the maintenance of health. Vaidehi (1994) has the opinion that if we make use of our tropical and under exploited fruits many of which are heavy yielding we may overcome the problem of deficiencies that are arising due to lack of certain vitamins and minerals. Buescher *et al.* (1999) opined that micronutrients from fruits are important for human health and maintenance. Mehta *et al.* (2002) remarked that fruits not only meet the quantitative needs of foods but also supply vitamins and minerals, which improve the quality of diet and maintain health. Therefore it is necessary to ensure their availability throughout the year in fresh, processed or preserved forms.

According to Geeta (1982) cheapest fruits are also highly nutritive as they are the storehouse of essential vitamins and minerals and comprise a rich diet of essential nutrients like vitamin C, carotene and various minerals. Bharwal (1999) reported that fruits being a rich source of vitamins, minerals, organic acids and dietary fibre are considered as protective foods, and have a special place in our daily diet. Kaur and Maini (2001) is of the opinion that fruits and vegetables contain phytochemicals and antioxidants, which have significant health promoting effects and can reduce the incidence of cardiovascular diseases, cancer, AIDS and various other degenerative diseases.

Dubey (1988) opined that fruits are known to provide the vigour and vitality. The chief energy constituent in fruit is carbohydrate mainly as sugars. He further reported that, fruits and vegetables contain the indigestible material called fibre, which adds bulk to stools, and thus acts as mild laxative.

2.1.2 Fruit Production in India

The fruit production in India has made remarkable progress during the last three decades (1961–1991). The area under fruits has increased from 1.22 million hectare in 1961 to 3.94 million hectare in 1994. Out of 370 MT of fruit production in the world, India accounts for 30 MT.

Jaiswal (2000) reported that large varieties of fruits both indigenous and introduced from abroad are produced in the country. India has emerged as the second largest producer of fruits and vegetables next to Brazil and China in the world. Reddy (2002) reported that India is the second largest producer of the fruits, next to China and their production has tripled over the last 50 years.

Indra (2004) reported that in the present scenario, India is stepping towards golden revolution and has made remarkable achievements in the production of horticultural crops, ranking second in both fruit (45.4 MT) and vegetable (90.8 MT) production.

Kumar *et al* (2003) indicated that India is the second largest horticultural produce in the world and accounts for 10 per cent of global share. According to Negi (2002) the annual fruit production is estimated to be 45.5 MT

2.1.2 Post harvest Technology of fruits and Need for processing

Verma (1995) has defined post harvest technology as a segment of food system, which begins after fruit is detached from the plant and ends by either the death (enzyme deactivation) or delivery to the consumer.

Post harvest is also the central connecting link between the grower and the consumer, where the product flows from the growers to the consumer and cash from the consumers to the growers (Sharma, 2004). Reddy (2001) opined that the grave situation of post harvest loss can be realized from the findings of food Ministry of India that we waste more fruit and vegetable than what the we consumes every year. He further reported that post harvest loss can be considered as a social evil, which eats up the grower's margin and pushes up the consumer's price. This post harvest loss is mainly due to improper and unscientific handling and packaging followed in India. In this era of globalization we should seriously think of coming forward with ideal packing of commodities so as to reduce post harvest loss and to compete in the domestic as well as international markets.

Bourne (1988) grouped causes of post harvest crop losses in developing countries into primary losses (insects, rodents, birds, microbes, contamination, sprouting and mechanical damage) and secondary losses (inadequate drying, storage, cooling and transportation facilities). Considerable losses occur during transport to various destinations. Neelgreevam *et al.* (1985) and Subrahmanyam (1986) found that the losses during transport might increase the cost up to 24.2 per cent.

Tindal and Proctor (1980) opined that deterioration results from the cumulative insults during post harvest handling and expressed the need for investigations on causes of losses in horticultural commodities in the tropics in the specific areas and conditions, in order to identify causes and adoption of preventive measures.

Khader and Malik (1985) opined that post harvest technology of horticultural crops envisages developing of appropriate techniques to reduce post harvest losses, to prevent spoilage and help utilize maximum crops in a nutritious and safe manner.

Thompson (1996) opined that post harvest technology should comprise as methods right from the field till the crop reach the hands of consumers either as fresh commodity or in the processed form.

Swaminathan (2000) is of the opinion that development of horticulture is closely associated with the growth of post harvest technology, as the unmarketable surplus horticultural produce during glut periods has to be properly preserved thus processing of food and vegetable needs greater encouragement and patronage. Food processing is a key industrial sector of India and India's future is linked to the progress of food processing industry in the 21st century. The food processing is of enormous significance for India's development because of the vital linkages and synergies that it promotes between the two pillars of the economy namely industry and agriculture (Joshi and Verma, 2000).

Potty (2003) pointed that at present, processed food industry constitutes a significant component of the country's industrial landscape, with large contribution to the GDP. Mallaya (2003) opined that food-processing industry contributes 18 per cent GNP and employment to 1.5 million workers i.e. about 20 per cent of our industrial labour.

Food processing accounts for a gross output of Rs.1.12 trillion representing 6.3 per cent of GDP, involves six per cent of the total industrial investment, 13 per cent exports and employs 18 per cent of the country's industrial labour force (Indian News and Notes, 2004).

Rao (1989) has defined processing as adding value to conventional and innovative basic food items through various combinations and permutations providing protection, preservation, packaging, convenience and disposability. Shaw *et al.* (1993) defined processing as the treatments between harvest to consumption, which include handling, transportation, refrigeration, holding, washing, trimming, bleaching, freezing, canning, drying, irradiation, chemical preservation, packaging and storage.

Sethi (1993) reported that in India inspite of huge production of fruits, 20-30 per cent of the produces are not utilized due to poor post harvest management practices. Poonia *et al.* (1994) stated that nearly 30 per cent of the fruits are lost due to spoilage during handling, transportation, lack of storage and processing facilities. The food processing sector needs to be developed on a priority basis as about 30 – 35 per cent of 140 MT fruits and vegetable produced in the country is wasted due to poor handling. Moreover, it is an offshoot of the

Agriculture and horticulture sector, which contribute nearly 28 per cent of the GDP (Indian News and Notes, 2004).

Shaw *et al.* (1993) opined that fruit industry can play an important role in salvaging prices during glut seasons, generate employment opportunities, meet the requirements of defence forces in border areas and earn foreign exchange for the country through the export of the products. Dhankar (2001) reported that processing of fruits and vegetables for both, food and non food uses will open up marketing alternatives to the sale of fresh produce, reduce post harvest losses, regulate prices during lean period and raise farm income and create employment.

2.1.3 Jackfruit – An under exploited Fruit for processing

According to Kumar *et al* (2003) Under exploited fruits may be defined as fruits, which have not been utilized for processing and preservation purposes. Geetha and Jaiswal (2003) are of the opinion that lesser known fruits are not cultivated widely but extensively grown in the wild areas. Singh and Gopalakrishnan (2002) remarked that under exploited fruits are not cultivated in the orchards, their nutrition and plant protection management are not cared and very little is known about their utilization.

Singh *et al.* (1998) reported that under utilized minor fruits provide nutrition, strength and vigour to our body and restore the loss of minerals and amino acids and thus protect against deficiencies and certain chronic diseases. According to Easwaran *et al.* (1995) under exploited fruits, which are produced in surplus, if processed and preserved will be available in the off season at remunerative prices

Roy and Sanjeev (2000) reported that the processing of the indigenous fruits could help the even distribution of fruits from places of abundance to the place of scarcity, the availability of fruit products even during off season and at reasonable price thereby improving the per capita availability as well as consumption

Srivastava and Sanjeev (2002) reported that the development of newer products from the under exploited fruits by the application of modern technology is essential to boost the morale of our processing sector and these products can attract wider spectrum of consumer market. The author further reported that, value added products prepared from under utilized fruits would play a significant role not only for their domestic market but also for their export.

Eipeson and Bhowmik (1992) are of the opinion that there is a vast potential to tap the under exploited minor fruits in India. Sarain (1992) advocated that apart from major fruits like banana, pineapple apples, mangoes, grapes etc. there are other rare ones like jackfruit, pomes, custard apple, litchis, chikkos, ber, plums, lemon, jamun, strawberries etc., which are considered as under exploited fruits and have tremendous marketing potential. Saini and Baini (1994) stressed that the fruits like jackfruit, kokum, phalsa, and other such minor fruits need to be utilized in processing and product development.

2.2 JACKFRUIT – ORIGIN, GEOGRAPHICAL DISTRIBUTION AND VARIETAL DIFFERENCES

Jackfruit (*Artocarpus heterophyllus* Lam) a member of the Moraceae family is an important fruit in India and is grown sporadically in other parts of the tropics mostly as a dooryard tree. The jackfruit indigenous to India is the single largest edible fruit and is a heavy yielder than other fruit trees (Singh, 1990).

Morton (1965) reported that the fruit is widely grown in Burma, Malaysia and Brazil. In India this fruit tree is distributed over Assam, Bihar, south India, Western Ghats and foothills of Himalayas in northern India.

According to Singh (1990) jackfruits are grouped into two main groups *viz.*, soft fleshed and firm fleshed type. In soft flesh, flesh can be separated very easily by thrusting the fingers while in firm flesh bulbs are crisp and firm.

Rudrakshki is another variety where the fruits are very small and spines on the surface of fruit are less in number and are not prominent. This is a highly precocious type tree bearing fruits in off-season *i.e.* during winter (September to December) (Singh (1990).

Srinivasan (1971) described a cultivar named Muttanvarikka, which produce fruits of average weight of 7.0 kg and 46 cm length and 23 cm width.

Bhore *et al.* (1981) found jackfruit grown in Ajra (Kolhapur). The fruit was noted for good for quality, smallness (1.3 kg), uniformity with high pulp content.

2.3 JACKFRUIT PRODUCTION AND HARVESTING

Bose and Mitra (1990) reported that the fruit bearing starts from the seventh to eighth year and the tree reaches its peak bearing stage within 15 to 16 years after planting. Normally a tree bears 500 – 700 kg of fruits per year. Chadha (2001) has the opinion that grafted trees bear fruit early i.e. third year onwards.

Singh (1990) is of the opinion that yield of jackfruit varies depending on age, climatic conditions, soil types, cultivar, management practices etc.

According to Madhavan (1994) among the fruits grown in Kerala, jackfruit tops the list in terms of production (14.9 lakh/hectare).

Samaddar (1985) reported that the tender fruit appears in the market in spring and continues until summer.

Singh (1990) reported that the trees generally bear after eight years, the sole exception to late bearing is the Singapore cultivar, which fruits at the age of three years only. The fruiting season lasts about four months. The expected yield from one tree is from a few to 250 fruits per annum each weighing about 3–5 kg although fruits as big as 55 kg have been obtained.

Bose and Mitra (1990) pointed that harvesting of tender jackfruits for vegetable purposes begins in early spring and continues through the summer. Singh (1991) reported that tender fruits are harvested for vegetable purposes. Ripe fruits are available from June onwards. Fruits are harvested by cutting the fruit stalk of individual fruit.

2.4 PHYSICOCHEMICAL CHARACTERISTICS OF JACKFRUIT

Singh (1972) reported that the fruits are oval or oblong measuring 1–2 feet in length and 6–12 feet in diameter, pale green to yellow brown in colour. He further stated that the fruit, constituted three regions, fruit axis, perianth and true fruit. The perianth is the most important part and constitutes major bulk of the fruit. It has three regions lower free and fleshy edible region, middle fused region and the upper free and horny non-edible region.

Narasimham (1990) reported that ripe jackfruit comprises several parts, bulbs, seeds, (embedded in bulbs) and the skin, rind, sheath, core and unfertilized floral parts. The bulbs comprise of 30 per cent of fruit weight. Seeds comprising around 12 per cent of fruit weight and the rest of the fruit are considered inedible being highly fibrous.

Selvaraj and Pal (1989) reported that on an average the bulbs, seeds and rind constitute 29, 12 and 59 per cent respectively in ripe jackfruit.

2.4.1 Nutritional composition of Jackfruit

The chemical composition of the fruits with respect to protein, fat, crude fibre, starch, reducing sugars, minerals and vitamin contents have been reported by various scientists.

2.4.1.1 Carbohydrates

Srivastava (1953), Hossain and Haque (1977) and Preunguvate (1981) reported that jackfruits 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 14.5 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). Water extract of jackfruit on hydrolysis was found to give glucose, xylose, rhamnose, arabinose, galactose and galacturonic acid (Sengupta and Rao, 1963).

More recently Zaghlol *et al.* (1984) studied the water soluble polysaccharides of the leaves and fruits of *A.integrifolia*. The acid fraction of both leaves and fruits were identified as D-galacturonic acid. The de-mineralized mixture of leaf and fruit polysaccharides comprised respectively 64.6 and 64.5 per cent galacturonic acid, 0.24 and 2.47 per cent galactose, 22.04 and 10.94 per cent glucose, 8.04 and 0.44 rhamnose, 0.06 and 0.18 per cent sugars. In addition the fruits contained 1.51 per cent arabinose and 10.42 per cent fructose.

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

Bobbio *et al.* (1978) reported that the seeds contain starch, which was 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 74.5^{0}C with peak viscosity at 94^{0}C.

An attempt has been made to study elaborately the carbohydrate profile of jack seed flour, its storability in the flour form and also its usefulness as a carbohydrate source when used as animal feed (KAU, 2004).

Kumar *et al.* (1988) analysed the proximate composition of jack seeds (Variety Kathari and Bharat Baramasi). They reported that jackfruit seeds are good source of carbohydrates, proteins and minerals.

Sadasivam and Neelkantan (1976) found that jackfruit bulbs are rich in sugars and contain fair amounts of carotene, protein and minerals. Nanjundaswamy and Mahadeviah (1993) reported that the edible bulb yield from jackfruit is about 29 per cent and contains 25 per cent carbohydrate and one per cent total ash.

Selvaraj and Pal (1989) studied the biochemical changes during the ripening of jackfruit. The results indicated that starch, tannins, soluble amino acids and free fatty acids decreased during ripening whereas the amount of sugars like glucose, fructose and sucrose increased during ripening.

2.4.1.2 Proteins Present in Jackfruit

Gomes and Zitade as early as in 1954 reported that jackfruit contains about 1.9 per cent protein on fresh weight basis. The dehydrated fruit containing 14.55 per cent protein was evaluated for its biological quality. The biological value was found to be exceptionally high and almost identical to the corresponding casein value. Chakraborty and Mandal (1981) reported a dipeptide 'aurantiamide acetate' from the jackfruit.

Novis and Coutinho (1952) reported that the protein content of jackfruit seeds was 9.4 per cent. The digestibility coefficient and biological value of the seed protein was reported to be 71.5 per cent and 28 per cent respectively. Chatterjee and Vaith (1973) found that jack fruit seed protein has a low biological value, which may be due to the occurrence of lectins.

2.4.1.3 Fats and Fatty Acid Composition

The total lipids (24.4 per cent) of wild jackfruit comprised (63 per cent) neutral lipids, 21 per cent glycolipids and 16 per cent phospholipids (Ngiefu *et al.* 1976). Bose and Mitra (1990) reported that fats present in ripe fruit were quite low (0.1 g/100 g of edible portion) as compared to 0.3 g per 100 g of edible portion in tender fruit. Moreover, fat present in seed was reported to be more (0.4 g/100 g of edible portion). Prakash and Chanderasekharappa (1984) analysed neutral lipids present in jackfruit seeds. The neutral lipids were mostly glycerides, free fatty acids and hydrocarbons with free sterols (1.3 per cent) and sterol esters (5 – 6 per cent) Linoleic acid and palmitic acids were predominant.

2.4.1.4 Vitamins and Minerals Present in Jackfruit

The jackfruit is a rich source of carotene, but is poor source of vitamin C content. According to Hossain and Haque (1979) jackfruit contains 2.64 – 11.77 mg of ascorbic acid and 250 – 1440 mg of carotene. The fruit contain 1.31 ± 0.83 mg/100 g of alpha tocopherol and small amounts of thiamine and riboflavin.

Candish (1983) reported that jack seeds are a good source of vitamin B_1 and B_2. The seeds also contain 1.31 ± 0.83 mg/100 g alpha tocopherol on fresh weight basis.

Lal and Pattabiraman (1976) reported that seeds contain acetylcholine and other pharmacologically active substances. He further reported that the mineral content of seeds is 1.5 per cent containing calcium 0.05 mg, phosphorus 0.13 mg and iron 1 – 2 mg/100.

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

2.4.1.5 Other Constituents Present in Jackfruit

Pectin

As early as in 1949, Krishnamurthi and Giri reported that jackfruit is an important source of pectin. The pectin recovered from jackfruit has been purified and characterized with respect to yield, moisture content, ash, calcium pectate, uronic anhydride, and 2 furaldehyde and methoxyl content by Dutta (1956). Bhatia *et al.*, (1955) and Jose (1968) found that jackfruit rind constitutes 59 per cent of the bulk of the fruit and is a good source of pectin. Bhatia *et al.* (1959) described a method for preparing pectin from different portions of rind of ripe jackfruit, and rind and core of raw jackfruit. The ripe fruits yielded 1.22 per cent crude pectin against 0.47 per cent in raw fruit.

Enzymes

Roy (1967) has reported that the fungus (*Rhizopus artocarpi*) which causes rot of jackfruit secrete amylase, invertase, protease, and proto pectinase. Singh, (1991) reported that the enzyme amylase was secreted only extra cellularly and protease gave a mixed reaction as extra cellular enzyme. He further reported that a strong pectolytic enzyme was secreted both intra and extra cellularly by the jackfruits.

Flavour and volatile components

Bose and Mitra (1990) reported that the ripe jackfruit emits a characteristic aroma which resembles that of durian. Aspiras and Tecino (1971) reported the occurrence of nine components in the essence recovered from the fruits. Swords *et al.* (1978) identified 20 components in jack fruit for its flavour and they were mainly esters from fruits.

Berry (1982) analysed the 'chempedak' essence and found as many as 30 components which include ethanol, butyl acetate, methyl butyrate, ethyl isovalerate, isoamyl, isovalerate, hexanol and octanol.

Wong *et al.* (1999) analysed the volatile flavour constituents of Chempedak (*A. polyphema.* Pers). He identified 54 volatile components of which 37.4 per cent were alcohols and 32.2 per cent carboxylic acid. Main constituents were three methyl butanoic acid (28.2 per cent) and three methyl butana-1-ol (24.3 per cent) other important flavour compounds found were two acetyl-1- pyroaline and 2, 5 – dimethyl, 1-4 hydroxy-3(2H) furanone. He further reported that jackfruit volatiles contained 45 components of which 32 have not been reported previously. Wong *et al.*, (1999) has opinion that esters represent a high proportion of jackfruit volatiles (31.9 per cent) and contribute for the flavour of the fruit.

2.4.1.6 Antinutrutional Factors

Azevedo and Ainouz (1981) isolated two isolectins of molecular weight 43,000 in jack fruit. These isolectins contained two subunits with molecular weight of 11,250 and 15,000 respectively. Soares and Sevanez (1982) studied the mitogenic and precipitating activities of jacalin lectin.

Kumar *et al.* (1983) isolated an alpha D galactase specific lectins from jackfruit seeds which were reported to be a glycoprotein containing three per cent carbohydrates and having a molecular weight of 39,500. Namjuntra *et al.* (1985) isolated a lectin specific for nitrosoacetyl galactosamine from jackfruit seeds, which possessed agglutinating activities.

Vijayakumar and Forrester (1986) isolated two isolectins from jackfruit seeds, which have the ability to agglutinate red blood cells. Majumdar and Chatterjee (1998) reported the distribution of jacaline in Artocarpus seeds. The study revealed that jackfruit seeds contain large amounts of the antilectin and jacaline.

Sumathi and Pattabiraman (1976) reported that jack seeds exhibit inhibitory activities against trypsin and chymotrypsin upon cooking under acidic conditions. Kundu and Sinha (1989) purified protease inhibitors from jackfruit seeds. The inhibitor (chymotrypsin inhibitor) contain three per cent neutral sugars and 1.8 per cent glucosamine. Bhatt and Pattabiraman (1990) found several forms of protease inhibitors such as trypsin, chymotrypsine and elastase in jackfruit seeds.

Jackfruit seed trypsin inhibitors (JSTI) was found to be rich in acidic acids and devoid of free thiol groups. The inhibitor was stable under conditions of extreme pH (3.0 – 12.0), high temperature and in the presence of denaturing agents (Annapurna *et al.*, 1992). Rangaswami and Swaminathan (1978) have shown the presence of indoleacetic a naturally occurring auxin in jackfruit seeds. Merlin and Palanisamy (2000) evaluated the viability and storability of jackfruit seeds, under ambient dry conditions with free air circulation. She further reported that the loss of seed moisture results in a significant reduction of seed germination. Seeds treated with carbendozim at 2g/kg in polythene bag at $10^{O}C$ recorded 24 per cent germination after 56 days of storage, while seeds stored in a cloth-bag under ambient conditions lost viability within 21 days.

2.5 SCOPE OF JACKFRUIT PROCESSING AND PRODUCT PROFILE

Product development is increasingly the lifeline of the food industry (Research News and Notes, 2004). Anvilla *et al.* (1993) opined that the consumption of processed foods is likely to increase in the future.

Krishaveni *et al.* (2000) opined that jackfruit is consumed as fresh fruit as well as used in the raw form for various culinary preparations. The author further reported that the fruit has a delicate delicious taste, captivating flavour, attractive colour and excellent quality, which make it suitable for processing and value addition.

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

2.5.1 Product Profile of Jackfruit

The scientific value of real fruit based beverage is far greater than that of synthetic products, which are being produced in large quantities. Varde (1991) reported that there is a noticeable shift from consumption of alcoholic beverages to natural fruit based beverages. .

Kalra *et al.* (1991) remarked that fruit drinks are engulfing the domestic markets. They are rightly being encouraged as they provide the much needed vitamins and minerals for the maintenance of health.

Khurdiya (1988) reported that fruit beverages can introduce variety in flavour, nutrients and other physiological benefits with a greater margin of safety, and lower inherent cost.

Ready to Serve jackfruit Beverages (RTS)

Ready to serve beverages can be prepared from fruits very easily with a constitution of 10 per cent of juice, 10 per cent of TSS and 0.3 per cent acidity (Chopra and Chauhan, 2001).

Singh *et al.* (2001) have formulated ready to serve beverages from jackfruit pulp with 10 per cent pulp content, 12 per cent TSS and 0.3 per cent acidity.

Jackfruit squash

As early as 1956, Bhatia *et al.* standardized a refreshing beverage with pleasant taste and aroma from the bulbs of ripe jackfruit, which was found to have a shelf life of 60 weeks when stored at room temperature (24-30^{0}C).

Sadasivam and Neelkantan (1976) found that jackfruit 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 jackfruit.

Bhatia *et al.* (1956) suggested fortification of jackfruit squash with vitamin C and found that ascorbic acid was 50-70 per cent when stored at room temperature, 6-13 per cent at 37^{0}C and 88-97 per centwhen stored at 2.5^{0}C. The ascorbic acid fortified samples exhibited increased browning especially at high temperatures during storage.

Jackfruit nectar

Fruit nectar is a concentrated form of fruit pulp having honey like consistency. Singh (2000) opined that nectar is a ready to serve beverage like juice. 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) standardized nectar from jackfruit pulp.

Clarified juice

Khader (1999) reported that the juice extracted from the various fruits contain mainly sugar and small quantities of vitamins and minerals. Attempts have been made by John and Narasimham (1993) to standardize the preparation of clarified juice from jackfruit, in which jackfruit pulp was subjected to enzyme treatment at 0.3 per cent level. Clarified juice recovery was 60 per cent with a pH of 0.15 to 0.20 per cent.

Jackfruit wine

Joshi and Bharathkumar (2004) reported that wine is the oldest known fermented food revealed in the ancient scriptures. Joshi *et al.* (1990) stated that there is a considerable scope for fruit based fermented beverages in India, especially wine and vinegar. Two fermented products, which can be prepared from jackfruit pulp are wine and vinegar.

Almost every civilization had characteristic wine or other alcoholic beverages. Composition wise fruit wines are far more nutritious than distilled beverages due to possession of sugar, acid, minerals and vitamins. Jackfruit in general contains high amount of easily fermentable sugars, which make it a suitable medium for the growth of wine yeasts. Krishnaveni *et al.* (2000) standardized wines from two varieties (Local and Vellipala) of jackfruit. Organoleptic qualities of the wines formulated were found to be acceptable and comparable with grape wine.

Jackfruit vinegar

Vinegar is another fermented product, which can be formulated from jackfruit. Datta and Biswas (1972) had described process for making vinegar from fruit juices. They further reported that the jackfruit vinegar recovered from the ripe fruits yielded seven per cent alcohol and six per cent acetic acid upon fermentation.

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

Canned Jackfruit products

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

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

Bhatia *et al.* (1956) reported that canned jackfruit when stored at room temperature (24–30^{0}C) was found to retain normal colour and characteristic taste and aroma however the product when stored at 37^{0}C for 19 weeks depicted deteriorative changes. Siddappa and Bhatia (1956) reported that canned jackfruits were found to retain ß-carotene content even after 6 months of storage.

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

Jackfruit chips

Jackfruit chips are prepared using raw bulbs. The oil used for frying influence the keeping quality of jackfruit chips. Shelf stability of jackfruit chips could be increased by adding antioxidants like butylated hydroxy toluene and sorbic acid.

Dehydrated jackfruit bulbs

Bhatia *et al.* (1956) recommended steeping of jackfruit bulbs in 0.1 per cent potassium metabisulphite 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 rate of 16 lbs sulphhur/ton/fruit/1000 cfl space (Shanmugam, 1992).

Candied jackfruit

Candying of fruits is widely practiced to extent their utilization. Giron *et al.* (1975) prepared candied jackfruit by osmotic dehydration. Jackfruit bulbs were sliced and immersed in sugar syrup of 70^0 Brix. It was then dried at 60^{0}C. Bindu (1995) conducted a study to standardize osmotic dehydration in two varieties of jackfruit. Results indicated that organoleptically acceptable and shelf stable products could be prepared by applying a pre-treatment of 30 minutes immersion in 70^0 brix at 50^{0}C.

containing 20 per cent glycerol for soft flesh variety of jackfruit. Same treatment without any preservatives could be applied for the firm flesh variety of jackfruit.

Dehydrated jackfruit flakes

Dehydrated jackfruit flakes with a shelf life of one year was standardized by KAU (1999). The flour prepared from dehydrated jackfruit flakes was found to be suitable for preparing chapattis, pazhampori and baji by replacing 25 per cent wheat flour, maida or Bengal gram flour respectively with jackfruit flours.

Jackfruit Bar

Ready to eat fruit bars are well-relished products and being commercially prepared and marketed in our country. Fruits like mango, papaya, pineapple, guava, jamun, jackfruit 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 jackfruit bar from two varieties of jackfruit. They also investigated the suitability of different packing material for the storage of the products. The results indicated that jackfruit bars stored in MPP recorded higher per cent of nutrient retention and minimum microbial count.

Jack pickles

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

Jackfruit papad

Jack fruit bulbs, which are neither fully mature nor completely raw could be used for preparing jackfruit papads. (Bhatia *et al.* 1956) He found that jackfruit papads had a shelf life of 4 – 6 months at room temperature (24 – 30^{0}C) wrapped in paper.

Jackfruit based sweets

Various sweet delicacies such as jackfruit halwa, elayappam, adda, jackfruit payasam etc could also be prepared from jackfruit bulbs KAU (1999) standardized jackfruit halwa by using pulp of varikka and koozha varieties. Halwla prepared in hot sugar syrup was found to be highly acceptable to the consumers.

Jackfruit jelly

Jackfruit rind contains fair amount 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.

Jackfruit seed flour

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

Singh (1991) analysed jackfruit seed flours and found that it contains 16.3 per cent protein and globulins and *in vitro* digestibility of seed protein was 89 per cent with emulsion capacity 17 per cent. Rajarajeshwari and Prakash (1999) studied the properties of seed protein and its utilization in product development. They found that jackfruit seeds are a good source of protein and exhibit 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, pazhampori, baji and puri by replacing 50 per cent of flours of cereals/pulses. The products were found highly acceptable in sensory evaluation test. It was further reported that flour prepared from seeds of varikka variety were better than koozha for the preparation of various products.

Roasted nuts

The roasted jack seeds are reported to resemble chestnuts in nutritive value and flavour and also much liked by people (Berry and Kalra (1987). However, the shelf life of fried seeds is low, as these cannot be stored for more than a few days at room temperature (24-30^{0}C) (Bhatia *et al.*, 1956).

2.6 BYPRODUCT RECOVERY FROM JACKFRUIT WASTE

Sivasankar *et al.* (1996) remarked that due to technological growth waste accumulation enhanced multifold and its disposal pose serious dimensions not only in western world but also in the third world countries.

Schieber *et al.* (2003) opined that waste accumulated during the processing of fruits and vegetable could serve as a potential source of natural additives and functional food ingredients.

Kalsi and Dhawan (2001) stated that during canning and preparation of juices, squashes, jellies, dried products etc. large quantities of waste material are accumulated, disposal of which poses serious problems. They further reported that waste in form of peels, cores, seeds, rinds, skin trimmings; over ripe and defective material must be utilized for the manufacture of byproducts in order to reduce the cost of production of main produce.

Berry and Kalra (1987) reported that the products, which can be recovered from jackfruit, are pectin, starch and fibre. These three products are of great commercial potential and find this way as a raw material for other industries. Anand and Maini (1997) reported that jackfruit peels, cores and seeds are left as waste during the processing of jackfruit, that could be utilized for the extraction of pectin, which find its application in food processing, pharmaceutical and several other industries.

Sengupta and Das (1965) isolated ammonium pectate from pericarp which was around 6.47 per cent on dry weight basis. Vilaschandran *et al.* (1986) reported that appreciable amounts of pectin was found in all parts of jackfruit and suggested that waste products such as skin and core could be used for pectin extraction. Madhav (2001) reported that jelly prepared out of jackfruit rind exhibited desirable consistency with slow setting capacity.

Stefan (2002) reported that pectin is a structural polysaccharide that is found in the cell wall of most higher plants, where in combination with cellulose it is largely responsible for the firmness of the plant tissue. The author further reported that the main source of commercial pectin is citrus fruits, apple and pomace.

Pilnik (1990) reported that pectins form gels under certain circumstances, and this property has made them a very important additive in jams, jellies, and marmalade, as well as in the confectionery industry.

Pilnik and Zwiker (1970) reported that pectins have also found wide application as stabilizers in acid milk products. Rolin and Varies (1990) reported that pectins because of their pharmaceutical activities (antidiarrhoea, detoxicant, regulation and protection of gastro intestinal tract), pectins are used in medical preparations.

Jackfruit seeds can be utilized for the production of starch and also for the preparation of flour based products. Kerr (1995) reported that starch is the reserve carbohydrate of the plant kingdom and is important to plants as much as glycogen to animals. Jacobson et al (1996) reported that starch has application in industries like paper, textile, food, confectionery, pharmaceuticals, adhesives, foundries, fertilizers, detergents, mining, engineering and metallurgical industries.

Delpenchi and Favier (1980) found large differences in jackfruit starches with respect to amylase hydrolysis and swelling power when compared to other fruit starches. Selvaraj and Pal (1989) reported that starch per cent in raw jackfruit is around 2.03 per cent (0 days of harvest), which decreases as the fruit ripens (0.69 per cent) after eight days of harvest.

Jackfruit is also a rich source of soluble fibre. KAU (1999) extracted fibre from the dried and powdered jackfruit rind. Kalsi and Dhawan (2001) has the opinion that the fibre content of jackfruit 30.77g/100 g of fruit wastes. The jackfruit seeds and flour also contains fibre 1.50 and 1.02 g/100 gm. The fibre is easily digestible and provides bulk to the diet.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Utilization of jackfruit for product diversification and byproduct recovery" is aimed at developing value added and diversified products from jackfruit bulbs and seeds. Attempts have also been made to utilize the waste arising from the jackfruit processing in an ecofriendly manner, by extracting byproducts. Products developed under the present investigation were studied in depth for its nutritional, physico-chemical, organoleptic and shelf life qualities along with consumer acceptance, consumer preference and economic viability. Byproducts extracted were also studied for their quality characteristics.

The methodology pursued for the investigation is presented under the following headings.

3.1 Selection of fruit for the study

3.2 Assessment of quality characteristics of jackfruit

3.3 Standardization of products and product development

3.4 Analytical work carried out in the developed products

3.5 Byproduct recovery and analysis of byproducts recovered

3.6 Statistical analysis

3.1 SELECTION OF FRUIT FOR THE STUDY

Jackfruit (*Artocarpus heterophyllus* Lam) is one of the largest fruits in nature, abundant with nutrients (Nair, 2003). It is an under exploited fruit which is promising from the point of view of processing (Saini and Baini 1994).

Eswaran *et al.* (1995) have the opinion that preservation of under exploited fruits which are produced in surplus if processed carefully will provide adequate nutrients that will make up the nutrient inadequacy among the population. According to Madhavan (1994) among the fruits grown in Kerala, jackfruit tops the list in terms of production (14.9 lakh tonnes). But, the fruit is not yet fully exploited by the food processing industries even today.

Taking into account of the above facts, jackfruit was selected for present investigation, with due interest of the following.

(1) It can form the raw material for a thriving fruit processing industry, as this resource is available in plenty at remunerative prices.

(2) The fruit has appreciable amount of pulp with excellent organoleptic qualities which are essential to meet the processing needs.

(3) The pulp could be blended well with other fruits so that various new products with varied taste could be formulated.

(4) This fruit is a rich source of essential nutrients and contains various phytochemicals, which are helpful for preventing many diseases.

Under the present investigation, two distinct varieties of jackfruit *viz.*, firm flesh and soft flesh found in Kerala were utilized. Under the firm flesh type, Muttan varikka – a variety evolved by Kerala Agricultural University and under the soft flesh a local 'koozha' variety was selected. Fruits were procured from Instructional Farm, College of Agriculture, Vellayani and also from the adjacent home yards for the study purpose.

3.2 ASSESSMENT OF QUALITY CHARACTERISTICS OF JACKFRUIT

Jackfruit varieties under investigation were analysed for various physico-chemical characteristics.

3.2.1 Physical Characteristics of the Fruit

According to Sharma (1988) the physical characteristics are found to be major determinant of quality and acceptability of fruits.

To analyse the physical characteristics of the fruit fully mature jackfruits cv. Muttan varikka (V_1) and Koozha (V_2) 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 (greenish yellow) and the number of days elapsed from fruit set (180 days). The harvested fruits were analysed for physical parameters such as weight, length, colour of fruit etc. Fruits were ripened to firm ripe stage in about four days at room temperature (35 - 38°C) RH (80-90 per cent) and used for further study. Once the fruit was ripe it was cut open. The size, weight, colour of the bulbs were recorded in both the varieties. Observations recorded were the means of thirty replicates of fruits selected at random.

3.2.2 Chemical and Nutritional Characteristics

As early as in 1969, Ranjit remarked that chemical composition is a major parameter influencing the quality of fruits. The different indicators ascertained in the jackfruit bulbs and seeds are as follows.

Table 1 Chemical and nutritional characteristics of jackfruit bulbs

Jackfruit bulb	Method
1) Acidity (per cent)	(Titrable acidity per cent. citric acid) Ranganna (1986)
2) pH	Using pH metre
3) Moisture (per cent)	Ranganna (1986)
4) TSS (°Brix)	Using Refractometer

Table 1 Continued

5) Total sugar (per cent)	Ranganna (1986)
6) Reducing sugar (per cent)	Ranganna (1986)
7) Total carbohydrate (per cent)	By difference
8) β-carotene (μg/100 g)	NIN (1991)
9) Vitamin C (mg/100 g)	Ranganna (1986)
10) Fibre (per cent)	AOAC (1976)
11) Polyphenols (g/100 g)	Ranganna (1986)
12) Pectin (g/100 g)	Ranganna (1986)
13) Starch (per cent)	Ranganna (1986)

3.3 STANDARDIZATION AND PRODUCT DEVELOPMENT

Standardization is an essential strive for production of high quality products (Crusius, 1984). Pruthi (1971) was of the opinion that standardization is the yardstick which when properly used, leads to considerable improvement in quality, enhancement of productivity, reduction of costs and results in optimum utilization of available resources.

Ericson and Desantis (1983) stated that efforts in product development and testing cover a broad spectrum of efforts which begins with the collection of recipes from the literature, its modification or adjustment in the basic recipe and then in order to get a new product, testing its suitability and finalizing a recipe acceptable among the consumers.

According to Ranjini *et al.*, (2000), food consumption pattern have witnessed a major change in the past few decades with the availability of a large quantity of convenience foods. Mathur and Sabikhi (2002) opined that today's consumers are more health conscious, which is the driving force of designing newer foods.

Fruits and vegetable occupy a larger section in our diet as they provide various macro and micro nutrients, besides phytochemicals which protect our body from various diseases.

A variety of fruits are being exploited to bring newer fruit based products in the market which have a greater consumer appeal. Jackfruit is one such fruit whose value addition is still in the infancy phase.

3.3.1 Products Developed under Study

3.3.1.1 Products from Fruit Pulp

Under the present investigation, product development utilizing jackfruit pulp and jackfruit seeds were explored. From the jackfruit pulp three products were standardized *viz.*, clarified juice, fruit nectar and fruit bar while from the jackfruit seeds health drink mixes and bakery and confectionary products were standardized.

3.3.1.1.1 Clarified Juice from Jackfruit Pulp

According to Ranganna (1986) clarified juice is an unsweetened juice which is 100 per cent pure obtained from the fruit pulp and is free of objectionable taints and flavours. Boopathy (1994) reported that to overcome low yield of juice and soluble fruit components such as colour and flavour compounds, the fruit pulp could be treated with pectin splitting enzymes. Sandhu *et al.* (1988) opined that pectolytic treatment increases juice yield and conserves loss of nutrients. Jackfruit yields thick pulp which is mucilaginous and viscous. Hence, under the present investigation enzyme treatment was attempted to get clarified juice from jackfruit. The clarified juice thus obtained could be further used for formulating fruit based beverages and products.

3.3.1.1.2 Fruit Nectar from Jackfruit

Mathur and Sabikhi (2002) reported that more and more beverages than any other products are being added to consumer's shelves today. These include, nutritionally enriched beverages such as vitamin fortified drinks, juices with added proteins and even herbal extracts. Fruit nectar is a readily drinkable beverage like juice, which provides instant energy and serves as source of various other nutrients. Singh *et al.* (2000) reported that jackfruit pulp could be utilized for formulating ready to serve beverages and nectars. Fruit nectar differs from ready to serve beverages (RTS) as it contains more fruit pulp with a TSS of >15°Brix and mild acidic in taste (acidity >0.3 per cent).

In the present study, two varieties of jackfruit were utilized for formulating fruit nectars individually and by blending with other fruit pulps so that nectars of different flavour and taste could be formulated.

3.3.1.1.3 Fruit Bars from Jackfruit

Ready to eat fruit bars are well established products that are being commercially prepared in our country (Krishnaveni *et al.*, 1999). According to Kumar and Manimegalai (2002b), fruit bars are prepared by drying fruit pulps after adjusting acidity and sugar concentration. They were also of the opinion that fruit bar offer tremendous advantage owing to simplicity, in investment and better consumer appeal. Gowda and Ramanjameneya (1995) had developed fruit bars from mango, papaya, pineapple, jamun and banana individually or in combination with different fruits. In the present study, jackfruit pulp of varikka and koozha variety was utilized individually as well as with other fruit pulps for formulating fruit bars.

3.3.1.2 Products from Jackfruit Seeds

In order to make effective utilization of seeds arising from jackfruit processing, they were explored for product development. Berry and Kalra (1987) reported that seeds can be used as a source of carbohydrates and energy. It also contains protein, calcium, iron potassium, phosphorus and magnesium. Two types of products attempted in the present study with seed flour were health drink mixes and bakery and confectionary products.

3.3.1.2.1 Health Drink Mixes from Seed Flour

Market for functional drinks with specifically endowed with nutritional and health benefits is reported to be growing at a rate not matched to other food sectors. Functional drinks comprising of enriched beverages, sports drinks, energy drinks and nutraceuticals are increasingly attracting the attention of 18-44 years old consumers looking for a healthy life style (Sharma, 2004). Sudhir *et al.* (2002) reported that health drink mixes are basically meant for people engaged in heavy physical activities as they provide electrolytes lost during exertion. The authors have further reported that formulation of health mixes requires technical knowledge of ingredients their interactions and the ways they are affected by processing treatments. Jackfruit seed flour is a good source of minerals, proteins and starch and can serve as a source of nutritious base for formulation of health mixes.

3.3.1.2.2 Bakery and Confectionary Products from Seed Flour

India is considered as the third largest producer of biscuit next to USA and China. Biscuit is a hygienically packed nutritious snack food available at very competitive prices, volumes and different tastes (Srivastava, 2004).

Arnold (1982) reported that biscuit is essentially a baked product dried down to low moisture content. It is made from soft flour, mostly rich in fat and sugar packed with high energy. Jackfruit seed flour can be productively used for formulation of biscuits and other confectionary products, in combination with other food ingredients.

3.3.2 Standardization of Products from Jackfruit Pulp

3.3.2.1 Standardization of Clarified Juice

Clarified juice was standardized from jackfruit pulp by subjecting the pulp to enzymatic treatment.

Processing of jackfruit pulp

Fresh bulbs of varikka variety was selected for the purpose. Bulbs were pulped thoroughly in the pulper without adding any other ingredients. This pulp was used for extracting juice. Steps for the extraction of juice are given in the flowchart (Fig.1).

Enzyme treatment

Pectic enzyme (pectinase from *A. niger*) was used to break up the pectin of the pulp and extraction of juice. Enzyme concentration, temperature and incubation period were determined in the preliminary steps involved in the standardization procedure. For determining the optimum concentration of the enzyme, the pulp was thoroughly mixed with the enzyme in different concentrations from 0.1 per cent up to five per cent with an increase of concentration by 0.5 per cent for each treatment. Optimum duration of incubation was determined based on the yield of juice, after incubating the pulp with 0.5 per cent enzyme at 30°C for different durations from one to five hours with an hourly increase in duration. Similarly optimum temperature of incubation was determined by incubating the pulp with 0.5 per cent enzyme for two hours at 35°C, 40°C and 50°C. For extraction of juice triplicate samples of 100 g each of jackfruit pulp was used.

A control sample without any enzyme treatment was maintained for comparison.

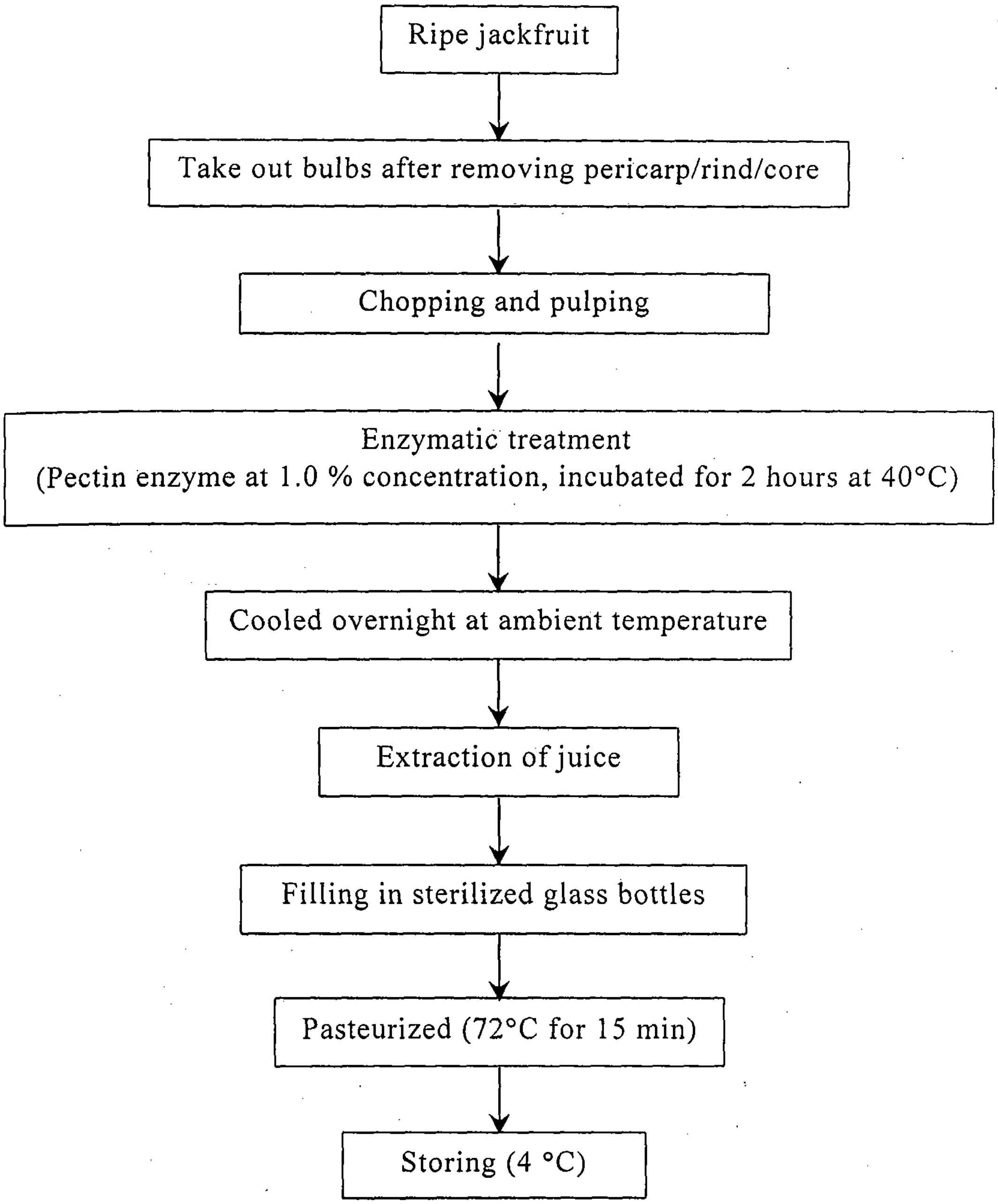


Fig. 1. Flowchart for clarified juice

Incubation : The jackfruit pulp was incubated at 40° C temperature for 2 hours adding 1 per cent pectin enzyme which was occasionally stirred. Enzyme treated pulp after incubation was taken out from the incubator, cooled and kept overnight (12 hours) at ambient temperature.

Extraction of juice : Clear juice filtered from the pulp was siphoned out leaving aside the residue. The juice thus obtained was sparkling clear with pale yellow colour.

Filling in the sterilized bottles : The juice was filled in sterilized glass bottles (200 ml) and sealed.

Pasteurization : The filled glass bottles were pasteurized at 72°C for 15 minutes. The bottles were taken out cooled and then stored in the refrigerator.

3.3.2.2 Standardization of Jackfruit Nectar

Beverages are delicious and have universal appeal unlike any other food products. Fruit beverages are gaining much popularity, as they are instant source of energy and nutrients.

A variety of fruit beverages *viz.*, RTS, squash, juice and nectars are popular in the Indian market. Nectar is a juice having honey like consistency and is readily drinkable (Kalra *et al.*, 1991).

Under the present investigation jackfruit nectar was standardized from two varieties of jackfruit individually and in combination with different fruit pulps in order to improve nutritive value and to add different taste and flavour.

Standardization procedure

In the standardization of each category of nectars, different proportions of ingredients as in the standard recipe were taken and different combinations were tried by 'trial and error'. Each category of nectar was prepared separately and presented simultaneously before the judge panel constituted specifically for the purpose. The judge panel comprising ten members were selected according to the standard procedure designed for the purpose. (Procedure appended Ia&b) In order to identify the best combination under each category, a score card was developed and presented to the panel judges (Appendix Ic). The above exercise was repeated thrice with an interval of one week to get concordant results. The various proportions of ingredients tried out under each category of nectars are presented in Table 2. Among the various proportions tried out, the best combination was selected from each category of nectars based on the average scores computed, from the score cards of ten panel judges. The proportion of best combination was identified for the final selection of each category of nectars. Thus four nectars from each variety of jackfruit were standardized under the present study.

Steps in the formulation of nectar

Collection of fruit

Mature, sound fruits of varikka and koozha were collected from the Instructional Farm, Vellayani and also from adjacent home yards. Fruits were allowed to ripen fully by keeping them at room temperature.

Preparation of pulp

Bulbs of the varikka jackfruit were taken out from the pericarp, removed the seeds and chopped. Chopped bulbs were fed to the pulper. In the case of koozha variety after removing the seeds bulbs were fed directly to the pulper and pulped thoroughly. In both the cases the pulp was run twice to get a smooth, uniform pulp. The initial TSS of the pulp was analysed for both the varieties and raised to 25° Brix by adding sugar.

The pulp was heated to 80°C temperature for 20 minutes. The pulp was then cooled and preservative was added (50 ppm KMS and 30 ppm sodium benzoate). The cooled pulp was filled in food grade containers and stored at 4 °C temperature. Steps for preparation of nectar are given in Flowchart (Fig.2).

Table 2 Proportions of ingredients tried out for the formulation of jackfruit nectars

Treatments	Combinations	Varikka variety					Koozha variety				
		*Jackfruit pulp with preservative added	Other fruit pulps	Water	Sugar	Citric acid	*Jackfruit pulp with preservative added	Other fruit pulps	Water	Sugar	Citric acid
Control jackfruit Nectar	1	1.0 (1 kg)	-	1.2 (1200 ml)	0.15 (150 g)	0.0025 (2.5 g)	1.0 (1 kg)	-	1.0 (1 litre)	0.10 (100 g)	0.005 (5 g)
	2	1.0 (1 kg)	-	1.5 (1500 ml)	0.25 (250 g)	0.005 (5 g)	1.0 (1 kg)	-	1.2 (1200 ml)	0.15 (150 g)	0.006 (6 g)
Pineapple blended nectar	1	0.5 (500 g)	0.5 (500 g)	1.5 (1500 ml)	0.25 (250 g)	0.005 (5 g)	0.5 (500 g)	0.5 (500 g)	1.2 (1200 ml)	0.15 (150 g)	0.006 (6 g)
	2	0.25 (250 g)	0.75 (750 g)	1.2 (1200 ml)	0.15 (150 g)	0.0025 (2.5 g)	0.25 (250 g)	0.75 (750 g)	1.0 (1 litre)	0.10 (100 g)	0.005 (5 g)
Papaya blended nectar	1	0.5 (500 g)	0.5 (500 g)	1.5 (1500 ml)	0.25 (250 g)	0.005 (5 g)	0.5 (500 g)	0.5 (500 g)	1.2 (1200 ml)	0.05 (50 g)	0.006 (6 g)
	2	0.5 (500 g)	0.75 (750 g)	1.2 (1200 ml)	0.15 (150 g)	0.0025 (2.5 g)	0.5 (500 g)	0.75 (750 g)	1.0 (1 litre)	0.05 (50 g)	0.006 (6 g)
Mango blended nectar	1	0.5 (500 g)	0.5 (500 g)	1.5 (1500 ml)	0.25 (250 g)	0.005 (5 g)	0.5 (500 g)	0.5 (500 g)	1.2 (1200 ml)	0.15 (150 g)	0.006 (6 g)
	2	0.25 (250 g)	0.75 (750 g)	1.2 (1200 ml)	0.15 (150 g)	0.0025 (2.5 g)	0.25 (250 g)	0.75 (750 g)	1.0 (1 litre)	0.10 (100 g)	0.005 (5 g)

*Pulp contains 100 ppm of sulphur dioxide

Figures in parenthesis denote quantity of ingredients by weight

Blending

Gopalan and Ram (1992) reported that pineapple fruit has an attractive, crunchy acidic taste and is a good source of vitamin B_1 compared to other fruits. Blending of pineapple with jackfruit not only increases iron and vitamin C content but also impart an acidic flavour to the finished product.

Papaya is a cheap, nutritive fruit rich in cellulose and hence can be categorized as a protective fruit. Hayes (1953) is of the opinion that papaya fruits with deep yellow colour could be blended ideally with jackfruit.

Mango fruit when blended with jackfruit pulp not only imparts an aromatic flavour but also increases the iron, carotene, niacin and vitamin C to the finished product. Considering the above factors papaya, pineapple and mango fruits was selected for blending. Papaya and mango fruits were peeled, chopped and pulped. Whereas for pineapple fruit, the crown was removed, fruit was peeled, after removing eyes and then grated on a steel grater. The grated pulp was squeezed to get a fine juice which could be blended with jackfruit pulp.

The proportions finalized as per the standardization procedure was taken for preparing plain and blended jackfruit nectars. In the formulation of plain jackfruit nectars jackfruit pulp along with other ingredients were used whereas in the blended jackfruit nectars fruit pulp from pineapple, papaya and mango along with jackfruit pulp were blended in order to obtain better quality nectars.

Mixing with other ingredients

After blending the jackfruit pulp with other fruit pulps, other ingredients *viz.*, sugar, citric acid, water etc. were added and mixed thoroughly in a blender.

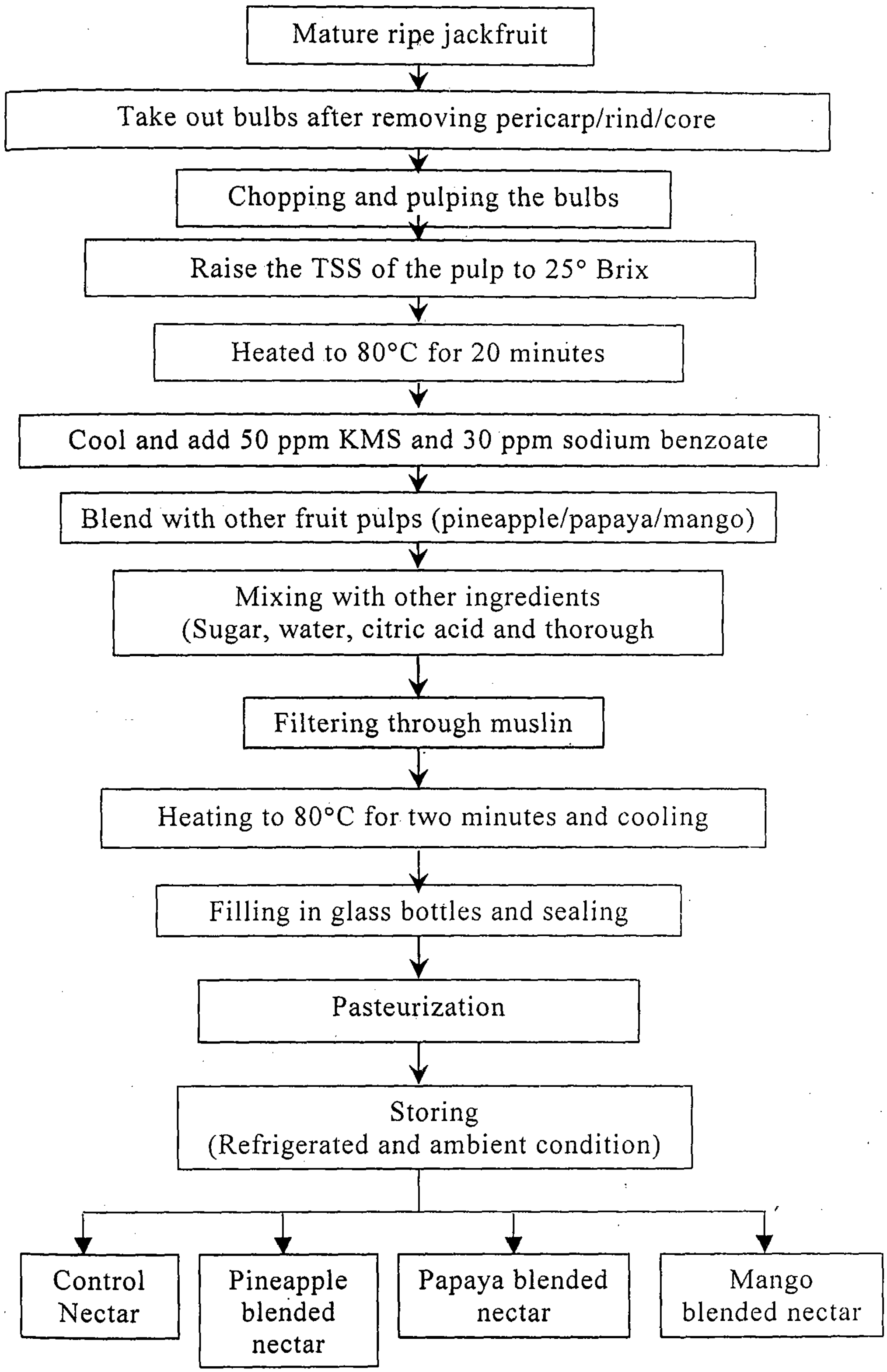


Fig. 2. Flowchart for jackfruit nectar

Filtration and heating

The prepared nectar was filtered through a fine muslin cloth and then heated to 80° for two minutes.

Sealing and pasteurization

Nectars prepared were filled in sterilized glass bottles (200 ml). The bottles were crown corked with sterilized metallic caps. The bottles were pasteurized after which they were cooled.

Storing

The cooled nectar bottles were stored under two different storage conditions. One set was stored under refrigerated condition (4°C) whereas other sets were stored under ambient condition.

3.3.2.3 Standardization of Jackfruit Bars

Among the various novel products developed across the country, fruit bars is relished well by all categories of people. Fruit bars of different types are available in the market *viz.*, mango bar, banana bar, pineapple bar, jackfruit bar, etc. Under the present investigation blended jackfruit bars were standardized in which jackfruit pulp was blended with other fruit pulps.

Standardization procedure

In the formulation of plain jackfruit bars, jackfruit pulp along with other ingredients were utilized whereas in the blended fruit bar, jackfruit pulp and pulp from papaya/mango were used. For the formulation of each category of fruit bar in the present study, different proportions of ingredients were taken as in the standard recipe and different combinations were tried out under each category. Details are presented in Table 3. Each category of fruit bar was standardized separately and presented simultaneously before the technical experts, to identify the best combination under each category using a scorecard developed for the

Table 3 Proportions of ingredients tried out for the formulation of jackfruit bars

Treatments	Combi-nations	Varikka variety						Koozha variety					
		*Jackfruit pulp with preservative added	Pulp of other fruits	Water	Sugar	Citric acid	Rice flour	*Jackfruit pulp with preservative added	Pulp of other fruits	Water	Sugar	Citric acid	Rice flour
Plain jackfruit bar	1	1.0 (1 kg)	-	0.25 (250 ml)	0.32 (320 g)	0.002 (2 g)	-	1.0 (1 kg)	-	0.20 (200 ml)	0.32 (320 g)	0.002 (2 g)	-
	2	1.0 (1 kg)	-	0.12 (120 ml)	0.32 (320 g)	0.001 (1 g)	-	1.0 (1 kg)	-	0.12 (120 ml)	0.12 (120 g)	0.003 (3 g)	-
Papaya blended bar	1	0.5 (500 g)	0.5 (500 g)	0.25 (250 ml)	0.32 (320 g)	0.002 (2 g)	0.04 (4 g)	0.5 (500 g)	0.5 (500 g)	0.12 (120 ml)	0.12 (120 g)	0.002 (2 g)	0.06 (6 g)
	2	0.25 (250 g)	0.75 (750 g)	0.25 (250 ml)	0.32 (320 g)	0.002 (2 g)	0.08 (8 g)	0.25 (250 g)	0.75 (750 g)	0.20 (200 ml)	0.32 (320 g)	0.003 (3 g)	0.08 (8 g)
Mango blended bar	1	0.5 (500 g)	0.5 (500 g)	0.25 (250 ml)	0.32 (320 g)	0.002 (2 g)	-	0.5 (500 g)	0.5 (500 g)	0.12 (120 ml)	0.12 (120 g)	0.002 (2 g)	-
	2	0.25 (250 g)	0.75 (750 g)	0.25 (250 ml)	0.32 ([illegible]20 g)	0.001 (1 g)	-	0.25 (250 g)	0.75 (750 g)	0.20 (200 ml)	0.32 (320 g)	0.003 (3 g)	-

*Pulp contains 100 ppm of sulphur dioxide

Figures in parenthesis denote quantity of ingredients by weight purpose. The scorecard is appended (Id). The above exercise was repeated thrice with an interval of one week to get concordant results. Thus three fruit bars from each variety of jackfruit with different colour, flavour and taste were standardized under the present study. Steps for formulation of fruit bars are given in the flowchart (Fig.3).

Steps in the formulation of jackfruit bars

Collection of fruit

Collection of jackfruit was done as mentioned in 3.3.2.2.

Preparation of pulp

Jackfruit pulp of two varieties was prepared as mentioned 3.3.2.2.

Blending

As per the proportions identified through standardization of jackfruit bars, jackfruit pulp and other fruit pulps were taken and mixed thoroughly to get uniform consistency.

Mixing with other ingredients

After blending the jackfruit pulp with other fruit pulps, other ingredients *viz.*, sugar, citric acid, water etc. were added and mixed thoroughly in a blender.

Spreading and drying the bars

The pulp mixture was spread on a greased steel tray in 1.5 cm thickness and dried at 60°C for 30 hours to get uniformly dried layer.

Packing and storing

The dried fruit bars were cut into rectangular size (9.0 x 2.6 x 1.0 cm) and packed in laminated foil covers and sealed. Sealed fruit bars were stored under ambient temperature for a period of six months.

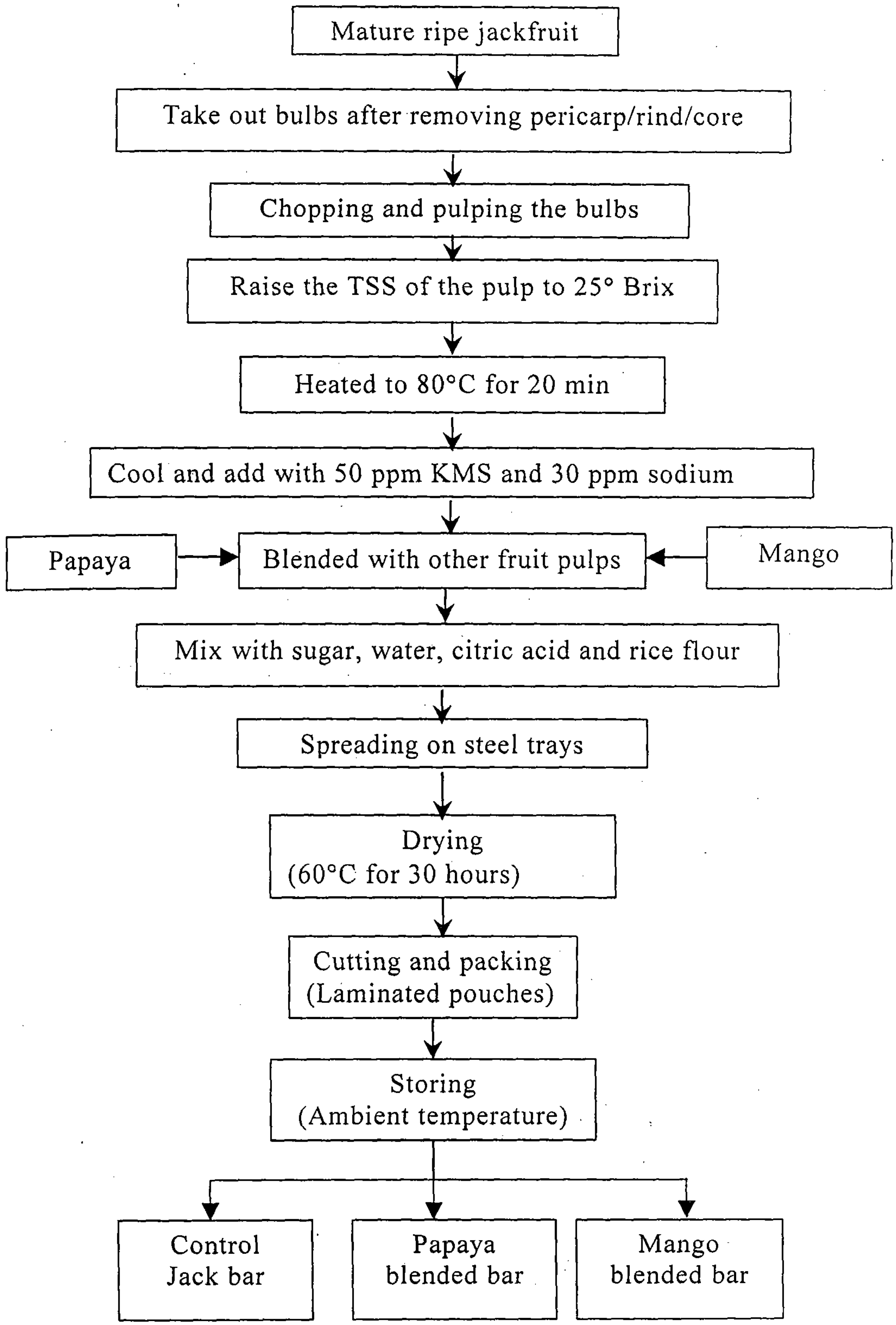


Fig. 3. Flowchart for jackfruit bar

3.3.3 Standardization of Products from Jackfruit Seed Flour

3.3.3.1 Formulation of Health Drink Mixes

Due to rapid industrial growth and urbanization there has been an ever increasing reliance on formula foods / health mixes / instant foods both in developed and developing countries. Apart from these socio-economic considerations such substitutes serve as savers of precious lives during vulnerable stages of infancy (Mathur, 1991).

Health mixes also provide energy, essential vitamins and minerals required for adolescents growth, as well as for pregnant and lactating mothers. It is a complete food in itself which can be taken by all categories of people.

Jackfruit seed flour being a rich source of protein, minerals *viz.*, iron, phosphorus, potassium can serve as a rich base for health mixes. Hence in the present study an attempt has been made to standardize health drink mixes in which jackfruit seed flour is used as a constituent, which are generally not been used effectively.

Standardization of Health Drink Mixes

The standardization procedure as mentioned earlier was strictly followed for the formulation of two types of health drink mixes under present investigation.

Formulation of malted health mix

Preliminary processing of raw materials

Preparation of seed flour

Seeds obtained after jackfruit processing were utilized for the preparation of seed flour. The method suggested by Rajarajeshwari *et al.* (1999) was followed for the preparation of seed flour. The outer white peel of the seeds were scrapped off. It was then washed thoroughly and subjected to thermal treatment to inactivate antinutritional factors present in the seeds. Seeds were pressure cooked for 20 minutes at 15 lbs pressure, cooled and then the red cuticle was peeled off and the seed was cut into smaller pieces and crushed in the grinder. Crushed material was dried at 50°C in a drier for 6-8 hours. The dried material was milled to get a fine flour. Flour was sieved using a fine mesh of 60 mm.Steps for preparation are given in flowchart (Fig. 4).

Preparation of malt

Wheat malt gives a modified (malty) flavour that is not obtainable with raw wheat. For the formulation of wheat malt, whole wheat was procured from local market. It was cleaned, dried in sunlight for four hours and kept for germination. The wheat sprouts came out after six to seven days, which was then dried and ground to powder form. The flour was sieved using a fine sieve of 60 mm mesh and dried 50°C for four hours.

Defatted soya flour

Incorporation of defatted soya flour in diets will not only enhance the protein content of the diet but also would raise its nutritive value (Anila *et al.*, 1994). Defatted soya flour required for the formulation of health drink mixes was procured from Sakti Soya, Coimbatore, Tamil Nadu.

Other ingredients like sugar, whole milk powder and glucon D were procured from the local market.

Preparation of malted health drink mix

The proportions of ingredients finalized for malted health mix are given in the Table 4.

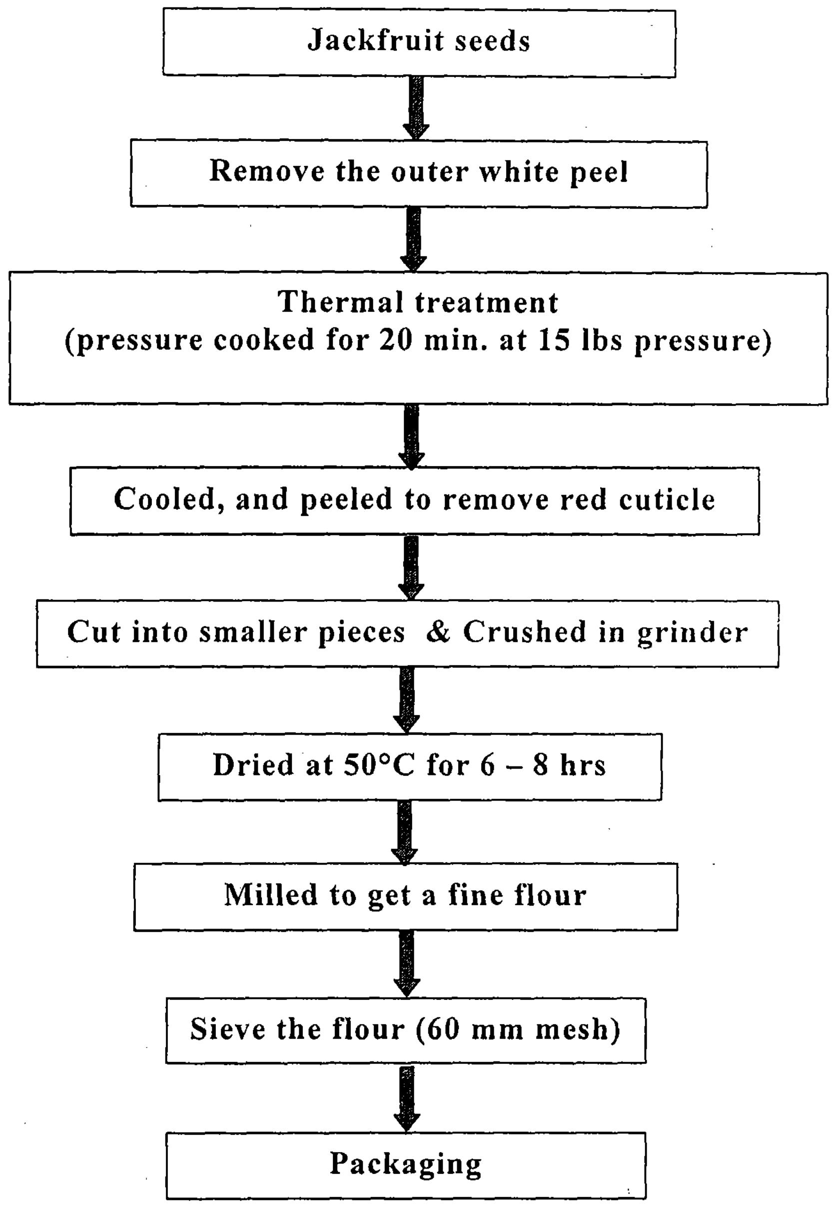


Fig. 4. Flowchart for preparation of jackfruit seed flour

Table 4 Ingredients of malted health drink mix

Ingredients	Amount (per cent)
Jack seed flour	35.00
Defatted soya flour	30.00
Wheat malt	10.00
Sugar	10.00
Whole milk powder	10.00
Glucon D	5.00

All the ingredients were mixed thoroughly and sieved. The health mix was packed in laminated pouches (100 g each) and stored for a period of six months. The health drink mixes standardized were presented before the panel judges for sensory evaluation (Appendix Ie).

Formulation of spiced health drink mix

Preliminary processing of raw materials

Jack seed flour, defatted soya flour, skimmed milk powder were processed/procured as mentioned earlier.

Greengram flour

The greengram was roasted on a slow flame until the flavour of dal was perceived. It was then allowed to cool and powdered in a mixie.

Jaggery

Sugarcane jaggery was used for sweetening and flavouring.

Coriander powder

The seeds contain about 0.5 to 1.0 per cent essential oil, which has an active principle – coriandrol, an isomer of geranial.

Black pepper powder

Piper nigrum contains about 2-5 per cent essential oil, which is responsible for characteristic flavours.

Dried ginger

Dried gingers contain about 1-3 per cent essential oil.

Cardamom

It is mainly used to add flavour to the health drink mix.

Fenugreek

Commonly known as Methi and is widely used in Indian culinary preparations. It stimulates the digestive process as well as the metabolism in general (Neeraja and Rajyalakshmi 1996).

Cumin

The seed contain about 2-4 per cent essential oil. The active principle is an aldehyde, cuminol.

All the condiments mentioned above were procured from the local market, cleaned, roasted, powdered in a mixie and sieved separately in order to get a fine powder.

Preparation of spiced health drink mix

The proportions of ingredients finalized for spiced health mix are given in the Table.

Table 5 Ingredients of spiced health drink mix

Ingredients	Amount (per cent)
Jack seed flour	25
Defatted soya flour	15
Whole milk powder	15
Greengram flour	15
Sugar	20
Coriander powder	3
Black pepper	1
Dried ginger	2
Cardamom	2
Fenugreek	1
Cumin	1

All the ingredients were mixed thoroughly and sieved. The health mix was packed in laminated pouches (100 g each) and stored for a period of six months.

3.3.3.2 Standardization of Bakery and Confectionary Products from Seed Flour

Bakery products are increasingly becoming popular due to their ready to eat, convenience, cost competitiveness, availability of various products with different taste and textural profiles, advantage of nutrition and adequate shelf life (Rao, 2004).

The consumption of bakery products is increasing at the rate of 10.07 per cent. Under the present study jackfruit seed flour was utilized for formulating biscuit and laddu using other food adjuncts.

Standardization procedure

Jackfruit seed flour biscuit was standardized using other food adjuncts.The biscuit standardized was evaluated by panel judges using a score card (Appendix If).

Preliminary processing of raw material

The different raw materials selected for the formulation of jackfruit biscuit were jack seed flour, defatted soya flour, maida, dalda, sugar, ammonium bicarbonate and flavours such as, vanilla essence, caramalised sugar and cashews.

Preparation of the biscuit

The biscuits were prepared according to the composition given below. The method of preparation is appended, (Appendix IIa)

Ingredients : Jack seed flour – 35 g, coconut milk powder 30 g, maida – 100 g, dalda 70 g, sugar 50 g, ammonia bicarbonate – a pinch, vanilla essence, caramalised sugar and cashew as desired.

Packing and storing

The biscuits were packed in food grade laminated pouches (250 g each) and stored for a period of two months under ambient condition.

Standardization of Laddu

Jackfruit seed flour was utilized to formulate laddu along with other food adjuncts. The above product was evaluated by panel members using a score card (Appendix I g).

Preliminary processing of raw material

The different raw material selected for the formulation of laddu was jack seed flour, maida, dalda, sugar, cashew, milk powder and curd.

Preparation of laddus

Laddus were prepared according to the composition given below;

Jack seed flour – 50 g, maida – 30 g, dalda – 35 g, sugar 75 g, whole milk powder – 25 g, curd 50 ml, cashews – as desired. The method of preparation is appended (Appendix IIb).

Packing and storing

The laddus were packed in food grade laminated pouches (50 g each) and stored for a period of 15 days under ambient condition.

3.4 ANALYTICAL WORK CARRIED OUT IN THE PRODUCTS DEVELOPED FROM JACKFRUIT

3.4.1 Assessment of Chemical and Nutritional Characteristics of the Products

Quality is the ultimate criterion of the desirability of any food product to the consumers. Poduval (2002) opined that quality standards are of great importance in facilitating both national and international trade. Quality of the product is determined by its chemical and nutritional composition.

Bhujan and Sharma. (1992) reported that physico-chemical characteristics of the products are indicative of its quality.

The following parameters were ascertained in the products standardized under study.

Parameters	Methods followed
Moisture (per cent)	Ranganna (1986)
Acidity (per cent)	Titrable acidity per cent. citric acid (Ranganna, 1986)
pH	pH metre
TSS (°Brix)	Refractometer
Total sugar (per cent)	Ranganna (1986)
Reducing sugar (per cent)	Ranganna (1986)
β-carotene (μg)	NIN (1991)
Vitamin C (mg)	Ranganna (1986)
Polyphenols (g/100 g)	Ranganna (1986)
Fibre (per cent)	AOAC (1976)
Pectin (g/100 g)	Ranganna (1986)
Starch (per cent)	Anthrone Method (Ranganna 1986),

Besides above constituents, following parameters were also ascertained in clarified juice, health drink and bakery products.

Product	Parameters	Methods followed
Clarified juice	Extent of browning (Absorbance at 440 nm)	Colorimetric method using aqueous ethanol extract of juice
Health drink	Fat	Soxlet Method (1977)
	Protein	Kjeldal Method (1977)
	Acid value	AOAC (1976)
	Peroxide value	AOAC (1976)
Bakery products	Fat	Soxlet Method (1977)
	Protein	Kjeldal Method (1977)
	Acid value	AOAC (1976)
	Peroxide value	AOAC (1976)
	per cent Ash	Dry ashing (Ranganna, 1986)

3.4.2 Assessment of Organoleptic Features of the Products Standardized

Organoleptic qualities of the products play an important role in evaluating the quality of any food product. According to Mc Dermott (1992) when the quality of food is assessed by means of human sensory organs, the evaluation is said to be sensory analysis. Rao *et al.* (1997) is of the opinion that sensory evaluation plays a vital role in the food industry, because as a scientific discipline, it represents a very unique technique that harnesses human behavioural instincts of perception, learning, cognition, psychophysics and psychometrics for the evaluation of quality of foods.

For conducting sensory evaluation, a panel of judges has to be selected, so as to ascertain consistent and accurate results.

3.4.2.1 Selection of Judge Panel

Sensory evaluation of the products standardized was conducted by a panel of judges selected on the basis of screening test suggested for the purpose. Duo Trio Test and Ranking Test suggested by Jellinek (1985) was carried out observing the rules suggested for the purpose. Screening test was conducted among 25 persons selected at random. The procedure for the screening test is given in Appendix Ia&b.

Among the 25 members, 10 members who had qualified in the test were selected as the panel for the study.

3.4.3 Shelf Stability Studies of the Products Standardized

The shelf life qualities of the products were analysed in terms of shelf stability, changes in the chemical and organoleptic qualities, occurrence of microbial infestation in the product, consumer acceptance, consumer preference, cost analysis of the product, fruit product yield ratio and confirmation with the FPO standards.

3.4.3.1 Assessment of Shelf Life Qualities of the Stored Products

Changes in the chemical constituents during storage of the products developed under the present investigation were monitored periodically drawing samples in triplicates. Jackfruit based nectars were analysed weekly upto 60 days whereas jackfruit bars were analysed monthly for a period of six months. The health drink mixes were monitored once in a month upto a period of six months.

In the case of baked products biscuits developed with seed flour was analysed once in a week upto a period of eight weeks while confectionary product was monitored once in five days for a total period of 15 days.

Samples were drawn from each category of products randomly in required quantities (in triplicate) for analysis.

Following Table (6) depicts the details regarding the monitoring interval and the storage media used for the products under investigation.

Table 6 Storage media used for storing jackfruit products

Sl. No.	Products	Packaging material	Quantity stored	Storage periods	Interval of analyses
1	Jackfruit nectar	Glass bottles	200 ml	2 months	Weekly
2	Jackfruit bar	Laminated pouches	250 g	6 months	Monthly
3	Health drink mixes	Laminated pouches	100 g	6 months	Monthly
4	Biscuits	Laminated pouches	250 g	2 months	Weekly
5	Confectionary products	Laminated pouches	15 g	15 days	After every five days

3.4.3.2 Assessment of Organoleptic Qualities of the Products

According to Jellinek (1985) chemical indices of deterioration alone will not decide the quality changes and it should be correlated with sensory evaluation of stored products. Hence periodical evaluation of the products was carried out with respect to the sensory parameters also using a score card by the selected panel to understand the deteriorative changes occurring in the stored products.

The interval of analyses is given in Table 6.

3.4.3.3 Assessment of Microbial Profile of the Products

The pour plate method (Taylor, 1962) was employed to estimate the population of the number of viable micro-organisms in food products. Ten gram weight of the food products were transferred to 90 ml sterile quarter strength Ringers solution (Wilson, 1935) taken in 100 ml Erlenmayer flasks above the flame of Bunsen burner under aseptic conditions in laminar floor chamber. Uniform suspension was prepared by shaking the flasks in a rotary shaker for five minutes. Serial dilutions of the suspension were thus prepared in the sterile diluents. One ml aliquots of the suspension was withdrawn from the first dilution using a sterile pipette and added to 9 ml portions of sterile diluents taken in test tubes of 25 ml capacity to prepare 10-2 dilution. Further dilutions were prepared using a fresh sterile pipette in each case. One ml of each dilution was poured into a sterile petri dish using a sterile pipette and 15 ml of molten agar at 45°C was poured inside Laminar Airflow Chamber. The contents were mixed by circular movements in clock wise and anticlockwise directions. The molten agar was allowed to solidify and the plates were kept in an inverted position in BOD incubator set at the required temperature for each organism. After the incubation, the colonies developed on agar surface are counted and the counts were recorded as colony forming units by multiplying with the dilution factor.

The following media are the culture (as per the composition in ATCC, 1984) and incubation temperatures for different groups of microorganisms.

General viable count	–	Plate count agar
		Incubation temperature - 30°C
Yeast and moulds	–	Malt extract agar
		Incubation temperature - 30°C
Bacteria	–	Rose Bengal chloramphenicol
		Incubation temperature - 34°C

Isolation and Identification of Microbial Cultures

The representation cultures were isolated and purified by streaking solidified agar medium recommended for the group of organisms. The morphological, cultural and biochemical characteristics were determined as per the procedure outlined in Harrigan *et al.* (1966).

3.4.3.4 Assessment of Consumer Acceptance

Watt (1989) reported that acceptance tests are used to determine the degree of consumer acceptance of a new product. He also stated that acceptance of a food product usually indicates actual use of the product. The products developed under present study were subjected to consumer acceptance testing by selecting consumers at random. Selected subjects consists of academic and non-academic personnel, students and workers. Score card designed for the purpose is appended.

3.4.3.5 Assessment of Consumer preference

Preference tests allow consumers to express a choice between samples, one sample is preferred and chosen over another or there is no preference (Watt, 1989). A preference test was conducted by asking the consumers (both trained and untrained) to score/rank the products served in the sequence of their liking. The preference evaluation was made inorder to select the most promising products for large scale production.

3.4.3.6 Cost Analysis of the Product

According to How (1990) information as accurate and uptodate as possible on supply demand and prices is essential for anyone directly involved in the business of marketing fresh fruits. Obtaining such information for these commodities is especially challenging because the way they widely fluctuate, in the production and use. Cost analysis was carried out based on the prices of different items used during the time of preparation of the product. Cost of the fruit and other ingredients used, cost of packing materials, fuel charges, labour cost, overhead charge @ 10 per cent were taken into account while deriving the individual cost of the product.

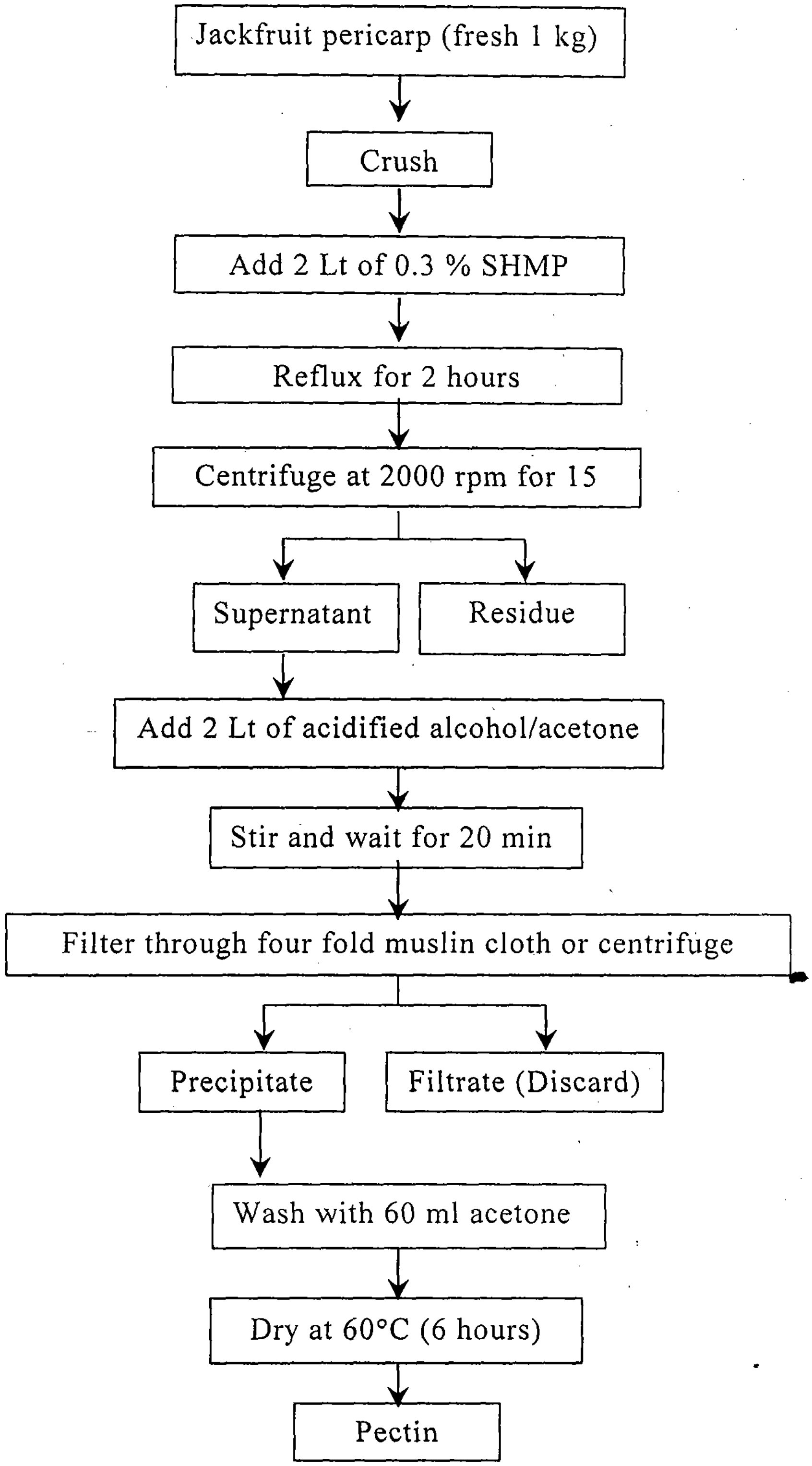


Fig. 5. Flowchart for extraction of pectin

3.4.3.7 Product Yield Ratio

Information on product yield ratio is indispensable in ensuring the output of a fixed quantity of finished product. This was analysed by considering the quantity of fruit used to produce a particular unit of each product.

3.4.3.8 Confirmation with the FPO Standards

Food is a sensitive commodity. It directly affects human health and safety. It therefore calls for special care in handling right from raw material through processing, packing and transport to the consumption point (Sohrab, 1993). The food industry has its special requirements which would call for tailoring the quality management system to suit the requirements of the industry and to have certification like HACCP, ISO-9000 etc. which are essential for food industries (Jain, 2001). HACCP is a logical and structured method of assessing the hazards and risks associated with the manufacturing of food products, enabling the identification of critical control points (CCP's) in the manufacturing process and the application of monitoring, control and verification requirements. HACCP can be used to better assure food safety (Early, 1995).

In India the quality of the preserved product is controlled by the government through the Fruit Product Order (FPO) 1955 and later modified in 1961 as Fruit products Amendment Order 1961. In the present study jackfruit products standardized from two varieties of jackfruit were compared with the prescribed standards for the similar products in order to ensure whether the products are in conformity with standards for quality.

3.5 BYPRODUCT RECOVERY FROM THE JACKFRUIT AND QUALITY ANALYSIS

Anand and Maini (1997) reported that jackfruit peels, cores and seeds are left as waste and can be utilized for extraction of pectin which finds application in many food processing and pharmaceutical industries.

Jackfruit seeds

↓ Steep in water
Containing 1 g KMS for 24 hours

Grind the seed adding

↓ Water to make a paste

Filter through muslin cloth

↓ Grind residue and filter again
(Repeat thrice)

Pool filtrates

↓ Add 1 g KMS and allow to settle
for 6 hours, sip for supernatants

Sedimentations

↓ Wash with water, adjust pH 10 or 11
with NaOH and agitate

Sedimentations

↓ Wash with $KMnO_4$
Decolourise with SO_2

Sedimentations

↓ Wash with water centrifuge

Starch

(Dry at 60°C overnight)

Fig. 6. Extraction of starch

Two byproducts *viz.*, pectin and starch were recovered from jackfruit waste. The details are given below.

3.5.1 Extraction of Pectin

Jackfruit rind and pericarp left after removing the bulbs were utilized for extraction of pectin. One kg pericarp (in triplicate) was taken and pectin was extracted using 0.3 per cent sodium Hexametaphosphate (SHMP) as suggested by Tandon *et al.*(1995) Method adopted is given in Fig.5 .

The quality of pectin extracted was analysed in terms of equivalent weight, viscosity, jelly grade, methoxyl content, jellying capacity, yield and cost benefit ratio as suggested by Ranganna (1986).

3.5.2 Extraction of Starch

The starch was extracted from fresh jackfruit seeds as presented in Fig.6 . Method was suggested by Tandon and Kalra (1989).

The extracted starch was analysed for quality in terms of Amylose content, alkali number, granule size, viscosity and yield and cost analysis as per the methods described by Ranganna (1986).

3.6 STATISTICAL ANALYSIS OF THE DATA

The generated data was subjected to suitable statistical analysis for meaningful interpretation. The data generated for physical and chemical characteristics of jackfruit and jackfruit seeds was subjected to 't' test, whereas the physico-chemical and organoleptic data was subjected to Completely Randomized Design (CRD) analysis.

The data for pectin and starch extracted from jackfruit waste was subjected to 't' test.

Results

4. RESULTS

Results of the present investigation entitled "Utilization of jackfruit for product development and byproduct recovery" are presented below under the following heads:

4.1 Assessment of physico-chemical characteristics of jackfruit

4.2 Standardisation and product development utilizing jackfruit bulbs and assessing the chemical, nutritional, organoleptic and shelf stability features of developed products

4.3 Standardisation and product development utilizing jack seed flour and assessing the chemical nutritional, organoleptic and shelf stability features of developed products

4.4 Assessment of microbial profile of the products standardized

4.5 Comparison of the products developed with FPO standards

4.6 Assessment of consumer acceptance and consumer preference of the products standardized

4.7 Economic viability of the jackfruit products developed

4.8 Byproduct recovery from jackfruit and its quality evaluation

4.1 ASSESSMENT OF PHYSICO-CHEMICAL CHARACTERISTICS OF JACKFRUIT

Jackfruit is widely cultivated in most tropical countries and considered as poor man's fruit, as it is very cheap and available in plenty during season. Fruit to fruit variation was observed with respect to physical and chemical characteristics of jackfruit. In order to obtain a comparative data about the fruit characteristics, physico-chemical analysis of two varieties of jackfruit *viz.*, varikka and koozha was carried out.

4.1.1 Assessment of Physical Characteristics of Jackfruit

Table 7 depicts a comparative data of the major physical characteristics of varikka and koozha varieties of jackfruit. Physical characteristics like colour of fruit, interspine distance, peduncle length, number of spines/unit area, weight and length of fruit, number of fruits/plant and yield per plant were assessed.

Table 7 Assessment of physical characteristics of jackfruit

Physical attributes	Varikka	Koozha	t value
Colour of fruit (ripe)	Bright yellow	Pale yellow	-
Interspine distance (cm)	1.26	0.99	1.89
Number of spines / unit area	5.07	4.23	14.04**
Peduncle length (cm)	60.70	60.10	0.97
Weight of fruit (kg)	5.45	6.61	9.67**
Length of fruit (cm)	80.12	100.04	56.85**
Number of fruits / plant	51.00	46.00	23.86**
Yield / plant (g)	276.00	298.00	14.44**

**Significant at 1 per cent level

Physical characteristics were recorded from 30 randomly selected fruits of each variety. Unripe fruits were green in colour for both the type of variety, which was mainly attributed to the spines present on the surface of jackfruit, but as the fruit matures the spines attained yellow colour, giving the fruit a yellowish appearance.

The outer surface of jackfruit is covered with spines and the interspine distance is considered as an indication of maturity of the fruit. Distance between the spines increases as the fruit matures and then flattens. The interspine distance was observed to be 1.26 cm on an average in varikka fruits and 0.99 cm in koozha fruits. The distance was not significantly different in the two varieties.

The number of spines per unit area decreases as the fruit ripens. Spines per unit area was observed to be 5.07 in varikka variety, which was significantly higher than koozha variety (4.23).

The peduncle length (midrib by which fruit is attached to the main branch). which passes across the entire fruit was estimated on an average 60.70 cm in varikka and 60.10 cm in koozha. which were statistically on par.

The weight and length of the fruits of varikka variety was observed to be 5.45 kg and 80.12 cm respectively, which was significantly less than that of koozha variety which recorded an average of 6.61 kg and 100.04 cm respectively.

The number of fruits per plant was more in varikka (51.00) than koozha (46.00) while per plant yield was more in koozha (298.00 kg) than varikka (276.00 kg).

4.1.2 Assessment of Cut Jackfruit

Table 8 represents the various parameters assessed in the cut jackfruit. The cut fruit was assessed for various bulb and seed characteristics *viz.*, colour of the bulb, length of the bulb, weight of the bulb, length of seed and weight of seed and number of seeds per fruit.

Table 8 Assessment of cut jackfruit

Parameters	Varikka	Koozha	t value
Colour of bulb	Bright yellow	Pale Yellow	-
Length of bulbs (cm)	10.26	12.38	29.75**
Weight of bulbs (g)	4.72	5.36	9.84**
Length of seeds (cm)	5.77	6.96	16.21**
Weight of seeds (g)	3.20	4.43	20.59**
Number of seeds per fruit	60.00	64.00	32.92**

**Significant at 1 per cent level

The colour of the bulbs was found to be bright yellow to somewhat yellowish orange for varikka variety while the bulbs of the koozha variety varied from pale to light yellow in colour.

Significant difference was observed in the length of bulbs in two varieties of jackfruit analysed (29.75**). The average length of koozha bulbs was observed to be 12.38 cm which was significantly higher than that of varikka bulbs (10.26 cm).

The weight of the bulbs was recorded to be significantly higher for koozha variety (5.36 g) as compared to varikka variety (4.72 g). The average length of the seeds of koozha variety (6.96 cm) was significantly more than that of varikka (5.77 cm). The mean weight of jackfruit seeds was also found to be more for koozha variety (4.43 g) in comparison with varikka variety (3.20 g).

The number of seeds per fruit was also high for koozha (64.00) than varikka (60.00).

4.1.3 Assessment of Chemical Constituents of Jackfruit Bulbs

Various chemical constituents *viz.*, moisture, acidity, pH, TSS, total sugars, reducing sugar, fibre, β-carotene, vitamin C, pectin and polyphenols were analysed in the bulbs of the jackfruit of both varieties. The results are presented in Table 9.

Table 9 Assessment of chemical constituents of jackfruit bulbs

Parameters	Varikka	Koozha	t value
Moisture (per cent)	76.56	78.10	2.49*
Acidity (per cent)	2.64	1.63	1.64
pH	3.96	4.13	2.20*
TSS (°Brix)	21.96	25.10	8.24**
Total sugar (per cent)	19.86	22.83	6.45**
Reducing sugar (per cent)	5.71	3.66	22.82**
Fibre (per cent)	1.03	1.22	1.54
β-carotene (μg)	163.66	178.36	5.64**
Vitamin C (mg/100 g)	10.36	9.70	2.13*
Pectin (g/100 g)	3.19	1.97	7.50**
Polyphenol (g per 100 g)	128.00	118.00	4.14**

*Significant at 5 per cent level, **Significant at 1 per cent level

The moisture content of jackfruit varieties was significantly high (78.10 per cent) as compared to varikka (76.56 per cent).

Acidity was not significantly different in both the varieties of jackfruit. Varikka variety recorded higher acidity (2.64 per cent) as compared to koozha variety (1.63 per cent). The pH was found to be 3.96 which was significantly less than that of koozha (4.13).

Significant difference was observed in TSS content of the two varieties of jackfruit bulbs being higher for koozha variety (21.96 and 25.10° Brix respectively in varikka and koozha respectively). The total sugar content was recorded higher in koozha variety (22.83 per cent) as compared to varikka variety (19.86 per cent), while reducing sugar content was markedly high in varikka (5.71 per cent) as compared to koozha variety (3.66 per cent).

No significant difference was observed in the fibre content of the bulbs and it was found 1.03 and 1.22 per cent respectively in varikka and koozha.

Nutritional characteristics were assessed in these two varieties of jackfruit. One of the important vitamin *viz.*, β-carotene was found to vary significantly (t 5.64**) between the two varieties. β-carotene content was found to be 163.66 μg in varikka variety which was significantly less than that of koozha variety (178.36 μg). Vitamin C content was high in varikka (10.36 mg/100 g) as compared to koozha variety (9.70 mg/100 g) respectively. No significant difference was observed in fibre content in the bulbs of two varieties.

Jackfruit is considered as a rich source of pectin. The pectin content of varikka variety was recorded as 3.19 g against 1.97 g in koozha variety. Pectin content was significantly higher in varikka (7.5**). The total polyphenolic content of varikka variety was 128 g while that of koozha variety was 118 g per 100 g. Polyphenolic content was significantly high in varikka (4.14*).

4.1.4 Assessment of Jackfruit Pulp

Bulbs of the two varieties of jackfruit was made into pulp and this pulp was further utilized for product development. Chemical constituents of the pulp in a way influence the quality of the products developed. Hence analysis of the chemical constituents of the pulp is an essential step in product development.

Table 10 represents the various chemical constituents ascertained in the two varieties of jackfruit pulp.

Table 10 Assessment of chemical constituents of jackfruit pulp

Parameters	Varikka	Koozha	t value
Moisture (per cent)	77.98	79.03	17.31**
Acidity (per cent)	3.03	2.93	1.38
pH	3.73	3.80	0.75
TSS (°Brix)	25.03	27.03	13.41**
Total sugar (per cent)	21.92	24.33	9.53**
Reducing sugar (per cent)	5.11	3.20	26.67**

**Significant at 1 per cent level

Moisture content of koozha pulp was higher than that of varikka. The moisture content of varikka pulp was 77.98 while that of koozha pulp was 79.03 per cent. Acidity of the pulp was recorded as 3.03 in varikka and 2.93 per cent in koozha which was also on par. The pH of jackfruit pulp from two varieties was not significantly different, 3.73 in varikka and 3.80 in koozha. Considerable difference was recorded in the TSS content of the pulp of the two varieties being 27.03°Brix for koozha variety and 25.03°Brix for varikka variety.

Total sugar found in the pulp of koozha variety was 24.33 per cent which was significantly higher than that of varikka (21.92 per cent).

Reducing sugar content of varikka pulp was significantly higher (5.1 per cent) than that of koozha variety (3.20 per cent).

4.1.5 Assessment of Jackfruit Seeds

Chemical characteristics ascertained in jackfruit seeds are depicted in Table 11.

Table 11 Assessment of jackfruit seeds

Parameters	Varikka	Koozha	t value
Moisture (per cent)	60.02	63.43	200.82**
Acidity (per cent)	0.03	0.08	20.00**
Total sugar (per cent)	4.60	5.60	10.96**
Reducing sugar (per cent)	2.70	2.30	13.00**
Protein (gm)	5.80	5.10	5.42**
Total carbohydrate (per cent)	12.70	13.83	9.87**
Starch (per cent)	14.13	13.86	2.41*
Total minerals (per cent)	1.46	1.26	4.24**
Fiber (per cent)	1.40	1.40	2.00

*Significant at 5 per cent level, **Significant at 1 per cent level

As indicated in Table 11 moisture content of the seeds of varikka and koozha was found to be 60.02 and 63.43 per cent respectively and it was significantly high in koozha. Acidity of the seeds was 0.03 and 0.08 per cent respectively in varikka and koozha varieties, which was significantly different.

Total sugar and reducing sugar observed in the seeds were 4.60 per cent and 2.70 per cent in varikka variety as against 5.60 per cent and 2.30 per cent respectively in koozha variety. Total sugar was high in koozha and reducing sugar was high in varikka seeds.

The nutritional constituents analysed in the seeds were protein, total carbohydrates, starch, fibre and total minerals. The protein content of the seeds vary significantly between varikka and koozha with a higher per cent protein in varikka (5.80 g) compared to koozha (5.10 g).

The carbohydrate content of varikka seeds was high (12.70 per cent) as against in koozha seeds (13.83 per cent) with significant difference between the varieties (9.87**).

The starch content of the seeds of varikka was higher (14.13 per cent) than that of koozha (13.86 per cent). The total mineral content of the varikka variety (1.46 per cent) was significantly higher than that of koozha seeds (1.26 per cent) while the fibre content of the seeds of both varieties accounted to be 1.40 per cent.

Assessment of physical characteristics of fruits revealed that varikka fruit and bulbs were bright yellow coloured whereas koozha fruits and bulbs were pale coloured. The results also revealed that the interspine distance and the peduncle length of the fruit for both the varieties was more or less same, whereas other features *viz.*, number of spines per unit area, weight of fruit, length of fruit, number of fruits per plant and yield per plant varied significantly between the two varieties. Number of spines per unit area and number of fruits per plant were higher for varikka whereas the weight, length and yield of fruit was more for koozha variety.

The length and the weight of koozha bulbs was more as compared to varikka bulbs. When the seeds were taken into account koozha seeds were found to have higher weight and length than varikka seeds. The number of seeds per fruit was found to be more for koozha jackfruit.

Chemical characteristics were assessed for jackfruit bulbs and it was found that pH was higher for koozha, whereas acidity was higher for varikka bulbs. TSS and total sugar was higher for koozha as compared to varikka, whereas reducing sugar was higher for varikka bulbs. β-carotene was higher for koozha as compared to varikka bulbs whereas vitamin C content was higher for varikka bulbs.

Assessment of jackfruit seeds revealed a higher moisture, acidity, total sugar and reducing sugar content for koozha seeds. Among the nutritional characters assessed, protein, starch and mineral content were high for koozha seeds whereas carbohydrate content was higher for varikka seeds. The fibre content was same for seeds from both the varieties.

4.2 STANDARDIZATION AND PRODUCT DEVELOPMENT UTILIZING JACKFRUIT BULBS

Standardization and product development play a key role in the growth of food industries. According to Poduval (2002) one of the foremost purposes of standardization is to facilitate the 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. Sohrab (2000) opined that standardization encapsulates technological results and becomes a vehicle for technology transfer while quality is the key for facilitating trade and satisfying consumers.

Jack fruit is an under exploited fruit, whose value addition is not yet explored to the maximum. In the present scenario of fast growing food industries newer and newer consumer foods are engulfing the market where jackfruit can also contribute, with products of good consumer appeal with lesser cost. This fruit of Kerala could be in the prime place of global market, if proper efforts are taken.

4.2.1 Standardization of Clarified Juice from Jackfruit Pulp

Unlike other fruits, jackfruit bulbs when pulped produce a viscous pulp and yield very little juice. One of the bottlenecks in processing of jackfruit is its thick pulp and strong flavour. This necessitates to identify some methods to get clear juice with a mild flavour from jackfruit. In the present investigation jackfruit pulp was subjected to enzyme treatment to obtain clarified juice.

Under the experiment the concentration of enzyme used, time of incubation and temperature to be maintained were standardized with respect to juice yield. Trials were carried out by treating the pulp at various concentrations of enzyme ranging from 0.5 per cent upto 5.0 per cent, at different incubation periods of 2 hours upto 4 hours and by varying the temperature from 30 upto 50°C with an interval of 10° Celsius. A control sample was maintained for comparison purpose, in which no enzyme treatment was given. Plate 1 depicts the photograph of the Clarified juice standardized from jackfruit.

4.2.1.1 Assessment of Chemical and Nutritional Characteristics of the Clarified Juice Standardized from Jackfruit

Results indicated that maximum yield of juice from jackfruit pulp was obtained when the pulp was treated with one per cent enzyme, incubated for two hours at 40°C. Table 12 represents the chemical and nutritional characteristics of Clarified juice from Jackfruit.

Table 12 Assessment of chemical and nutritional characteristics of the clarified juice developed from jackfruit

Parameters	Without enzyme	With enzyme	t value
Acidity (per cent)	2.05	1.86	8.85**
pH	5.60	5.02	23.59**
TSS (°Brix)	11.12	15.03	35.27**
Total sugar (per cent)	8.42	8.89	13.40**
Reducing sugar (per cent)	6.73	7.56	6.69**
β-carotene (μg)	136.16	121.70	4.59**
Vitamin C (mg/100 g)	2.01	1.02	149.00**
Pectin (g/100 g)	0.16	0.00	10.78**

**Significant at 1 per cent level

The acidity of the clarified juice was recorded to be significantly lower (1.86 per cent) than the control (2.05 per cent). The pH of the clarified juice was recorded as 5.60 and 5.02 respectively in control and treated juice.

The TSS of the clarified juice extracted from jackfruit pulp with enzyme treatment was 15.03°Brix and was significantly higher than that of control (11.12°Brix).

Plate 1. Clarified juice standardised from varikka jackfruit

Both total sugar and reducing sugar content of the enzyme treated clarified juice was found to be higher than that of control. It was 8.89 per cent and 7.56 per cent respectively in enzyme treated juice, and was 8.42 per cent and 6.73 per cent respectively in the control sample.

The β-carotene content was recorded to be significantly higher for the untreated juice (136.16 μg) as compared to enzyme treated (121.70 μg) juice. Vitamin C content of the untreated juice was almost double than that contained in clarified juice. It was accounted to be 2.01 and 1.02 mg/100 g respectively in untreated and enzyme treated sample. Pectin content of the control juice was 0.16 while it was absent in the enzyme treated clarified juice.

The clarity of the juice, juice yield and extent of browning, were assessed in the clarified juice obtained with enzyme treatment under investigation. Pectin treated juice was sparkling clear without any sediments, when compared to the control sample. The juice yield was significantly higher in the enzyme treated sample (131 ml/100g) as compared to untreated sample (110 ml/100g). The discolouration occurred in the juice due to pectin treatment indicated that certain level of browning had occurred in the clarified juice when treated with pectin enzyme. The extent of browning recorded for enzyme treated sample was monitored and it was 0.10 at 440 nm absorbance. However no browning was detected in the untreated samples.

4.2.2 Standardization of Jackfruit Nectars

Fruit beverages introduce variety in flavour, nutrients and other physiological benefits with greater margin of safety with lower inherent cost. The nutritional value of real fruit based beverages is far greater than that of the synthetic beverages. Jackfruit contains high amounts of sugars, vitamins and minerals which are beneficial for the production of beverages.

Fruit nectars are readily drinkable beverages with greater consumer appeal. Nectars prepared from different fruits are readily available in the market at present. Jackfruit nectars are not seen, hence jackfruit nectars were standardized from the two varieties of jackfruit pulp individually and blending with other fruit pulps.

Preliminary trials were carried out where in different proportion of pulp and other ingredients were taken to formulate nectars of good consumer appeal. Based on the organoleptic features, the best proportion was selected from each category of nectars from the two varieties of jackfruit and presented in Table 13. Thus in the present study nectars of different taste and flavour were standardized from the two varieties of jackfruit, blending with pineapple, papaya and mango. Plate 2 depicts the various jackfuit nectars standardized in the study.

Table 13 Composition of jackfruit nectars standardised

Sl. No.	Treatments	Jackfruit pulp with preservative added	Other fruit pulps	Water	Sugar	Citric acid
1	Control varikka nectar	1.0	-	1.2	0.15	0.002
2	Control koozha nectar	1.0	-	1.0	0.10	0.005
3	Pineapple blended varikka nectar	0.5	0.5	1.5	0.25	0.005
4	Pineapple blended koozha nectar	0.5	0.5	1.2	0.15	0.006
5	Papaya blended varikka nectar	0.5	0.5	1.5	0.25	0.005
6	Papaya blended koozha nectar	0.5	0.5	1.2	0.15	0.006
7	Mango blended varikka nectar	0.5	0.5	1.5	0.25	0.005
8	Mango blended koozha nectar	0.5	0.5	1.2	0.15	0.006

4.2.2.1 Assessment of Chemical and Nutritional Features of Jackfruit Nectars Standardized

Jackfruit nectars standardized under the present investigation appeared thick and resembled honey like consistency. Table 14 represents chemical and nutritional characteristics of the nectars standardized from the two varieties of jackfruit.

Plain jackfruit varikka nectar

Pineapple blended jackfruit varikka nectar

Papaya blended jackfruit varikka nectar

Mango blended jackfruit varikka nectar

Plain jackfruit koozha nectar

Pineapple blended jackfruit koozha nectar

Papaya blended jackfruit koozha nectar

Mango blended jackfruit koozha nectar

Plate 2. Jackfruit nectar standardised from two varieties along with blends

Table 14 Chemical and nutritional characteristics of nectars standardized from jackfruit

Treatments	Acidity (per cent)	pH	TSS (°Brix)	Total sugar (per cent)	Reducing sugar (per cent)	β-carotene (μg)	Vitamin C (mg/100 g)	Polyphenols (g/100 g)
V_1T_1	0.4	4.81	24.72	23.11	2.51	121.61	7.7	23.45
V_1T_2	0.59	4.11	21.14	22.13	3.54	128.85	8.58	29.8
V_1T_3	0.45	4.8	23.03	21.22	3.15	298.65	9.42	65.35
V_1T_4	0.54	4.97	24.12	24.13	3.53	400.72	8.03	98.85
V_2T_1	0.38	5.21	19.11	18.36	2.75	118.8	7.73	26.87
V_2T_2	0.41	4.91	18.06	17.06	3.35	129.28	9.55	41.78
V_2T_3	0.33	5.71	19.06	20.03	3.83	294.32	11.49	54.3
V_2T_4	0.44	4.9	19.99	21.27	2.75	353.56	8.43	87.72
F	5133.01**	12579.10**	0.59	4590.32**	516.84**	1549.10**	2957.10**	1705.87**
CD	0.002	0.015	-	0.053	0.059	1.122	0.039	0.561

V_1T_1 – Varikka control nectar, V_1T_2 – Pineapple blended varikka nectar, V_1T_3 – papaya blended varikka nectar, V_1T_4 – Mango blended varikka nectar

V_2T_1 – Koozha control nectar, V_2T_2 – Pineapple blended Koozha nectar, V_2T_3 – papaya blended Koozha nectar, V_2T_4 – Mango blended Koozha nectar

Table 14 revealed a significant difference in the acidity of the various nectars standardized. In general, acidity was high in varikka than koozha. In varikka, maximum acidity was estimated when blended with pineapple (0.59 per cent) followed by mango (0.54 per cent). All the blended nectars were found to have higher acidity than control. In koozha, varieties maximum acidity was recorded when blended with mango (0.44 per cent) followed by pineapple (0.41 per cent). Acidity was significantly low when blended with papaya (0.33 per cent) than the control (0.41 per cent). The mean acidity of the nectars formulated from varikka fruit were 0.40 (V_1T_1), 0.59 (V_1T_2), 0.45 (V_1T_3) ad 0.54 (V_1T_4) whereas, that of koozha nectars were 0.38 (V_2T_1), 0.41 (V_2T_2), 0.33 (V_2T_3) and 0.44 (V_2T_4). The acidity was found to be higher for varikka nectars as compared to koozha nectars. Pineapple blended varikka nectar recorded highest acidity (0.59 per cent) while papaya blended koozha nectar recorded lowest acidity (0.33 per cent).

Significant difference was observed in the pH of the nectar standardized under the present study. The pH was comparatively higher for koozha blended nectars as compared to varikka nectars. In varikka variety maximum pH was observed in mango blended nectar (4.97) followed by control varikka nectar (4.81). The lowest pH was recorded for pineapple blended varikka nectar (4.11). In the case of koozha maximum pH was recorded for papaya blended (5.71) followed by control koozha nectar, (5.21). pH was significantly low when blended with mango (4.90). The mean pH of the nectars formulated from varikka fruit for various treatment were 4.81 (V_1T_1), 4.11 (V_1T_2), 4.80 (V_1T_3) and 4.97 (V_1T_4) whereas, that of koozha nectars were 5.21 (V_2T_1), 4.91 (V_2T_2), 5.71 (V_2T_3) and 4.90 (V_2T_4). Papaya blended koozha nectar (5.71) recorded highest pH while pineapple blended varikka nectar (4.11) recorded the lowest pH.

The TSS content of the nectars formulated ranged from 18.06°Brix to 24.72°Brix. Significant difference was observed with respect to TSS between the various treatments applied. The TSS content of varikka nectars was found to be higher as compared to koozha nectars. In varikka maximum TSS was estimated in control varikka nectar (24.72°Brix) followed by mango blended (24.12°Brix). In the case of koozha maximum TSS was estimated when blended with mango (19.99°Brix) followed by control koozha nectar (19.11°Brix). The mean TSS of nectars formulated from varikka fruit for various blends attempted were 24.72 (V_1T_1), 21.14 (V_1T_2), 23.03 (V_1T_3) and 24.12 (V_1T_4) whereas, that of koozha nectars were 19.11 (V_2T_1), 18.06 (V_2T_2), 19.06 (V_2T_3) and 19.99 (V_2T_4). The highest TSS was observed for mango blended varikka nectar (24.12°Brix) whereas the lowest TSS was recorded for pineapple blended koozha nectar (18.06°Brix).

Significant difference was also observed with respect to total sugar content of the nectars formulated from jackfruit. In general total sugar content was low in koozha nectars compared to varikka nectars. In varikka maximum sugar content was found when blended with mango (24.13 per cent). Total sugar content was significantly less when blended with pineapple (22.13 per cent) and papaya (21.22 per cent) in comparison with control (23.11 per cent). However in koozha, papaya blended (23.03 per cent) and mango blended (21.27 per cent) registered higher sugar content in comparison with control (18.36 per cent) while pineapple blended nectar (17.06 per cent) registered the lowest sugar content. The mean total sugar content of the various nectars formulated from varikka fruit were 23.11 (V_1T_1), 22.13 (V_1T_2), 21.22 (V_1T_3) and 24.13 (V_1T_4) as against 18.36 (V_2T_1), 17.06 (V_2T_2), 20.03 (V_2T_3) and 21.27 (V_2T_4) for koozha nectar. Mango blended varikka nectar recorded highest (24.13 per cent) in total sugar content while lowest was recorded for pineapple blended koozha nectar (17.06 per cent).

The reducing sugar content of the nectars formulated under the present study ranged from 2.51 to 3.83 per cent. Significant difference was observed with respect to reducing sugars among the various blended nectars. In varikka nectars the highest reducing sugar content was observed when blended with pineapple (3.54 per cent) followed by mango (3.53 per cent). For koozha variety highest reducing sugar content was observed for papaya blended nectar (3.83 per cent) followed by pineapple blended (3.35 per cent) in comparison with control (2.75 per cent) which was on par with mango blended nectar (2.75 per cent). The mean reducing sugar content of various fruit nectars were 2.54 per cent (V_1T_1), 3.54 (V_1T_2), 3.15 (V_1T_3), 3.53 (V_1T_4) whereas for koozha nectars, it was 2.75 per cent (V_2T_1), 3.35 (V_2T_2), 3.83 (V_2T_3) and 2.75 per cent (V_2T_4) respectively.

Important nutrients present in the jackfruit nectars were also ascertained. High variation was observed in β-carotene content in both varikka and koozha when blended with other fruits. When blended with mango both types of jackfruit *viz.*, varikka and koozha nectar registered higher β-carotene (400.72 and 353.76). This was followed by papaya blended nectars (298.65 and 294.32). Though pineapple blended nectars also registered comparatively higher values (128.85 and 129.28) in comparison with control (121.61 and 118.80). But these values were significantly low when compared to nectars developed by blending with mango and papaya.

The vitamin C content of the nectars vary from 7.70–11.49 mg/100 g. A significant difference was observed with respect to vitamin C among the various nectars formulated. Vitamin C was on an average higher in koozha nectars in comparison with varikka nectars. In both the types papaya blended nectars registered higher vitamin C content. The values being 11.49 in koozha and 9.42 in varikka variety. This was followed by pineapple blended nectars (8.58 and 9.55). All the blended nectars were having higher vitamin C content in comparison with control. The highest vitamin C content was observed for papaya blended koozha nectar (11.49 mg/100 g) and lowest for control varikka nectar (7.70 mg/10 g). The mean vitamin C content of various nectars formulated from varikka variety was 7.70 (V_1T_1), 8.58 (V_1T_2), 9.42 (V_1T_3) and 8.03 (V_1T_4) as against 7.73 (V_2T_1), 9.55 (V_2T_2), 11.49 (V_2T_3) and 8.03 (V_2T_4) for nectars formulated from koozha variety.

Polyphenols were high in mango blended nectars of both the types of jackfruit, 98.85 for a varikka and 87.72 for koozha. This was followed by papaya blended nectars (65.35 and 54.30). When blended with pineapple, high variation was observed for koozha (41.78) nectars in comparison with varikka nectars(29.80). However, all the blended nectars were having high phenolic content. The mean polyphenolic content of the nectars standardized from varikka variety were 23.45 (V_1T_1), 29.80 (V_1T_2), 65.35 (V_1T_3) and 98.85 (V_1T_4) as against 26.87 (V_2T_1), 41.78 (V_2T_2), 54.30 (V_2T_3) and 87.72 (V_2T_4) from koozha variety. Mango blended varikka nectar (98.85 g/100 g) recorded highest polyphenolic content whereas control varikka nectar recorded the lowest (23.45 g/100 g). Significant difference (CD0.561) was also observed with respect to polyphenolic content between the various nectars tried out.

As inferred from the above results, it can be concluded that, the varikka variety nectars had a higher per cent of acidity, TSS, total sugar, reducing sugar, β-carotene and polyphenolic content compared to its counterpart koozha nectars. As far as treatments are concerned, significant difference was observed with respect to all the chemical and nutritional attributes assessed in the nectars except the TSS content of the nectars.

4.2.2.2 Organoleptic Qualities of Nectars Standardized from Jackfruit

Organoleptic qualities of the products play an important role in evaluating the sensory appeal of any food product.

The nectars standardized under the present study were assessed organoleptically by a panel of ten judges on a five point scale.

Table 15 represents the organoleptic qualities of the nectars standardized from jackfruit.

As depicted in Table 15, no significant difference was observed with respect to organoleptic qualities among various nectars formulated except for the flavour attribute. The mean appearance scores obtained for various nectars formulated from varikka variety were 3.97 (V_1T_1), 4.12 (V_1T_2), 4.30 (V_1T_3) and 4.18 (V_1T_4) whereas for koozha scores were 3.96 (V_2T_1), 3.98 (V_2T_2), 4.16 (V_2T_3) and 4.16 (V_2T_4) respectively. The appearance score was observed, highest for papaya blended varikka nectar (4.30) and lowest for control koozha nectar (3.96).

Table 15 Organoleptic features of nectars standardized from jackfruit

Organoleptic attributes	V_1T_1	V_1T_2	V_1T_3	V_1T_4	V_2T_1	V_2T_2	V_2T_3	V_2T_4	F	CD
Appearance	3.97	4.12	4.30	4.18	3.96	3.98	4.16	4.16	0.82	-
Colour	4.04	4.11	4.29	4.18	4.12	4.10	4.28	4.21	0.12	-
Flavour	3.87	4.06	4.00	3.99	3.86	3.86	3.74	3.73	6.28**	0.113
Taste	3.96	4.03	3.83	3.96	3.84	3.90	3.67	3.96	0.76	-
Consistency	3.97	3.97	3.98	3.96	3.98	4.00	3.96	3.98	0.34	-
Overall acceptability	3.95	3.97	3.93	3.94	3.91	3.94	3.88	3.94	0.32	-

V_1T_1 – Varikka control nectar, V_1T_2 – Pineapple blended varikka nectar, V_1T_3 – papaya blended varikka nectar, V_1T_4 – Mango blended varikka nectar

V_2T_1 – Koozha control nectar, V_2T_2 – Pineapple blended Koozha nectar, V_2T_3 – papaya blended Koozha nectar, V_2T_4 – Mango blended Koozha nectar

The colour scores of the nectars formulated ranged from 4.04–4.29. Papaya blended varikka nectar recorded the highest score of 4.29 for colour and that of control varikka nectar recorded the lowest (4.04). The mean colour scores attained for various nectars formulated from varikka variety were 4.04 (V_1T_1), 4.11 (V_1T_2), 4.29 (V_1T_3) and 4.18 (V_1T_4) as against 4.12 (V_2T_1), 4.10 (V_2T_2), 4.28 (V_2T_3) and 4.21 (V_2T_4) in koozha variety. No significant difference was observed with respect to the above attribute between the various blends tried out.

Significant difference (CD 0.113) was observed with respect to flavour attribute between the various nectars attempted in the study. The flavour scores were higher for varikka nectars as compared to koozha nectars. The highest score for flavour was secured by pineapple blended varikka nectar (4.06) and the lowest by mango blended koozha nectar (3.73). The mean flavour scores obtained for various nectars formulated from varikka variety were 3.87(V_1T_1), 4.06 (V_1T_2), 4.00 (V_1T_3) and 3.99 (V_1T_4) as against 3.86 (V_2T_1), 3.86 (V_2T_2), 3.74 (V_2T_3) and 3.73 (V_2T_4) for koozha nectars.

The taste scores ranged from 3.67 to 4.03 for the nectars formulated from jackfruit. No apparent difference was observed with respect to taste between the nectars formulated. The mean taste scores obtained for various nectars formulated from varikka variety were 3.96 (V_1T_1), 4.03 (V_1T_2), 3.83 (V_1T_3) and 3.96 (V_1T_4) as against 3.84 (T_1), 3.90 (V_2T_2), 3.67 (V_2T_3) and 3.96 (V_2T_4) for nectars formulated from koozha variety. Pineapple blended varikka nectar stood first (4.03) for taste attribute whereas papaya blended koozha nectar scored the lowest (3.67).

The consistency of the nectar was more or less the same for all the nectars formulated. No significant difference was observed with respect to the above attribute between the various nectars attempted. The mean scores obtained for consistency for varikka nectars were 3.97 (V_1T_1), 3.97 (V_1T_2), 3.98 (V_1T_3) and 3.96 (V_1T_4) as against 3.98 (V_2T_1), 4.00 (V_2T_2), 3.96 (V_2T_3) and 3.98 (V_2T_4) in koozha nectars. Pineapple blended koozha nectar (4.00) was the best for consistency, while papaya blended koozha nectar and mango blended varikka nectar (3.96) was the lowest.

The overall acceptability scores of the nectars ranged from 3.88 to 3.97 out of five. Pineapple blended varikka nectar (3.97) was adjudged to be the best in overall performance while the papaya blended koozha nectar (3.88) was the lowest. However no significant difference was observed with respect to overall acceptability scores for the nectars formulated. The overall acceptability scores for varikka nectars formulated were 3.95 (V_1T_1), 3.97 (V_1T_2), 3.93 (V_1T_3) and 3.94 (V_1T_4) as against 3.91 (V_2T_1), 3.94 (V_2T_2), 3.88 (V_2T_3) and 3.94 (V_2T_4).

Organoleptic evaluation of the nectars indicated that overall sensory features scores ranged between 3.88 to 3.97 indicating that plain and blended nectars formulated from two varieties were acceptable to the judges. In the attributes *viz.*, appearance, flavour, taste and consistency, nectars formulated from varikka variety stood superior to the nectars formulated from koozha variety. Although koozha nectars were also found to be equally acceptable to the consumers. Organoleptic attributes *viz.*, appearance, colour, taste, consistency did not vary significantly between the various treatments attempted. However flavour attribute was found to vary significantly with the treatments applied.

4.2.2.3 Changes in the Chemical and Nutritional Constituents of Jackfruit Nectar with Storage

Jackfruit Nectars when stored undergo changes with respect to chemical and nutritional constituents, which will be an indication of the deteriorative changes occurring in the products. Shelf stability of the formulated nectars could thus be ascertained. Formulated nectars were stored at two different conditions *viz.*, refrigerated and ambient temperature and evaluated periodically (once in 15 days) for a period up to two months. The results obtained are presented in the following tables.

Acidity

Mehta *et al.* (2002) reported that acidity indicates flavour as well as wholesomeness of the product. Acidity is one of the prime chemical constituents which indicate the deteriorative changes in the product. Table 16 represents the changes in the acidity of jackfruit nectars and its interaction between variety, products, storage condition and storage period.

A significant difference was observed in the acidity of jackfruit nectars of both the varieties. The mean value for acidity of the nectars formulated from the two varieties over a period of 60 days was found to be 0.50 per cent and 0.39 per cent respectively. Nectars formulated from varikka variety were found to be more acidic compared to koozha nectars throughout the storage period.

Table 16 Changes in the percentage acidity of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (initial)	0.44	0.36	0.35	0.46	0.35	0.45	0.40	0.40	0.40
P_1 (1^{st} week)	0.46	0.37	0.36	0.47	0.36	0.46	0.42	0.41	0.41
P_2 (2^{nd} week)	0.47	0.37	0.37	0.48	0.37	0.47	0.43	0.41	0.42
P_3 (3^{rd} week)	0.48	0.38	0.38	0.49	0.38	0.48	0.45	0.42	0.43
P_4 (4^{th} week)	0.50	0.39	0.39	0.50	0.39	0.49	0.46	0.42	0.44
P_5 (5^{th} week)	0.51	0.40	0.40	0.51	0.40	0.50	0.47	0.43	0.45
P_6 (6^{th} week)	0.53	0.40	0.42	0.52	0.41	0.52	0.49	0.45	0.47
P_7 (7^{th} week)	0.54	0.41	0.42	0.53	0.42	0.53	0.50	0.45	0.48
P_8 (8^{th} week)	0.55	0.43	0.44	0.54	0.43	0.54	0.51	0.46	0.49
Mean V/T/R	**0.50**	**0.39**	**0.39**	**0.50**	**0.39**	**0.49**	**0.46**	**0.43**	**0.44**
R_1 (Room)	0.52	0.40	0.41	0.51	0.40	0.51			
R_2 (Refrigerated)	0.47	0.38	0.38	0.49	0.37	0.47			
T_1	0.40	0.38							
T_2	0.59	0.41							
T_3	0.45	0.33							
T_4	0.54	0.44							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 52013.83**
$F_{3,288}$ T = 16896.21**
$F_{8,288}$ P = 1802.61**

$F_{1,288}$ R = 4010.83**
$F_{8,288}$ VP = 116.90**
$F_{24,288}$ TP = 2.78**
$F_{8,288}$ PR = 129.09**
$F_{1,288}$ VR = 1033.98*
$F_{3,288}$ TR = 35.81*
$F_{3,288}$ VT = 5133.01**

CD (V) = 0.002
CD (T) = 0.003
CD (P) = 0.001
CD (R) = 0.002
CD (VP) = 0.006
CD (TP) = 0.003
CD (PR) = 0.002
CD (VR) = 0.003
CD (TR) = 0.002
CD (VT) = 0.002

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the acidity of the various blended nectars tried out in the study. The highest acidity was recorded for pineapple blended nectar (0.50 per cent) followed by mango blended nectars 0.49 per cent) of both varieties. The nectars of control jackfruit nectars and papaya blended nectars stood next to mango blended nectars in acidity with an average value of 0.39 per cent.

Acidity of the jackfruit nectar of both varieties increased slowly when stored under two conditions of storage. The increase in acidity of nectars stored under ambient temperature ranged from 0.40 – 0.51 per cent while under refrigerated condition it ranged from 0.40 – 0.46 per cent. Significant difference was observed in the acidity of nectars stored under two different storage conditions.

Acidity increases from an initial value of 0.40 to 0.49 towards the end of storage period. The increase in acidity occurred gradually and the change was glaring after one week.

Significant interaction was observed between variety and storage period indicating variety of the fruit and storage period influence the acidity of formulated nectars under investigation.

Similarly interaction was also observed between variety and storage condition. The mean value of nectars formulated from varikka and koozha variety stored under refrigerated condition was found to be 0.47 and 0.38 per cent respectively whereas nectars stored under ambient condition, it was 0.52 and 0.40 per cent respectively.

Interaction was also observed between variety and treatment. The mean value of acidity for the nectars formulated from varikka variety for various treatments were, (0.40 per cent) control nectar, (0.59 per cent) pineapple blended, (0.45 per cent) papaya blended, and (0.54 per cent) mango blended nectar respectively whereas the mean value of koozha nectars were found to be (0.38 per cent) control nectar, (0.41 per cent) pineapple blended, (0.33 per cent) papaya blended, and (0.44 per cent) mango blended nectar respectively. It can be concluded that the type of blend and the variety used for formulating nectar affected the percentage acidity in the nectar.

Significant interaction was observed between treatment and storage period. The acidity increased as the storage period advanced. The initial acidity found for various blends *viz.*, T_1, T_2, T_3 and T_4 were 0.35, 0.46, 0.35 and 0.45 per cent respectively. However after a storage of 60 days the acidity found for the various blends T_1, T_2, T3 and T_4 was 0.44, 0.54, 0.43 and 0.54 per cent respectively. Significant interaction was observed within the treatments and storage condition. It was found that the level of acidity was lower for nectars stored under refrigerated condition.

Interaction was also observed between treatment and storage condition. The mean values for various blends stored under refrigerated condition were found to be (0.38 per cent) T_1, (0.49 per cent) T_2, (0.37 per cent) T_3 and (0.47 per cent) T_4 respectively, whereas for nectars, stored under ambient condition the mean values of acidity were (0.4 per cent) T_1, (0.51 per cent) T_2, (0.40 per cent) T_3 and (0.51 per cent) T_4 respectively.

Significant interaction was also observed with respect to storage period and storage condition. The mean values for acidity obtained for nectars stored under refrigerated condition over a period of 60 days ranged from 0.40 – 0.46 per cent and whereas it ranged from 0.40 – 0.51 per cent for nectars stored under ambient condition which indicate that the storage period and the type of storage condition affects the percentage acidity in the nectars standardized.

pH

Table 17 represents the changes in the pH of the nectar and its interaction between variety, products, storage condition and storage period. pH is an indirect measure of sweetness or sourness of the products.

Table 17 Changes in the pH of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (initial)	4.76	5.26	5.10	4.58	5.35	5.00	5.01	5.01	5.01
P_1 (1st week)	4.72	5.26	5.08	4.56	5.33	4.99	4.97	5.01	4.99
P_2 (2nd week)	4.71	5.23	5.05	4.55	5.30	4.98	4.92	5.01	4.97
P_3 (3rd week)	4.68	5.18	5.01	4.51	5.25	4.95	4.92	4.93	4.93
P_4 (4th week)	4.67	5.17	5.00	4.50	5.25	4.93	4.92	4.92	4.92
P_5 (5th week)	4.65	5.17	4.99	4.50	5.23	4.93	4.90	4.92	4.91
P_6 (6th week)	4.63	5.13	4.95	4.45	5.20	4.90	4.83	4.92	4.88
P_7 (7th week)	4.63	5.13	4.95	4.45	5.20	4.90	4.83	4.92	4.88
P_8 (8th week)	4.61	5.12	4.95	4.45	5.18	4.88	4.81	4.92	4.86
Mean V/T/R	**4.67**	**5.18**	**5.01**	**4.51**	**5.25**	**4.94**	**4.90**	**4.95**	**4.92**
R_1 (Room)	4.64	5.16	4.98	4.48	5.23	4.91			
R_2 (Refrigerated)	4.70	5.20	5.04	4.53	5.28	4.97			
T_1	4.81	5.21							
T_2	4.11	4.91							
T_3	4.80	5.71							
T_4	4.97	4.90							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 66994.84**
$F_{3,288}$ T = 24996.39**
$F_{8,288}$ P = 313.84**

$F_{1,288}$ R = 715.38**
$F_{8,288}$ VP = 2.90*
$F_{24,288}$ TP = 1.35
$F_{8,288}$ PR = 55.74**
$F_{1,288}$ VR = 4.65*
$F_{3,288}$ TR = 5.42**
$F_{3,288}$ VT = 12579.10**

CD (V) = 0.005
CD (T) = 0.017
CD (P) = 0.013
CD (R) = 0.003
CD (VP) = 0.012
CD (PR) = 0.013
CD (VR) = 0.012
CD (TR) = 0.021
CD (VT) = 0.015

*Significant at 5 per cent level, **Significant at 1 per cent level

It is of importance as a measure of acidity which not only influence the flavour or palatability of a product but also affects the keeping quality and the processing requirement of a product (Mehta *et al.*, 2000).

A significant difference was observed in the pH of nectars formulated from two varieties of jackfruit. The mean pH of the nectars formulated from the two varieties of jackfruit (varikka and koozha) over a period of 60 days was found to be 4.67 and 5.18 respectively. The nectars formulated from koozha variety had a higher pH as compared to nectars from varikka nectars.

A significant difference was also observed in pH between the various blended nectars. The pH was higher in papaya blended nectar (5.25) followed by control nectar (5.01), Mango blended nectar (4.94) and pineapple blended nectars (4.51) of both the varieties recorded the lowest pH throughout the entire storage period.

pH of the jackfruit nectars of both varieties was found to decrease when stored under two conditions upto 60 days. Significant difference was observed in the pH of nectars stored. The mean pH of the nectars observed under ambient and refrigerated conditions were 4.90 and 4.95 respectively. The decrease in pH ranged from 5.01 – 4.81 in nectars stored under ambient condition whereas it ranged from 5.01 – 4.92 for nectars stored under refrigerated conditions. Overall decrease in the pH was accounted to be only 1.79 per cent over a period of 60 days in the nectars and this decrease do not affect the quality of the nectars.

A significant decrease in the pH was observed when nectars were stored for 60 days. The decrease in pH with respect to storage period was 5.01 – 4.86.

Significant interaction was observed in pH between variety and storage period. The initial pH for varikka and koozha nectars was found to be 4.76 and 5.26 respectively whereas the final pH was 4.61 and 5.12.

The above results indicate that the variety of jackfruit and the storage period influenced the pH of the nectars.

Significant interaction was also observed between variety and storage condition which indicate, variety of fruit and storage condition influenced the pH of the nectars. The pH of nectars for varikka and koozha variety stored under refrigerated condition were 4.70 and 5.20 respectively whereas for nectars stored under ambient condition the pH was 4.64 and 5.16 respectively.

Significant interaction was also observed with respect to pH between variety and the treatments applied. The mean values of pH for nectars of varikka variety for various treatments were found to be 4.81 (V_1T_1), 4.11 (V_1T_2), 4.80 (V_1T_3) and 4.97 (V_1T_4) whereas the pH for koozha variety was found to be 5.21 (V_2T_1), 4.91 (V_2T_2), 5.71 (V_2T_3), 4.90 (V_2T_4) respectively.

No interaction was observed between various treatments and storage period. Hence it can be concluded that pH of nectars was not affected by the treatment applied and the storage period of 60 days.

Significant interaction was observed between the treatments and storage condition. The mean pH values for nectars stored under ambient condition were 4.98 (T_1), 4.48 (T_2), 5.23 (T_3), 4.91 (T_4) whereas for nectars stored under refrigerated condition the pH was 5.04 (T_1), 4.53 (T_2), 5.28 (T_3) and 4.97 (T_4) respectively.

Significant interaction was also observed with respect to pH between storage period and storage condition which indicate storage period and storage condition affected the pH of the nectars.

Total soluble solids

TSS gives an indication of sweetness in the product, which otherwise influence the acceptability of the product (Mehta *et al.*, 2000). Table 18 represents the TSS of jackfruit nectars and its interaction between variety, treatments, storage period and storage condition.

Table 18 Changes in the TSS content of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Week	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (initial)	22.25	18.89	20.00	19.43	20.75	21.88	20.57	20.57	20.57
P_1 (1st week)	22.25	18.94	20.00	19.48	20.97	21.90	20.60	20.59	20.59
P_2 (2nd week)	22.28	18.99	20.04	19.50	21.00	21.97	20.65	20.60	20.63
P_3 (3rd week)	22.31	19.01	20.07	19.53	21.02	21.99	20.71	20.61	20.66
P_4 (4th week)	22.38	19.07	20.13	19.61	21.05	22.06	20.73	20.62	20.73
P_5 (5th week)	22.42	19.13	20.19	19.64	21.11	22.13	20.79	20.72	20.77
P_6 (6th week)	22.47	19.14	20.21	19.68	21.13	22.17	20.82	20.75	20.83
P_7 (7th week)	22.56	19.18	20.28	19.76	21.17	22.21	20.90	20.79	20.88
P_8 (8th week)	22.37	19.18	20.32	19.78	21.22	22.23	20.94	20.83	20.98
Mean V/T/R	**23.25**	**19.06**	**21.92**	**19.60**	**21.04**	**22.06**	**21.63**	**20.68**	**20.96**
R_1 (Room)	24.19	19.08	23.73	19.62	21.12	22.07			
R_2 (Refrigerated)	22.31	19.04	20.10	19.58	20.97	22.05			
T_1	24.72	19.11							
T_2	21.14	18.06							
T_3	23.03	19.06							
T_4	24.12	19.99							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 22.38**
$F_{3,288}$ T = 1.62
$F_{8,288}$ P = 1.06

$F_{1,288}$ R = 1.17
$F_{8,288}$ VP = 1.01
$F_{24,288}$ TP = 1.00
$F_{8,288}$ PR = 1.00
$F_{1,288}$ VR = 1.07
$F_{3,288}$ TR = 1.01
$F_{3,288}$ VT = 0.35

CD (V) = 1.746

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the TSS of jackfruit nectars of both varieties. The mean value of TSS of the nectars formulated from the two varieties (varikka and koozha) over a period of 60 days was found to be 23.25 and 19.06 °Brix respectively. The nectars formulated from koozha variety had a lower TSS as compared to nectars from varikka variety.

As far as treatments were taken into account no significant difference was observed between the various nectars tried out. The highest TSS was observed for mango blended nectars (22.06°Brix) followed by control nectar (21.92 °Brix), papaya blended nectar (21.04 °Brix) and lastly pineapple blended nectar (19.06 °Brix).

Storage condition did not influence the TSS content of the nectars. The TSS content of the nectars stored under room and refrigerated conditions ranged from 20.57–20.94 °Brix and 20.57–20.83 °Brix respectively.

Storage period did not influence the TSS content of the nectars. The initial TSS was recorded to be 20.57 which increased to 20.98 by the end of two months.

No significant interaction was observed with respect to TSS between variety and storage period, storage condition and treatments.

Interaction was also not observed with respect to TSS between treatments and storage period, treatments and storage condition and storage period and storage condition.

Total sugar

Table 19 represents the total sugar content of nectars and its interaction between variety, treatments, storage period and storage condition.

Table 19 Changes in the total sugar content of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (initial)	22.30	19.11	20.58	19.40	20.32	22.52	20.70	20.70	20.70
P_1 (1^{st} week)	22.45	19.11	20.63	19.48	20.43	22.59	20.81	20.75	20.78
P_2 (2^{nd} week)	22.52	19.12	20.65	19.51	20.48	22.63	20.85	20.78	20.82
P_3 (3^{rd} week)	22.60	19.12	20.68	19.53	20.61	22.65	20.92	20.81	20.86
P_4 (4^{th} week)	22.67	19.15	20.71	19.58	20.65	22.69	20.95	20.87	20.91
P_5 (5^{th} week)	22.74	19.19	20.78	19.64	20.70	22.73	21.04	20.89	20.96
P_6 (6^{th} week)	22.77	19.23	20.82	19.68	20.74	22.77	21.09	20.91	21.00
P_7 (7^{th} week)	22.85	19.27	20.87	19.74	20.81	22.83	21.15	20.97	21.06
P_8 (8^{th} week)	22.93	19.30	20.90	19.82	20.85	22.90	21.22	21.02	21.12
Mean V/T/R	**22.65**	**19.18**	**20.73**	**19.60**	**20.62**	**22.70**	**20.97**	**20.86**	**20.91**
R_1 (Room)	22.73	19.21	20.78	19.64	20.74	22.72			
R_2 (Refrigerated)	22.57	19.15	20.69	19.55	20.51	22.68			
T_1	23.11	18.36							
T_2	22.13	17.06							
T_3	21.22	20.03							
T_4	24.13	21.27							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 67913**
$F_{3,288}$ T = 9480.34**
$F_{8,288}$ P = 45.69**

$F_{1,288}$ R = 70.98**
$F_{8,288}$ VP = 12.44**
$F_{24,288}$ TP = 1.02
$F_{8,288}$ PR = 3.37**
$F_{1,288}$ VR = 15.50**
$F_{3,288}$ TR = 10.61**
$F_{3,288}$ VT = 4590.32**

CD (V) = 0.034
CD (T) = 0.045
CD (P) = 0.027
CD (R) = 0.039
CD (VP) = 0.083
CD (PR) = 0.081
CD (VR) = 0.045
CD (TR) = 0.057
CD (VT) = 0.053

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the total sugar content of nectars formulated from the two varieties of jackfruit. The mean value for total sugar content of the nectars formulated from the two varieties of jackfruit (varikka and koozha) over a period of 60 days was found to be 22.65 and 19.18 per cent respectively. The nectars formulated from varikka variety had a higher percentage of total sugars as compared to nectars from koozha variety throughout the storage period.

Significant difference was observed in the total sugar content of the various blended nectars. The highest total sugar was observed in mango blended nectars (22.70 per cent) followed by control jackfruit nectars (20.73 per cent) and papaya blended nectars (20.62 per cent) during storage. Total sugar content of pineapple blended nectars was found to be the lowest (19.60 per cent).

Jackfruit nectars of both varieties when stored under two storage condition, total sugar content was found to increase significantly. The total sugar content increased in the nectars of both varieties irrespective of storage conditions, however the increase was more rapid in the nectars stored under ambient condition when compared to those stored under refrigerated condition. The total sugar content of the nectars stored under ambient condition was 20.97 as against 20.86 in nectars stored under refrigerated.

As the storage period advanced the total sugar content also increased significantly. The increase in total sugar ranged between 20.70–21.12 per cent.

Significant interaction was observed between variety and storage period. The increase in total sugar per cent of nectars of varikka ranged from 22.30 – 22.93 per cent whereas for koozha nectars ranged between 19.11 – 19.30 per cent.

Significant interaction was observed between variety and storage condition. The mean values for total sugar of nectars stored under ambient condition for varikka and koozha variety were found to be 22.73 per cent and 19.21 per cent respectively whereas for nectars stored under refrigerated condition it was found to be 22.57 and 19.15 per cent respectively.

Significant interaction was also observed between variety and treatments. The mean values for total sugar content of nectars of varikka variety were found to be 23.11 (V_1T_1), 22.13 (V_1T_2), 21.22 (V_1T_3) and 24.13 (V_1T_4) respectively whereas for koozha nectars the total sugar per cent was 18.36 (V_2T_1), 17.06 (V_2T_2), 20.03 (V_2T_3) and 21.27 (V_2T_4) per cent respectively.

No interaction was observed between treatments and storage period. However interaction was observed between treatments and storage condition. The mean values of total sugar content of nectars stored under ambient condition were found to be 20.78 (T_1), 19.64 (T_2), 20.74 (T_4) and 22.72 (T_4) whereas for nectars stored under refrigerated conditions the total sugar percentage was found to be 20.69 (T_1), 19.55 (T_2), 20.51 (T_3) and 22.68 (T_4) respectively.

Significant interaction was also observed between storage period and storage condition with respect to total sugar content from which it can be concluded that the total sugar content of nectars formulated was influenced by the duration of storage and storage condition.

Reducing sugar

Table 20 represents the changes in the reducing sugar of nectar and its interaction between variety, treatments, storage condition and storage period.

No difference was observed in the reducing sugar content of nectars of both the varieties during storage. The mean reducing sugar content of

Table 20 Changes in the reducing sugar content of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (initial)	2.55	2.99	2.31	3.00	3.09	2.68	2.58	2.58	2.77
P_1 (1st week)	2.70	3.03	2.41	3.18	3.26	2.94	2.68	2.58	2.97
P_2 (2nd week)	2.85	3.03	2.33	3.06	3.16	2.83	2.78	2.65	2.86
P_3 (3rd week)	3.06	3.10	2.51	3.35	3.44	3.02	2.93	2.97	3.10
P_4 (4th week)	3.19	3.14	2.58	3.47	3.52	3.12	2.97	3.05	3.20
P_5 (5th week)	3.37	3.20	2.68	3.58	3.64	3.24	3.05	3.13	3.20
P_6 (6th week)	3.51	3.29	2.85	3.68	3.70	3.37	3.31	3.23	3.40
P_7 (7th week)	3.66	3.35	2.94	3.79	3.78	3.51	3.42	3.38	3.50
P_8 (8th week)	3.76	3.42	3.03	3.90	3.83	3.58	3.59	3.40	3.59
Mean V/T/R	**3.18**	**3.17**	**2.63**	**3.45**	**3.49**	**3.14**	**3.03**	**2.99**	**3.17**
R_1 (Room)	2.95	3.11	2.44	3.35	3.40	2.95			
R_2 (Refrigerated)	3.41	3.23	2.81	3.54	3.58	3.34			
T_1	2.51	2.75							
T_2	3.54	3.35							
T_3	3.15	3.83							
T_4	3.53	2.75							

T_1 = Control jackfruit nectar
T_2 Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 0.70
$F_{3,288}$ T = 874.50**
$F_{8,288}$ P = 189.39**

$F_{1,288}$ R = 435.39**
$F_{8,288}$ VP = 56.25**
$F_{24,288}$ TP = 4.94**
$F_{8,288}$ PR = 12.14**
$F_{1,288}$ VR = 157.20**
$F_{3,288}$ TR = 16.73**
$F_{3,288}$ VT = 516.84**

CD (T) = 0.045
CD (P) = 0.067
CD (R) = 0.039
CD (VP) = 0.083
CD (TP) = 0.112
CD (PR) = 0.081
CD (VR) = 0.044
CD (TR) = 0.058
CD (VT) = 0.059

*Significant at 5 per cent level, **Significant at 1 per cent level

the nectars formulated from the two varieties (varikka and koozha) over a period of 60 days was found to be 3.18 and 3.17 per cent respectively.

Treatments applied showed significant impact on the reducing sugar content of the jackfruit nectars. The highest reducing sugar content was observed in papaya blended nectar (3.49) followed by pineapple blended nectar (3.45 per cent), mango blended nectar (3.14 per cent) while lowest reducing sugar content was noted in control jackfruit nectar (2.63 per cent).

Reducing sugar content of jackfruit nectars of both varieties when stored under two conditions for 60 days was found to increase significantly. The increase in reducing sugar content of nectars stored under ambient condition ranged from 2.58–3.59 per cent whereas increase in reducing sugar content for refrigerated samples was 2.58–3.40 per cent.

Storage period was found to influence significantly the reducing sugar content of the nectars of both varieties of 60 days. The increase in the reducing sugar content with storage ranged from 2.77 to 3.59.

Significant interaction was observed between variety and storage period. The initial reducing sugar content of nectars from varikka and koozha variety was found to be 2.55 and 2.99 per cent whereas at the end of 60^{th} day the reducing sugar content was found to be 3.76 and 3.42 per cent respectively.

Interaction was also observed between variety and storage condition. Reducing sugar content of nectars stored under ambient condition was found to be 2.95 and 3.11 per cent in varikka and koozha nectars respectively as against 3.41 and 3.23 per cent respectively in nectars stored under refrigerated condition. Significant interaction was also observed between variety and treatment. The mean value of reducing sugar content of various blended nectars from varikka variety were 2.51 (V_1T_1), 3.54 (V_1T_2), 3.15 (V_1T_3) and 3.53 (V_1T_4) per cent respectively whereas for koozha variety the reducing sugar content was 2.75 (V_2T_1), 3.35 (V_2T_2), 3.83 (V_2T_3) and 2.75 (V_2T_4) per cent respectively.

Significant interaction was also found between treatment and storage condition. The mean values of reducing sugar for various blended nectars stored under ambient condition was found to be 2.44 (T_1), 3.35 (T_2), 3.40 (T_3) and 2.95 (T_4) per cent respectively whereas for nectars stored under refrigerated conditions the reducing sugar content was found to be 2.81 (T_1), 3.54 (T_2), 3.58 (T_3) and 3.34 (T_4) per cent respectively.

Significant interaction was also observed between storage period and storage condition.

β-carotene

Table 21 represents the changes in the β-carotene content of nectars and its interaction between variety, products, storage condition and storage period.

Significant difference was observed in the β-carotene content of nectars of both the varieties (CD0.562). The β-carotene content of the nectars formulated from the two varieties over a period of 60 days was found to be 237.46 and 223.99 μg respectively.

Significant difference was observed in the β-carotene content of the various blended nectars tried out (CD 0.794) in the study. The highest β-carotene content was recorded in mango blended nectar (377.14 μg) followed by papaya blended nectar (296.48 μg), pineapple blended nectar (129.06 μg) and lastly control jackfruit nectar (120.21 μg) of both varieties.

β-carotene content of jackfruit nectar of both varieties when stored under two conditions decreased slowly. The decrease in β-carotene content for nectars stored under ambient condition ranged between 273.17 – 153.73 μg while under refrigerated condition it ranged between 273.17–

Table 21 Changes in the β-carotene of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (Initial)	277.54	268.80	159.72	167.00	340.38	425.58	273.17	273.17	273.17
P_1 (1^{st} week)	268.26	263.59	155.33	161.61	332.59	414.17	260.18	271.67	265.93
P_2 (2^{nd} week)	260.71	253.23	146.20	153.03	323.54	405.10	248.61	265.32	256.97
P_3 (3^{rd} week)	249.96	240.23	135.28	142.37	309.54	393.20	233.36	256.83	245.10
P_4 (4^{th} week)	238.50	226.75	122.37	131.18	297.41	379.55	217.10	248.15	232.63
P_5 (5^{th} week)	229.54	213.35	110.42	118.83	289.06	367.47	202.99	239.90	221.44
P_6 (6^{th} week)	217.25	198.38	98.00	107.33	273.14	352.79	185.99	229.65	207.82
P_7 (7^{th} week)	204.38	183.41	83.78	96.44	258.30	337.05	169.43	218.36	193.89
P_8 (8^{th} week)	191.00	168.17	70.78	83.78	244.38	319.39	153.73	205.45	179.59
Mean V/T/R	**237.46**	**223.99**	**120.21**	**129.06**	**296.48**	**377.14**	**216.06**	**245.39**	**230.72**
R_1 (Room)	220.46	211.66	108.34	121.39	278.78	355.74			
R_2 (Refrigerated)	254.46	236.32	132.08	136.74	314.19	398.55			
T_1	121.61	118.80							
T_2	128.85	129.28							
T_3	298.65	294.32							
T_4	400.72	353.56							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 2215.68**
$F_{3,288}$ T = 196430.50**
$F_{8,288}$ P = 5775.36**

$F_{1,288}$ R = 10493.36**
$F_{8,288}$ VP = 56.08**
$F_{24,288}$ TP = 12.06**
$F_{8,288}$ PR = 427.23**
$F_{1,288}$ VR = 263.83**
$F_{3,288}$ TR = 451.46**
$F_{3,288}$ VT = 1549.10**

CD (V) = 0.562
CD (T) = 0.794
CD (P) = 1.195
CD (R) = 0.563
CD (VP) = 1.682
CD (TP) = 2.383
CD (PR) = 1.684
CD (VR) = 0.795
CD (TR) = 0.234
CD (VT) = 1.122

*Significant at 5 per cent level. **Significant at 1 per cent level

205.45 μg respectively. As indicated by CD (0.563) significant difference in β-carotene content was observed in the nectars stored under different storage conditions.

Significant decrease in β-carotene content was observed along with a storage period of 60 days. As inferred from CD (1.195) a significant decrease in β-carotene content was observed even after storage of one week. The decrease in β-carotene content of nectars accounted to be 34.25 per cent over a storage period of 60 days.

Significant interaction was observed between variety and storage period indicating the variety of the fruit and storage period affected the β-carotene content of the formulated nectars.

Significant interaction was also observed between variety and storage condition. The β-carotene content of nectars formulated from varikka and koozha varieties stored under refrigerated condition was found to be 254.46 and 236.32 μg respectively whereas nectars stored under ambient condition the β-carotene content was found to be 220.46 and 211.66 μg respectively.

Interaction was also observed between variety and treatment. The β-carotene content for the nectars formulated from varikka variety for various treatments was found to be 121.61 (V_1T_1), 128.85 (V_1T_2), 298.65 (V_1T_3) and 400.72 μg (V_1T_4) respectively whereas the β-carotene content for koozha nectar was found to be 118.80 (V_2T_1), 129.28 (V_2T_2), 294.32 (V_2T_3) and 353.56 (V_2T_4) respectively. It can be concluded that the type of blend and the variety used for formulating nectars affected the β-carotene content of nectars.

Significant interaction was observed between treatments and storage period. The β-carotene content decreased as the storage period advanced. As inferred from CD value (2.383) significant decrease was observed in the β-carotene content for all the four treatments after a storage period of one week.

Significant interaction was observed within the treatments and storage condition. It was found that the β-carotene content was retained better in the refrigerated samples as compared to nectars stored under ambient condition.

Significant interaction was also observed with respect to β-carotene content between storage period and storage condition. The β-carotene content of nectars stored under refrigerated condition ranged from 273.17–205.45 μg whereas it ranged from 273.17 – 153.73 μg in the nectars stored in ambient condition, indicating that the storage period and storage condition affects the β-carotene content in the nectars standardized.

Vitamin C

Table 22 represents the changes in the vitamin C content of nectar and its interaction between variety, treatments, storage condition and storage period.

Significant difference was observed in the vitamin C content of nectars of both the varieties. The mean value for vitamin C content of the nectars formulated from the two varieties (varikka and koozha) over a period of 60 days was found to be 8.43 mg/100 g and 9.30 mg/100 g respectively.

Significant difference was observed between the vitamin C content of various blended nectars. The highest vitamin C content was observed in papaya blended nectar (10.45 mg/100 g) followed by pineapple blended nectar (9.07 mg/100 g) mango blended nectar (8.23mg/100gm)and control jack fruit nectar (7.72 mg/100 g) respectively in both the varieties.

Vitamin C content of the jackfruit nectars of both varieties when stored under two different storage conditions was found to decrease significantly.

Table 22 Changes in the vitamin C content of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Days (Mean)
P_0 (Initial)	9.94	9.75	8.57	10.02	11.53	9.27	9.85	9.85	9.85
P_1 (1^{st} week)	9.80	9.67	8.51	9.92	11.33	9.18	9.66	9.81	9.73
P_2 (2^{nd} week)	9.54	9.58	8.34	9.73	11.16	9.00	9.44	9.68	9.56
P_3 (3^{rd} week)	9.19	9.45	8.13	9.48	10.94	8.73	9.15	9.50	9.32
P_4 (4^{th} week)	8.17	9.33	7.85	9.17	10.62	8.43	8.80	9.24	9.02
P_5 (5^{th} week)	8.27	9.20	7.62	8.92	10.29	8.13	8.46	9.02	8.74
P_6 (6^{th} week)	7.54	9.05	7.22	8.58	9.80	7.59	7.77	8.82	8.30
P_7 (7^{th} week)	6.70	8.91	6.75	8.08	9.34	7.04	7.09	8.52	7.80
P_8 (8^{th} week)	6.20	8.75	6.47	7.70	9.04	6.71	6.75	8.21	7.48
Mean V/T/R	**8.43**	**9.30**	**7.72**	**9.07**	**10.45**	**8.23**	**8.55**	**9.18**	**8.86**
R_1 (Room)	7.88	9.22	7.38	8.82	10.14	7.87			
R_2 (Refrigerated)	8.99	9.38	8.06	9.31	10.76	8.59			
T_1	7.70	7.73							
T_2	8.58	9.55							
T_3	9.42	11.49							
T_4	8.03	8.53							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,288}$ V = 11239.05**
$F_{3,288}$ T = 21387.57**
$F_{8,288}$ P = 4842.98**

$F_{1,288}$ R = 435927.59**
$F_{8,288}$ VP = 1727.53**
$F_{24,288}$ TP = 11.50**
$F_{8,288}$ PR = 502.58**
$F_{1,288}$ VR = 3396.34**
$F_{3,288}$ TR = 40.32**
$F_{3,288}$ VT = 2957.10**

CD (V) = 0.023
CD (T) = 0.024
CD (P) = 0.033
CD (R) = 0.022
CD (VP) = 0.051
CD (TP) = 0.075
CD (PR) = 0.057
CD (VR) = 0.024
CD (TR) = 0.033
CD (VT) = 0.039

*Significant at 5 per cent level. **Significant at 1 per cent level

The decrease in the vitamin C content ranged from 9.85–6.75 in nectars stored under ambient condition whereas it ranged from 9.85–8.21 in nectars stored under refrigerated condition.

Significant decrease in the vitamin C was observed over a storage period of 60 days. The decrease in vitamin C content with storage ranged from 9.85 – 7.48 mg/100 g. Significant interaction was observed between variety and storage period. The initial vitamin C content of varikka and koozha variety was found to be 9.94 and 9.75 mg/100 g whereas after 60 days of storage the vitamin C content of the nectars was found to be 6.20 and 8.75 mg/100 g respectively.

Significant interaction was also observed between variety and storage condition. Variety of fruit and storage condition influenced the vitamin C content of the nectars. The vitamin C content of nectars for varikka and koozha variety stored under ambient condition was found to be 7.88 and 9.22 mg/100 g whereas vitamin C content for nectars stored under refrigerated condition was 8.99 and 9.38 mg/100 g respectively.

Significant interaction was observed with respect to vitamin C between variety and treatments applied. The mean value of vitamin C content of nectars for varikka variety were found to be 7.70 (V_1T_1), 8.58(V_1T_2), 9.42 (V_1T_3) and 8.03 (V_1T_4) respectively whereas the vitamin C for koozha variety was found to be 7.73 (V_2T_1), 9.55 (V_2T_2), 11.49 (V_2T_3) and 8.53 (V_2T_4) respectively.

Significant interaction was observed between treatments and storage period. Hence it can be concluded that vitamin C content of nectars was influenced by the treatments and storage period.

Significant difference was also observed between the treatments and storage condition. The mean vitamin C content for nectars stored under ambient condition were found to be 7.38 (T_1), 8.82 (T_2), 10.14 (T_3) and 7.87 (T_4) whereas for nectars stored under refrigerated condition, the vitamin C content were 8.06 (T_1), 9.31 (T_2), 10.76 (T_3) and 8.59 (T_4) respectively.

Polyphenols

Table 23 represents the polyphenolic content of the nectar and its interaction between variety, treatments and storage period.

Table 23 Changes in the polyphenol content of jackfruit nectar and its interaction between variety, treatments and storage period

Storage period (P) Weeks	Variety (V)		Treatments (T)				Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	Days (Mean)
P_0 (Initial)	62.51	60.68	32.18	43.18	65.48	105.03	61.60
P_1 (Final)	46.22	44.65	17.63	28.40	54.17	81.53	45.43
Mean V/T	**54.36**	**52.67**	**25.16**	**35.79**	**59.83**	**93.28**	**53.51**
T_1	23.45	26.87					
T_2	29.80	41.78					
T_3	65.35	54.30					
T_4	98.35	87.72					

$F_{1,32}$ V = 151.04** CD (V) = 0.283
$F_{3,32}$ T = 47953.90** CD (T) = 0.402
$F_{1,32}$ P = 13717.68** CD (P) = 0.284
$F_{3,32}$ VT = 1705.87** CD (VT)= 0.563
$F_{1,32}$ VP = 0.89 CD (TP) = 0.561
$F_{3,32}$ TP = 352.11**

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the polyphenolic content of nectars of both the varieties. The polyphenolic content of the nectars formulated from the two varieties over a period of 60 days was found to be 54.36 and 52.67 g/100 g respectively.

Similarly significant difference was also observed in the polyphenolic content of the various blended nectars tried out (CD0.402) in the study. The highest polyphenolic content was observed in mango blended nectar (93.28) followed by Papaya blended nectar (59.83) pineapple blended nectar (35.79) and lastly control jackfruit nectar (25.16 g/100 g) of both the varieties respectively.

Significant decrease in polyphenolic content was observed along with a storage period of 60 days (CD0.284). The decrease in polyphenolic content ranged from 61.60–45.53 g/100 g for a period of 60 days.

Significant interaction was observed between variety and treatment.

The polyphenolic content of nectars formulated from varikka variety for various treatments was found to 23.45 (V_1T_1), 29.80 (V_1T_2), 65.35 (V_1T_3) and 98.35 (V_1T_4) whereas for koozha variety the polyphenolic content was 26.87 (V_2T_1), 41.78 (V_2T_2), 54.30 (V_2T_3) and 87.72 (V_2T_4) g/100 g respectively.

Significant interaction was observed with respect to treatments and storage period. The polyphenolic content decreased as the storage period advanced.

As inferred from the above results, varietal difference was shown in the chemical constituents such as acidity, pH, TSS, total sugar, vitamin C and polyphenol. However, varietal difference was not reflected for reducing sugar content of nectars. Treatments applied in the study were found to have distinct impact on the chemical and nutritional constituents of nectars except TSS. All the chemical and nutritional features were found to be influenced by the storage condition except TSS. The nectars stored under refrigerated condition were less subjected to changes as compared to its counterpart to stored under ambient temperature. The various characters ascertained in their nectars were found to vary significantly as the storage period advanced except TSS.

4.2.2.4 Changes in the Organoleptic Features of Nectars with Storage

Sensory evaluation of the food products plays a major role in determining the acceptability and shelf stability of the products. In order to ascertain the shelf life of food products, organoleptic evaluation has to be conducted periodically. The organoleptic qualities of the nectars formulated from jackfruit were assessed periodically (every 15 days) so as to ascertain the shelf stability of the products. The results obtained are presented below.

Appearance

The appearance of the food products is contributed by surface characteristics *viz.*, size, shape, colour, transparency, opaqueness, turbidity, dullness etc. (Srilakshami, 2003).

Table 24 represents the changes in the appearance of nectar and its interaction between variety, treatments, storage condition and storage period.

Significant difference was observed in the appearance, attribute of nectars formulated from the two varieties of jackfruit. As inferred from CD value (0.053) the appearance score decreased significantly in varikka nectars after a period of 30 days as against 45 days in koozha nectars. The mean appearance score of the nectars formulated from varikka and koozha varieties of jackfruit over a period of 60 days of storage was found to be 4.14 and 4.07 respectively in varikka and koozha. Nectars prepared from varikka variety excelled in appearance compared to koozha nectars during storage.

Significant difference was observed in the appearance attribute of the various blended nectars. Among the various blended nectars tried out, papaya blended nectar scored highest for appearance (4.23) followed by mango blended (4.17), pineapple blended (4.05) and lastly control jackfruit nectars (3.97) of both varieties.

Appearance scores of jackfruit nectar of both varieties decreased slowly when stored under two conditions for 60 days and the decrease was from 4.16 to 3.89 (6.4 per cent) when stored under ambient condition

Table 24 Changes in the appearance of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.23	4.10	4.00	4.10	4.30	4.25	4.16	4.16	4.16
P_2 (15 days)	4.23	4.10	4.00	4.10	4.30	4.25	4.16	4.16	4.16
P_3 (30 days)	4.21	4.10	4.00	4.10	4.30	4.23	4.16	4.15	4.16
P_4 (45 days)	4.13	4.09	3.98	4.03	4.25	4.18	4.13	4.09	4.11
P_5 (60 days)	3.93	3.94	3.85	3.93	4.00	3.95	3.98	3.89	3.93
Mean V/T/R	**4.14**	**4.07**	**3.97**	**4.05**	**4.23**	**4.17**	**4.11**	**4.09**	**4.10**
R_1 (Room)	4.13	4.05	3.95	4.03	4.23	4.15			
R_2 (Refrigerated)	4.16	4.08	3.98	4.07	4.23	4.19			
T_1	3.97	3.96							
T_2	4.12	3.98							
T_3	4.30	4.16							
T_4	4.18	4.16							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 10.96**
$F_{4,720}$ P = 14.39**
$F_{3,720}$ T = 25.84**
$F_{1,720}$ R = 1.38

CD (V) = 0.053
CD (P) = 0.072
CD (T) = 0.061

*Significant at 5 per cent level. **Significant at 1 per cent level

whereas the decrease was from 4.16 to 3.98 (4.3 per cent) in the nectars stored under refrigerated condition. However, decrease in appearance scores was not significant. Thus storage condition used in the present study was not found to influence the appearance attribute of the nectars formulated.

Appearance score was found to be affected with the advancement of storage. Steady decrease in the appearance score was observed in the nectars formulated after 45 days of storage.

Colour

Colour is used as an index to the quality of number of foods. In addition to giving pleasure, the colour of food is associated with other attributes, e.g., ripeness (red colour), sourness (green colour) etc.

Table 25 represents the changes in the colour of nectar and its interaction between variety. Treatments, storage condition and storage period.

No significant difference was observed in the colour attribute of nectars of two varieties of jackfruit with storage. The mean colour score of the nectars formulated from the two varieties of jackfruit over a period of 60 days storage was found to be 4.16 and 4.18 respectively in varikka and koozha nectars. Nectars prepared from koozha variety excelled in colour compared to varikka variety.

Significant difference was observed in the colour attribute of the various nectars formulated under the present study. Among the various blended nectars tried out, papaya blended nectar scored highest for colour (4.29) followed by mango blended nectar (4.20), pineapple blended (4.11) and control jackfruit nectar (4.08) of both varieties.

Significant difference was also noted (at 5 per cent level) in the colour attribute of the nectars stored under ambient and refrigerated conditions. The colour attribute scores decreased with storage and the

Table 25 Changes in the colour of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.28	4.28	4.20	4.20	4.40	4.30	4.28	4.28	4.28
P_2 (15 days)	4.26	4.23	4.15	4.18	4.38	4.28	4.21	4.28	4.24
P_3 (30 days)	4.21	4.23	4.13	4.15	4.35	4.25	4.18	4.26	4.22
P_4 (45 days)	4.11	4.20	4.05	4.07	4.30	4.20	4.13	4.19	4.16
P_5 (60 days)	3.91	3.96	3.88	3.93	4.00	3.95	3.90	3.98	3.94
Mean V/T/R	**4.16**	**4.18**	**4.08**	**4.11**	**4.29**	**4.20**	**4.14**	**4.20**	**4.16**
R_1 (Room)	4.13	4.15	4.05	4.07	4.27	4.16			
R_2 (Refrigerated)	4.18	4.21	4.11	4.14	4.30	4.23			
T_1	4.04	4.12							
T_2	4.11	4.10							
T_3	4.29	4.28							
T_4	4.18	4.21							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 0.65
$F_{4,720}$ P = 18.56**
$F_{3,720}$ T = 11.07**
$F_{1,720}$ R = 4.20*

CD (P) = 0.093
CD (T) = 0.084
CD (R) = 0.053

*Significant at 5 per cent level, **Significant at 1 per cent level

decrease was from 4.28 – 3.90 (8.87 per cent decrease) in the nectar stored under ambient condition, while it was 4.28 – 3.98 (7.00 per cent decrease) for the nectars stored under refrigerated conditions. As inferred from CD value (0.053) the colour score decreased significantly after 15 days in the nectars stored under room temperature whereas only after 45 days for nectar stored under refrigerated condition. Hence it can be concluded that storage condition used influenced the colour attribute of the nectars with storage of 60 days. Nectars stored under refrigerated condition excelled in colour attribute.

Significant difference in the colour score was also noted with storage period of 60 days. As inferred from CD value (0.093) significant decline in colour attribute was observed after a period of 30 days of storage in the nectars. The decrease in the colour score ranged from 4.28–3.94 (7.94 per cent decrease) over a period of 60 days.

Flavour

Flavour is the combination of taste and smell. Taste includes sweet, salty and sour characters in a product. While smell could be fragrant, acidic, burnt etc. due to enzymatic, physico-logical or chemical changes.

The Table 26 represents the changes in the flavour of nectar and its interaction between variety, treatments, storage condition and storage period. Significant difference was observed in the flavour attribute of nectars of both varieties. As inferred from CD(0.054) significant decrease in flavour was observed in the nectars after 30 days of storage. The mean flavour score of the nectars formulated from the two varieties of jackfruit over a period of 60 days storage was found to be 3.98 and 3.80 respectively in varikka and koozha nectars. Nectars prepared from varikka variety excelled in flavour when compared to koozha nectars during storage.

Flavour attribute of nectars formulated was found to be less affected with respect to treatments. Among the various blended nectars

Table 26 Changes in the flavour of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.25	4.00	4.05	4.20	4.10	4.15	4.13	4.13	4.13
P_2 (15 days)	4.21	4.00	4.07	4.15	4.07	4.13	4.07	4.14	4.11
P_3 (30 days)	4.07	3.95	4.00	4.00	4.03	4.03	3.98	4.05	4.01
P_4 (45 days)	3.83	3.68	3.73	3.80	3.80	3.68	3.69	3.81	3.75
P_5 (60 days)	3.54	3.36	3.48	3.50	3.50	3.33	3.31	3.59	3.45
Mean V/T/R	**3.98**	**3.80**	**3.87**	**3.93**	**3.90**	**3.86**	**3.84**	**3.94**	**3.89**
R_1 (Room)	3.92	3.75	3.81	3.87	3.85	3.81			
R_2 (Refrigerated)	4.04	3.85	3.92	3.99	3.95	3.91			
T_1	3.87	3.86							
T_2	4.00	3.86							
T_3	4.06	3.74							
T_4	3.99	3.73							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 44.45**
$F_{4,720}$ P = 88.13**
$F_{3,720}$ T = 2.43*
$F_{1,720}$ R = 15.42**
$F_{3,720}$ VT = 6.28**
$F_{4,720}$ PR = 2.87*

CD (V) = 0.054
CD (P) = 0.083
CD (T) = 0.011
CD (R) = 0.052
CD (VT) = 0.113
CD (PR) = 0.129

*Significant at 5 per cent level, **Significant at 1 per cent level

tried out pineapple blended nectars scored highest for flavour (3.93) followed by papaya blended nectar (3.90) control jackfruit nectar (3.87) and mango blended nectar (3.86) of both varieties.

Significant interaction was also observed between the variety and various treatments proposed in nectars. It can be concluded that variety of jackfruit and the treatment applied influenced the flavour of nectars formulated under the present investigation. In case of varikka, blending helped to improve the flavour and no significant difference was observed when blended with different fruits. But in case of koozha nectar, blending did not improve the flavour except pineapple blend which was on par with control nectar (3.86).

Significant difference was noted in the flavour attribute of the nectars stored under ambient and refrigerated conditions. As inferred from the CD (0.052) significant decrease in flavour was observed for nectars stored under ambient condition after 15 days, whereas nectars stored under refrigerated condition, the decrease was noted after 30 days. The flavour scores decreased from 4.13–3.31 (19.85 per cent decrease) in the nectar stored under ambient condition while it was 4.13–3.59 (13.07 per cent decrease) for the nectars stored under refrigerated condition. Thus storage condition was found to influence the flavour attribute of the nectars formulated. In other words flavour was better retained in the nectars stored under refrigerated condition.

Significant interaction was also observed between storage period and storage condition. A significant decrease was observed in the flavours scores along with storage period. As inferred from CD value (0.083) the decrease was more prominent only after 30 days of storage. The decrease in flavour scores ranged from 4.13–3.45 (16.46 per cent decrease) over a period of 60 days.

Taste

Table 27 represents the changes in the taste of nectar and its interaction between variety, treatments, storage condition and storage period.

Table 27 Changes in the taste of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.25	4.20	4.20	4.30	3.95	4.15	4.15	4.15	4.15
P_2 (15 days)	4.23	4.05	4.20	4.28	3.95	4.13	4.11	4.16	4.14
P_3 (30 days)	4.05	3.86	4.00	4.05	3.85	3.93	3.91	4.00	3.96
P_4 (45 days)	3.74	3.60	3.68	3.75	3.65	3.60	3.61	3.73	3.67
P_5 (60 days)	3.46	3.31	3.43	3.45	3.35	3.33	3.25	3.53	3.39
Mean V/T/R	**3.95**	**3.78**	**3.90**	**3.97**	**3.75**	**3.83**	**3.81**	**3.91**	**3.86**
R_1 (Room)	3.89	3.73	3.84	3.91	3.70	3.78			
R_2 (Refrigerated)	4.00	3.83	3.96	4.02	3.80	3.87			
T_1	3.96	3.84							
T_2	4.03	3.90							
T_3	3.83	3.67							
T_4	3.96	3.69							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 34.91**
$F_{4,720}$ P = 103.94**
$F_{3,720}$ T = 10.45**
$F_{1,720}$ R = 13.32**
$F_{4,720}$ PR = 2.62*

CD (V) = 0.063
CD (P) = 0.094
CD (T) = 0.085
CD (R) = 0.062
CD (PR) = 0.131

*Significant at 5 per cent level, **Significant at 1 per cent level

According to Kramer and Twigg (1970), among the various quality attributes, taste is the primary and the most important quality parameter.

Significant difference was observed in the taste attribute of nectars of both the varieties. As indicated by CD (0.063) significant decrease in taste attribute was observed after a period of 30 days for varikka and after a period of 15 days in koozha nectars. The mean taste scores of nectars formulated from the two varieties of jackfruit over a period of 60 days of storage was found to be 3.95 and 3.78 respectively in varikka and koozha nectars. On the whole nectars formulated from varikka variety excelled in taste compared to koozha nectars, during storage.

Significant interaction was observed among the various blended nectars formulated out. The pineapple blended nectars of both variety scored highest for taste (3.97) followed by control jackfruit nectar (3.90). It was observed that mango blended nectar (3.83) and papaya blended nectar (3.75) of both varieties stood next to pineapple blended nectars in taste attribute.

Storage condition was found to influence the taste of the nectars formulated under study. As inferred from CD(0.062) significant decrease in taste was observed after 30 days of storage for both the nectars. The taste scores decreased and the decrease ranged from 4.15-3.25 (21.6 per cent decrease) in the nectar stored under ambient condition, while it was 4.15 – 3.53 (14.93 per cent decrease) for the nectars stored under refrigerated condition.

Significant interaction with effect to taste was observed between storage period and storage condition. The type of storage condition and the storage period affected the taste of nectars standardized.

Significant difference was observed in the taste scores over a period of 60 days. As inferred from CD (0.094) a significant decrease in taste scores was observed after a period of 30 days of storage. The taste scores decreased with storage and the decrease was accounted to be 18.31 per cent (4.15 to 3.39).

Consistency

Consistency of the nectars is one of the most important attribute of beverages.

Table 28 represents the changes in the consistency of nectars and its interaction between variety, treatments storage condition and storage period.

Varietal difference was not reflected in the consistency of nectars standardized. The mean scores for consistency were 3.98 and 3.97 respectively for varikka and koozha varieties.

Similarly no difference was observed in consistency in the different blended nectars formulated. Among the various blended nectars tried out, mango blended nectar scored best for consistency (3.99) closely followed by control jackfruit nectar (3.98) pineapple blended and papaya blended nectars (3.97) of both varieties.

Unlike the other two parameters significant difference was observed in the consistency of various blended nectars with storage condition. As inferred from CD value (0.044) significant decrease in consistency score was observed after 30 days of storage in the nectars stored under ambient condition and refrigerated condition. Scores for consistency decreased with storage and the decrease ranged from 4.13–3.60 (12.83 per cent decrease) in the nectars stored under ambient condition while it was 4.13–3.81 (7.74 per cent decrease) when stored under refrigerated condition which indicate that consistency of nectars was more stable when stored under refrigerated condition.

Significant interaction was observed between storage period and storage condition on the consistency attribute of the nectars. It can be concluded that consistency of nectars was influenced by the duration of storage and storage condition.

Table 28 Changes in the consistency of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.13	4.13	4.10	4.10	4.10	4.20	4.13	4.13	4.13
P_2 (15 days)	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
P_3 (30 days)	4.01	4.01	4.03	4.00	4.00	4.03	4.00	4.03	4.01
P_4 (45 days)	3.94	3.93	3.95	3.95	3.90	3.93	3.91	3.95	3.93
P_5 (60 days)	3.73	3.69	3.70	3.70	3.73	3.70	3.60	3.81	3.71
Mean V/T/R	**3.98**	**3.97**	**3.98**	**3.97**	**3.97**	**3.99**	**3.95**	**4.00**	**3.97**
R_1 (Room)	3.95	3.95	3.94	3.95	3.94	3.96			
R_2 (Refrigerated)	4.01	4.00	4.01	3.99	3.99	4.02			
T_1	3.97	3.98							
T_2	3.97	4.00							
T_3	3.98	3.96							
T_4	3.96	3.98							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 0.19
$F_{4,720}$ P = 44.00**
$F_{3,720}$ T = 0.23
$F_{1,720}$ R = 5.36*
$F_{4,720}$ PR = 3.10*

CD (R) = 0.044
CD (PR) = 0.107
CD (P) = 0.078

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant decrease in the consistency score was also observed when nectars were stored for 60 days. Significant decrease in the consistency score of nectars was observed after 30 days of storage (CD0.078). The mean scores for consistency ranged from 4.13 – 3.71 (10.61 per cent decrease) over a period of 60 days.

Overall acceptability

Table 29 represents the overall acceptability of nectars and its interaction between variety, treatments, storage condition and storage period.

Varietal difference was not reflected in the overall acceptability scores of nectars of both the varieties. The mean overall acceptability scores for varikka and koozha nectars were 3.94 and 3.91 respectively.

Similarly no difference was observed in the overall acceptability scores of various blended nectars of two varieties. Among the various blended nectars tried out pineapple blended nectars (3.98) got the maximum score, followed by control jackfruit nectar (3.92). Papaya blended jackfruit nectar (3.90) and lastly mango blended jackfruit nectar (3.84).

It was also observed that overall acceptability of the nectars was not found to be influenced by storage condition. The mean overall acceptability score for the nectars stored under ambient condition was found to be 3.92 as against 3.94 in refrigerated condition.

Significant influence was observed in the overall acceptability scores of nectars with respect to storage period of 60 days. As indicated by CD (0.402) the decrease in overall acceptability score was observed after 30 days of storage. The overall acceptability scores decreased from 4.00 – 3.83 (4.25 per cent decrease) for a period of 60 days.

It can be concluded from the above results that appearance, flavour and taste attributes of nectars were influenced by the variety of the fruit, whereas colour, consistency and overall acceptability of nectars remained unaffected by the variety of jackfruit. It was also seen that among the

Table 29 Changes in the overall acceptability of nectar and its interaction between variety, treatments, storage condition and storage period

Storage period (days)	Variety (V)		Treatments (T)				Storage condition (R)		Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	T_4	R_1 (Room)	R_2 (Refrigerated)	Mean (days)
P_1 (Initial)	4.01	3.98	4.00	4.01	3.97	3.88	4.00	4.00	4.00
P_2 (15 days)	4.01	3.97	4.04	4.00	3.91	3.86	3.98	3.99	3.99
P_3 (30 days)	3.97	3.93	3.99	3.97	3.91	3.84	3.94	3.96	3.95
P_4 (45 days)	3.89	3.87	3.98	3.96	3.87	3.83	3.87	3.89	3.88
P_5 (60 days)	3.84	3.83	3.97	3.95	3.86	3.81	3.81	3.86	3.83
Mean V/T/R	**3.94**	**3.91**	**3.92**	**3.98**	**3.90**	**3.84**	**3.92**	**3.94**	**3.93**
R_1 (Room)	3.92	3.91	3.93	3.91	3.92	3.89			
R_2 (Refrigerated)	3.95	3.93	3.97	3.95	3.94	3.93			
T_1	3.95	3.90							
T_2	3.97	3.94							
T_3	3.93	3.88							
T_4	3.93	3.94							

T_1 = Control jackfruit nectar
T_2 = Pineapple blended jackfruit nectar
T_3 = Papaya blended jackfruit nectar
T_4 = Mango blended jackfruit nectar

$F_{1,720}$ V = 1.26
$F_{4,720}$ P = 5.85**
$F_{3,720}$ T = 0.76
$F_{1,720}$ R = 0.49

CD (P) = 0.042

*Significant at 5 per cent level. **Significant at 1 per cent level

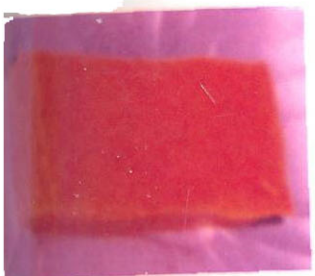
various treatments applied, appearance and colour attribute was preferred in the nectars blended with papaya, whereas taste and flavour was improved when blended with pineapple and mango. Consistency of the nectars was more or less the same for all the nectars. For all the attributes *viz*., appearance, colour, flavour, taste, consistency and overall acceptability the refrigerated samples excelled as compared to those stored under ambient condition. Refrigerated condition maintain the sensory features of nectars when compared to non-refrigerated condition.

However, the storage period influenced all the sensory attributes in the nectars. The mean score for all the attributes including overall acceptability declined with storage over a period of 60 days. Overall scores of the nectars gradually declined towards the end of two months.

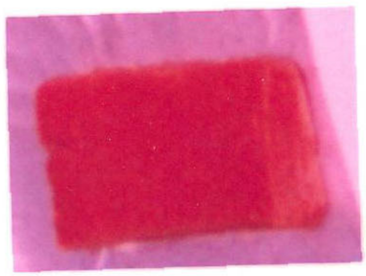
4.2.3 Standardization of Jackfruit Bars

Fruit bars are novel products developed across the country. They are prepared by drying fruit pulps after attaining acidity and sugar concentration to a desired level (Berry and Kalra1987).

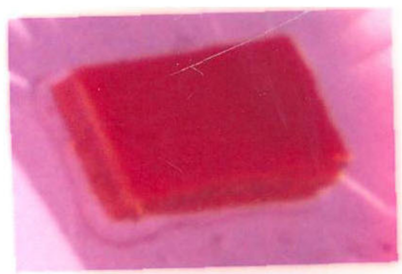
Fruit bars were standardized from the two varieties of jackfruit individually and along with blending with other fruit pulps such as papaya and mango. Trials were carried out initially by varying the proportions of ingredients for obtaining bars of good consumer appeal. Based on the organoleptic features and scores, the best proportions were selected in each category of fruit bars from the two varieties of jackfruit and presented in Table 30. Thus a total of three types of fruit bars of different taste and flavour were standardized from the two varieties of jackfruit under the present investigation. Plate 3 depicts the various jackfruit bars standardized from jackfruit.



Control varikka bar

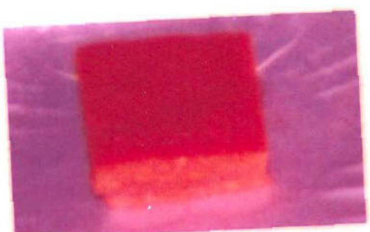


Papaya blended jackfruit varikka bar



Mango blended jackfruit varikka bar

Control Koozha bar



Papaya blended jackfruit koozha bar

Mango blended jackfruit koozha bar

Plate 3. Jackfruit bars standardised from two varieties along with blends

Table 30 Composition of jackfruit bars standardized

Sl. No.	Treatments	Jackfruit pulp with preservative	Pulp of other fruits	Water	Sugar	Citric acid	Rice flour
1	Control varikka jackfruit bar	1.0	-	0.25	0.32	0.002	-
2	Control koozha jackfruit bar	1.0	-	0.20	0.32	0.002	-
3	Papaya blended varikka bar	0.5	0.5	0.25	0.32	0.002	0.04
4	Papaya blended koozha bar	0.5	0.5	0.12	0.12	0.002	0.04
5	Mango blended varikka bar	0.5	0.5	0.25	0.32	0.002	-
6	Mango blended koozha bar	0.5	0.5	0.12	0.12	0.002	-

4.2.3.1 Assessment of Chemical and Nutritional Features of Jackfruit Bars Standardized

Fruit bars standardized under the present investigation resembled mango bars in appearance. Table 31 represents chemical and nutritional characteristics of the bars standardized from the two varieties of jackfruit.

Table 31 Chemical and nutritional characteristics of bars standardized from jackfruit

Treatments	Moisture (per cent)	Acidity (per cent)	pH	TSS (°Brix)	Total sugar (per cent)	Reducing sugar (per cent)	β-carotene (μg)	Vitamin C (mg/100 g)	Polyphenols (g/100 g)
V_1T_1	11.4	0.52	4.5	65.28	59.63	12.3	184.2	3.1	29.67
V_1T_2	11.67	0.56	4.57	72.3	56.76	11.88	221.53	3.31	29.42
V_1T_3	10.76	1.07	4.65	71.43	69.78	12.54	320.72	3.12	28.72
V_2T_1	9.15	0.52	4.62	66.29	61.7	12.53	165.8	2.7	27.7
V_2T_2	10.79	0.66	4.57	71.28	59.73	12.55	201.53	2.85	28.12
V_2T_3	10.91	1.06	4.73	71.51	66.51	12.46	328.72	2.85	27.57
F	128.45**	73.04**	27.07**	7224.00**	4007.33**	30.32**	34.62**	7.81**	4.14*
CD	0.213	0.013	0.023	0.021	0.112	0.142	5.163	0.072	0.441

V_1T_1 – Varikka control bar, V_1T_2 – Papaya blended varikka bar, V_1T_3 – Mango blended varikka bar,
V_2T_1 – Koozha control bar, V_2T_2 – Papaya blended Koozha bar, V_2T_3 – Mango blended Koozha bar,

As indicated in the Table 31, a significant difference (CD 0.213) was observed in the moisture content of bars standardized. The mean moisture content of the fruit bars formulated from varikka variety were

11.40 (V_1T_1), 11.67 (V_1T_2) and 10.76 (V_1T_3) as against 9.15 (V_2T_1), 10.79 (V_2T_2) and 10.91 (V_2T_3) from koozha variety. The moisture content for varikka fruit bars was comparatively higher when compared to koozha bars. The highest moisture content was observed in papaya blended varikka bar (11.67 per cent) and the lowest in control koozha bar (9.15 per cent).

The acidity of the fruit bars ranged from 0.52– 1.07 per cent. Mango blended varikka bar recorded highest acidity (1.07 per cent) whereas control fruit bars of both the varieties recorded the lowest (0.52 per cent). A significant difference (CD 0.013) was observed with respect to acidity between the various fruit bars tried out. The mean acidity of fruit bars formulated from varikka variety were 0.52 per cent (V_1T_1), 0.56 (V_1T_2) and 1.07 (V_1T_3) as against 0.52 per cent (V_2T_1), 0.66 per cent (V_2T_2) and 1.06 (V_2T_3) in koozha fruit bars.

As far as pH of fruit bar is concerned a significant difference (CD 0.023) was observed with respect to pH between the various fruit bars formulated. The highest pH was observed in mango blended koozha bar (4.73) and the lowest for control varikka bar (4.50). The mean pH of fruit bars formulated from varikka variety was 4.50 (V_1T_1), 4.57 (V_1T_2) and 4.65 (V_1T_3) as against 4.62 (V_2T_1), 4.57 (V_2T_2) and 4.73 (V_2T_3) in koozha fruit bars.

A significant difference (CD 0.021) was observed with respect to TSS content between the fruit bars formulated from jackfruit. Papaya blended varikka bar recorded the highest TSS content (72.30 °Brix) whereas the lowest TSS was observed in control varikka bar (65.28°Brix). The mean TSS content of the fruit bars from varikka variety was 65.28 (V_1T_1), 72.30 (V_1T_2) and 71.43 (V_1T_3) and that of koozha bars was 66.29 (V_2T_1), 71.28 (V_2T_2) and 71.51 (V_2T_3).

The total sugar content ranged from 56.76 – 69.78 per cent in the fruit bars formulated from the two jackfruit varieties. A significant difference (CD 0.112) was observed between the TSS content of the fruit bars formulated. The lowest total sugar content was observed in the papaya blended varikka bar (56.76 per cent), whereas the highest was recorded in mango blended koozha bar (69.78 per cent). The total sugar content of the fruit bars from varikka variety were 59.63 (V_1T_1), 56.76 (V_1T_2) and 69.78 (V_1T_3) as against 61.70 (V_2T_1), 59.73 (V_2T_2) and 66.51 (V_2T_3) in koozha fruit bars.

A significant difference (CD 0.142) was observed with respect to reducing sugar content between the various fruit bars formulated. The reducing sugar content of the fruit bars formulated from varikka variety was 12.30 (V_1T_1), 11.88 (V_1T_2) and 12.54 (V_1T_3) whereas it was 12.53 (V_2T_1), 12.55 (V_2T_2) and 12.46 (V_2T_3) respectively for koozha bars. The highest reducing sugar content was observed for papaya blended koozha bar (12.55 per cent) and the lowest for papaya blended varikka bar (11.88 per cent).

The nutritional composition assessed in the fruit bars indicated a significant difference (CD 5.163) was observed with respect to β-carotene content. The highest β-carotene content was observed for mango blended koozha bar (328.72 μg) and the lowest for koozha control bar (165.80 μg). The β-carotene content of the fruit bars formulated from varikka variety were 184.20 (V_1T_1), 221.53 (V_1T_2) and 320.72 (V_1T_3) whereas it was 165.80 (V_2T_1), 201.53 (V_2T_2) and 328.72 (V_2T_3) respectively for koozha bars.

A significant difference (CD– 0.072) was observed with respect to vitamin C content of the fruit bars formulated jackfruit. The vitamin C content was found to be higher for varikka bars as compared to koozha bars. The highest vitamin C content was observed in papaya blended varikka bar (3.31 mg / 100 g) and the lowest for control koozha bar (2.70 mg/100 g). The vitamin C content of the varikka fruit bars was 3.10 (V_1T_1), 3.31 (V_1T_2) and 3.12 (V_1T_3) while that of koozha bars was 2.70 (V_2T_1), 2.85 for V_2T_2 and V_2T_3 respectively.

The polyphenolic content was more or less same for the bars formulated from the two varieties of jackfruit. However a significant difference (CD 0.441) was observed with respect to polyphenol content between the mango blended varikka and koozha bars (1.15). Difference was also observed between mango blended varikka bar and control (0.95) and papaya blended bar (0.70). Significant difference was also observed between mango blended bar and papaya blended koozha bar (0.55). The highest phenolic content was recorded in control varikka bar (29.67 g/100g) and lowest in mango blended koozha bar (27.57 g/100 g). The mean phenolic content for varikka bars was 29.67 (V_1T_1), 29.42 (V_1T_2) and 28.72 (V_1T_3) whereas 27.70 (V_2T_1), 28.12 (V_2T_2) and 27.57 (V_2T_3) for koozha bars.

The above results clearly indicate that the chemical attributes varied with the variety of jackfruit. The treatments applied also influenced the chemical constituents of the bars. A significant difference was observed with respect to all the chemical attributes between the various treatments tried out.

4.2.3.2 Organoleptic Features of the Fruit Bars Standardized from Jackfruit

The organoleptic features of the fruit bars standardized from jackfruit were assessed on a five point scale. Table 32 represents the various organoleptic attributes of the six blends of fruit bars standardized from jackfruit.

The appearance of the fruit bars was more or less same for the various blends tried out under the present investigation. The highest mean score for appearance was recorded for papaya blended koozha bar (4.26) whereas lowest was observed (4.01) for the control fruit bars of both the varieties. The mean appearance scores of varikka bars were 4.01 (V_1T_1), 4.10 (V_1T_2), 4.03 (V_1T_3) as against 4.01 (V_2T_1), 4.26 (V_2T_2) and 4.10 (V_2T_3) respectively in koozha bars.

Table 32 Organoleptic features of bars standardized from jackfruit

Organoleptic attributes	V_1T_1	V_1T_2	V_1T_3	V_2T_1	V_2T_2	V_2T_3	F	CD
Appearance	4.01	4.10	4.03	4.01	4.26	4.10	2.21	-
Colour	3.99	4.19	4.10	4.10	4.19	4.07	1.82	-
Flavour	3.84	3.70	4.04	3.86	3.67	3.94	0.75	-
Taste	3.80	3.67	4.06	3.70	3.63	4.00	0.17	-
Texture	3.86	3.96	3.63	3.79	3.96	3.59	0.31	-
Overall acceptability	4.17	3.91	4.37	3.92	3.89	4.09	3.99*	0.622

V_1T_1 – Varikka control bar, V_1T_2 – Papaya blended varikka bar, V_1T_3 – Mango blended varikka bar, V_2T_1 – Koozha control bar, V_2T_2 – Papaya blended Koozha bar, V_2T_3 – Mango blended Koozha bar.

The colour scores for the fruit bars ranged from 3.99 – 4.19 out of 5. Papaya blended fruit bars of both jackfruit varieties scored highest for colour (4.19) whereas lowest score was secured for control varikka bar (3.99). No significant difference was observed with respect to colour between the various blends tried out. The mean colour scores obtained for varikka bars were3.99 (V_1T_1), 4.19 (V_1T_2) and 4.10 (V_1T_3) as against 4.10 (V_2T_1), 4.19 (V_2T_2) and 4.07 (V_2T_3) for koozha bars.

As far as flavour of fruit bars is concerned highest flavour score was recorded in mango blended varikka bar (4.04) while lowest was in papaya blended koozha bar (3.67). However no significant difference was observed with respect to flavour between the treatments applied in the study. The mean flavour scores for varikka bars were 3.84 (V_1T_1), 3.70 (V_1T_2) and 4.04 (V_1T_3) as against 3.86 (V_2T_1), 3.67 (V_2T_2) and 3.94 (V_2T_3) for koozha bars.

The taste scores of fruit bars formulated in the present study ranged from 3.63 – 4.06. Mango blended varikka bar recorded highest score for taste (4.06) whereas papaya blended koozha bar recorded the lowest (3.63). However, no significant difference was observed with respect to taste between the various treatments tried out. The mean taste scores for bars formulated from varikka variety were 3.80 (V_1T_1), 3.67 (V_1T_2) and 4.06 (V_1T_3) whereas it was 3.70 (V_2T_1), 3.63 (V_2T_2) and 4.00 (V_2T_3) for koozha bars.

Significant difference was observed with respect to texture attribute between the various blends tried out. The highest score in texture was observed for papaya blended bars of both the varieties (3.96) whereas lowest scores was for mango blended koozha bars (3.59). The mean texture score of the various bars formulated from varikka variety were 3.86 (V_1T_1), 3.96 (V_1T_2) and 3.63 (V_1T_3) as against 3.79 (V_2T_1), 3.96 (V_2T_2) and 3.59 (V_2T_3) for koozha bars.

The overall acceptability scores of jackfruit bars ranged from 3.89–4.37. Mango blended varikka bar recorded highest (4.37) for overall acceptability scores whereas lowest score (3.89) was obtained for papaya blended koozha bar. A significant difference (0.62) was observed with respect to overall acceptability scores between the various treatments tried out. The mean overall acceptability scores for varikka fruit bars were 4.17 (V_1T_1), 3.91 (V_1T_2) and 4.37 (V_1T_3) as against 3.92 (V_2T_1), 3.89 (V_2T_2) and 4.09 (V_2T_3) for koozha bars.

Above findings confirm that sensory attributes of fruit bars formulated from two varieties of jackfruit do not vary much so also the treatment applied. None of the attributes *viz.*, appearance, colour, flavour, taste and texture varied significantly with respect to variety and treatment applied. However, a significant difference was observed with respect to overall acceptability between the treatments attempted.

4.2.3.3 Changes in the Chemical and Nutritional Characteristics of Fruit Bars with Storage

Fruit bars is a dried product popular in different parts of India. Stability of the original qualities of any product during storage is of paramount importance (Pathak, 1980). Hence the compositional changes in fruit bars under study were assessed for a period upto six months. The fruit bars standardized were stored in laminated pouched and monitored in a monthly interval. The results obtained are presented below.

Moisture

Table 33 represent the changes in the moisture content of bar and its interaction between variety, treatments and storage period.

Table 33 Changes in the moisture content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	9.86	9.64	9.85	9.47	9.93	9.75
P_1 (30 day)	11.03	9.79	10.00	10.83	10.40	10.41
P_2 (60 days)	11.23	10.21	10.22	11.27	10.68	10.72
P_3 (90 days)	11.46	10.34	10.35	11.45	10.90	10.90
P_4 (120 days)	11.57	10.47	10.40	11.62	11.03	11.02
P_5 (150 days)	11.71	10.66	10.52	11.80	11.23	11.18
P_6 (180 days)	12.09	10.87	10.60	12.17	11.67	11.48
Mean V/T	**11.28**	**10.28**	**10.28**	**11.23**	**10.84**	**10.78**
T_1	11.40	9.15				
T_2	11.67	10.79				
T_3	10.76	10.91				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 262.14** CD (V) = 0.123
$F_{2,84}$ T = 80.84** CD (T) = 0.155
$F_{6,84}$ P = 48.40** CD (P) = 0.234
$F_{6,84}$ VP = 4.77** CD (VP) = 0.323
$F_{12,84}$ TP = 5.34** CD (TP) = 0.401
$F_{2,84}$ VT = 128.45** CD (VT) = 0.213

*Significant at 5 per cent level, **Significant at 1 per cent level

A significant difference was observed in the moisture content of jackfruit bars of both the varieties during the storage period. The mean moisture content of jackfruit bars formulated from the varikka and koozha varieties was found to be 11.28 and 10.28 per cent respectively during storage of six months.

Moisture content of the jackfruit bars was found to vary significantly between the different blends formulated (CD 0.155). The moisture content was found to be highest in papaya blended jackfruit bar (11.23 per cent) followed by mango blended (10.84 per cent) and control jackfruit bars (10.28 per cent) of both varieties.

Significant difference was also observed with respect to moisture content in jackfruit bars along with storage of 180 days. As inferred from the CD value (0.234) moisture content was found to enhance with storage and changes were significant after 30 days of storage in the fruit bars. Though the increase did not affect the quality of the product. The increase in moisture content was accounted to be 17.74 per cent.

A significant interaction with respect to moisture was observed between variety and storage period. The percentage increase in moisture content of fruit bars was higher in varikka variety (9.8 per cent higher) as compared to koozha variety. As inferred from the CD (0.323) a significant increase in moisture content was observed in the varikka bars after a period of 30 days whereas for koozha bars the significant increase was observed after 60 days.

Significant interaction was also observed in moisture content with respect to variety and treatment. Moisture content of jackfruit bars formulated from varikka variety was 11.40 (V_1T_1), 11.67 (V_1T_2) and 10.76 (V_1T_3) respectively whereas in koozha fruit bars the moisture content was found to be 9.15 (V_2T_1), 10.79 (V_2T_2) and 10.91 (V_2T_3) respectively.

Significant interaction was also observed with respect to moisture content between treatments and storage period. As inferred from CD value (0.401) a significant increase in moisture content was observed for control jackfruit bar after 60 days of storage, whereas in papaya and mango blended jackfruit bars, significant increase in moisture content was observed after 30 days of storage.

Acidity

Table 34 represents the changes in the percentage acidity of fruit bar and its interaction between variety, treatments and storage period.

Table 34 Changes in the percentage acidity of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	0.51	0.55	0.37	0.46	0.76	0.53
P_1 (30 day)	0.56	0.58	0.41	0.50	0.81	0.57
P_2 (60 days)	0.61	0.61	0.45	0.53	0.85	0.61
P_3 (90 days)	0.66	0.68	0.52	0.59	0.91	0.67
P_4 (120 days)	0.73	0.74	0.56	0.65	0.99	0.73
P_5 (150 days)	0.86	0.90	0.63	0.72	1.30	0.88
P_6 (180 days)	1.12	1.14	0.71	0.83	1.85	1.13
Mean V/T	**0.72**	**0.74**	**0.52**	**0.61**	**1.07**	**0.73**
T_1	0.52	0.52				
T_2	0.56	0.66				
T_3	1.07	1.06				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 37.95** CD (V) = 0.011
$F_{2,84}$ T = 7049.12** CD (T) = 0.012
$F_{6,84}$ P = 1561.78** CD (P) = 0.012
$F_{6,84}$ VP = 2.08* CD (VP) = 0.002
$F_{12,84}$ TP = 299.13** CD (TP) = 0.034
$F_{2,84}$ VT = 73.04** CD (VT) = 0.013

*Significant at 5 per cent level, **Significant at 1 per cent level

A significant difference was observed in acidity of jackfruit bars of both the varieties. The mean acidity of the bars formulated from the two varieties of jackfruit was 0.72 per cent and 0.74 per cent respectively in varikka and koozha during storage.

Significant difference was observed in acidity between the various blended jackfruit bars formulated. Mango blended jackfruit bar recorded highest acidity (1.07 per cent) followed by papaya blended bar (0.61 per cent) and control jackfruit bar (0.52 per cent). As inferred from CD value (0.012) significant difference in acidity was observed between all the treatments.

Acidity of the jackfruit bars showed an increase with storage and it was recorded to be significant after 30 days of storage (CD 0.012). The acidity of the jackfruit bars formulated from both varieties increased from 0.53 per cent – 1.13 per cent over a period of 180 days.

Interaction was observed with respect to acidity between variety and storage period. Significant interaction was also observed between variety and treatment. Acidity of jackfruit bars formulated from varikka variety was 0.52 per cent (V_1T_1), 0.56 (V_1T_2) and 1.07 (V_1T_3) whereas in koozha fruit bars acidity was found to be 0.52 per cent in V_2T_1, 0.66 per cent in V_2T_2 and 1.06 per cent in V_2T_3.

Significant interaction was also observed between treatments and storage period with respect to acidity. As inferred from CDvalue (0.043) a significant increase in acidity was observed for all the three treatments after 30 days of storage.

pH

Table 35 represents the changes in the pH of jackfruit bar and its interaction between variety, treatment and storage period.

Table 35 Changes in the pH of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	5.69	4.97	5.25	5.31	5.42	5.33
P_1 (30 day)	5.27	4.82	5.02	5.04	5.07	5.04
P_2 (60 days)	4.71	4.63	4.67	4.58	4.76	4.67
P_3 (90 days)	4.29	4.59	4.39	4.39	4.54	4.44
P_4 (120 days)	4.19	4.53	4.29	4.33	4.46	4.36
P_5 (150 days)	3.99	4.48	4.17	4.20	4.34	4.24
P_6 (180 days)	3.87	4.46	4.11	4.13	4.24	4.16
Mean V/T	**4.57**	**4.64**	**4.56**	**4.57**	**4.69**	**4.60**
T_1	4.50	4.62				
T_2	4.57	4.57				
T_3	4.65	4.73				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 95.71** CD (V) = 0.012
$F_{2,84}$ T = 157.65** CD (T) = 0.023
$F_{6,84}$ P = 2377.62** CD (P) = 0.033
$F_{6,84}$ VP= 778.15** CD (VP) = 0.045
$F_{12,84}$ TP = 4.74** CD (TP) = 0.046
$F_{2,84}$ VT = 27.07** CD (VT) = 0.023

*Significant at 5 per cent level, **Significant at 1 per cent level

A significant difference was observed in the pH content of jackfruit bars of both the varieties with storage. The mean pH of jackfruit bars formulated from koozha variety depicted a higher pH (4.64) as compared to varikka variety (4.57) during the entire storage period.

pH was found to vary between the various blended fruit bars (CD0.023). The pH was found to be highest for mango blended bars (4.69) followed by papaya blended (4.57) and control jackfruit bars (4.56) of both varieties.

Storage period was also found to influence the pH of the jackfruit bars. The decrease in pH was from 5.33 to. 4.16 in fruit bars formulated under study with 180 days of storage. As inferred from the CDvalue (0.033) a significant decrease in pH was observed after 30 days of storage and the overall decrease in the pH was found to be 21.95 per cent.

Significant interaction in pH was observed between variety and storage period. The percentage decrease in pH was higher for varikka variety 31.98 per cent as compared to koozha variety (10.26 per cent decrease).

The pH of fruit bars formulated from varikka variety was 4.50 (T_1), 4.57 (T_2) and 4.65 (T_3) respectively whereas it was 4.62 (T_1), 4.57 (T_2) and 4.73 (T_3) respectively in koozha variety.

Significant interaction was also observed between variety and treatment with respect to pH. In case of varikka bars, the pH was found to increase when blended with papaya or mango while in case of koozha blending with papaya reduced the pH. In both the varieties maximum pH was observed when blended with mango.

Significant interaction was also observed in pH between treatments and storage period. As inferred from C D value (0.046) decrease in pH was significant for all the three treatments after 30 days of storage.

Total soluble solid

Table 36 represents the changes in the TSS content (°Brix) of bar and its interaction between variety, treatments and storage period.

Table 36 Changes in the TSS content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	69.47	69.39	65.55	71.58	71.15	69.43
P_1 (30 day)	69.53	69.51	65.63	71.68	71.25	69.52
P_2 (60 days)	69.59	69.60	65.75	71.73	71.30	69.59
P_3 (90 days)	69.66	69.68	65.80	71.75	71.45	69.67
P_4 (120 days)	69.72	69.77	65.88	71.78	71.57	69.74
P_5 (150 days)	69.78	69.90	65.90	71.93	71.68	69.84
P_6 (180 days)	69.93	70.00	65.95	72.05	71.90	69.97
Mean V/T	**69.67**	**69.69**	**65.78**	**71.79**	**71.47**	**69.68**
T_1	65.28	66.29				
T_2	72.30	71.28				
T_3	71.43	71.51				

T_1 = Control jackfruit bar $F_{1,84}$ V = 0.59
T_2 = Papaya blended jackfruit bar $F_{2,84}$ T = 322539.00** CD (T) = 0.021
T_3 = Mango blended jackfruit bar $F_{6,84}$ P = 413.00** CD (P) = 0.032
$F_{6,84}$ VP = 14.00** CD (VP) = 0.043
$F_{12,84}$ TP = 24.50** CD (TP) = 0.043
$F_{2,84}$ VT = 7224.00** CD (VT) = 0.021
*Significant at 5 per cent level, **Significant at 1 per cent level

No difference was observed in the TSS content of bars of both the varieties. The mean TSS content of the jackfruit bars formulated from varikka variety was 69.67 °Brix as against 69.69 °Brix in koozha bars.

However significant difference was observed in the TSS content between the various blended fruit bars. The TSS content was found to be highest in papaya blended bar (71.79° Brix) followed by mango blended bar (71.47 °Brix) and control jackfruit bars (65.78 °Brix) of both varieties. As inferred from CDvalue (0.021) significant difference in the TSS content was observed between all the treatments.

TSS content of jackfruit bars standardized in the study was found to increase significantly with storage of 180 days and the significant increase in TSS content was observed after 30 days of storage (CD 0.032).

Significant interaction with respect to TSS content was observed between variety and storage period. The percentage increase in TSS content of fruit bars was 0.87 per cent in koozha bars as compared to 0.66 per cent in varikka bars.

Significant interaction was also observed with respect to TSS content between variety and treatment. The TSS content of fruit bars formulated from varikka variety was 65.28 (V_1T_1), 72.30 (V_1T_2) and 71.43 (V_1T_3) while it was 66.29 (V_2T_1), 71.28 (V_2T_2) and 71.51 (V_2T_3) in koozha variety.

Significant interaction was also recorded with respect to TSS content between treatments and storage period. As inferred from CDvalue (0.043) a significant increase in TSS content was observed for all the three treatments after 30 days of storage.

Total sugars

Table 37 represents the changes in the total sugar content of bar and its interaction between variety, treatments and storage period.

Table 37 Changes in the total sugar content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	61.29	61.03	59.43	56.90	67.15	61.16
P_1 (30 day)	61.47	61.24	59.78	57.00	67.28	61.36
P_2 (60 days)	61.90	62.24	60.25	57.90	68.07	62.07
P_3 (90 days)	61.99	62.42	60.33	58.08	68.20	62.21
P_4 (120 days)	62.33	63.63	61.45	58.92	68.58	62.98
P_5 (150 days)	62.56	63.90	61.65	59.22	68.82	63.23
P_6 (180 days)	62.87	64.06	61.77	59.68	68.93	63.46
Mean V/T	**62.06**	**62.65**	**60.67**	**58.24**	**68.15**	**62.35**
T_1	59.63	61.70				
T_2	56.76	59.73				
T_3	69.78	66.51				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 371.70** CD (V) = 0.062
$F_{2,84}$ T = 37620.45** CD (T) = 0.073
$F_{6,84}$ P = 494.90** CD (P) = 0.112
$F_{6,84}$ VP = 72.45** CD (VP) = 0.163
$F_{12,84}$ TP = 10.33** CD (TP) = 0.207
$F_{2,84}$ VT = 4007.33** CD (VT) = 0.112

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the total sugar content of bars of the two varieties of jackfruit. The mean value for total sugar content of the fruit bars formulated from varikka and koozha varieties over a period of 180 days was found to be 62.06 and 62.65 per cent respectively.

Among the different blends formulated total sugar content vary significantly CD value (0.073). The highest total sugar content was observed in mango blended bar (68.15 per cent) followed by control jackfruit bar (60.67 per cent) and lastly papaya blended bar (58.24 per cent).

Storage period also influenced the total sugar content of fruit bars. A significant increase in total sugar content was observed after 30 days of storage (CDvalue 0.112). Total sugar content enhanced from 61.16 to 63.46 °Brix with 180 days of storage.

A significant interaction with respect to total sugar was observed between variety and storage period. The percentage increase in total sugar content of fruit bars with storage was 4.96 per cent higher for koozha bars whereas it was 2.57 per cent for varikka bars.

Significant interaction was also observed with respect to total sugar content between variety and treatments. The total sugar content of bars formulated from varikka variety were 59.63 (T_1), 56.76 (T_2) and 69.78 (T_3) whereas for koozha bars the total sugar content was found to be 61.70 in T_1, 59.73 in T_2 and 66.51 in T_3.

Interaction was also observed with respect to total sugar content between treatment and storage period. As inferred from CDvalue (0.207) a significant increase in total sugar content was observed for control jackfruit bars after a storage of 30 days whereas in the case of papaya and mango blended bars, significant increase in total sugar content was observed after 60 days of storage.

Reducing sugar

Table 38. represents the changes in the reducing sugar content of jackfruit bars and its interaction between variety, treatments and storage period.

Table 38 Changes in the reducing sugar content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	10.93	11.67	11.15	11.28	11.47	11.30
P_1 (30 day)	11.00	11.91	11.82	11.73	12.02	11.86
P_2 (60 days)	12.06	12.13	12.10	11.93	12.25	12.09
P_3 (90 days)	12.29	12.32	12.35	12.13	12.43	12.31
P_4 (120 days)	12.53	12.58	12.63	12.35	12.68	12.56
P_5 (150 days)	12.88	13.28	13.28	12.83	13.12	13.08
P_6 (180 days)	13.20	13.71	13.58	13.25	13.53	13.46
Mean V/T	**12.24**	**12.51**	**12.42**	**12.22**	**12.50**	**12.38**
T_1	12.30	12.53				
T_2	11.88	12.55				
T_3	12.54	12.46				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 49.74** CD (V) = 0.087
$F_{2,84}$ T = 18.17** CD (T) = 0.102
$F_{6,84}$ P = 196.05** CD (P) = 0.151
$F_{6,84}$ VP = 7.02** CD (VP) = 0.213
$F_{12,84}$ TP = 1.30 CD (VT) = 0.142
$F_{2,84}$ VT = 30.32**

*Significant at 5 per cent level, **Significant at 1 per cent level

Reducing sugar content of fruit bars vary significantly between the two varieties of jackfruit. The mean value of reducing sugar content of fruit bars formulated from varikka was 12.24 as against 12.51 per cent in bars of koozha variety.

Significant variation was observed in the reducing sugar content between the various blended fruit bars formulated. The reducing sugar content was found to be highest for control jackfruit bar (12.42 per cent) followed by mango blended bar (12.50 per cent) and papaya blended bar (12.22 per cent). As inferred from CD (0.102) significant difference was observed in the reducing sugar content of fruit bars in all the treatments attempted.

Difference was also observed with respect to reducing sugar content in the bars along with storage period of 180 days. As inferred from CDvalue (0.151) significant increase in reducing sugar content was witnessed after a storage of 30 days for the two varieties. However in case of koozha bars significant reduction in reducing sugar content was no observed between 60-90 days. The overall increase in reducing sugar content of fruit bars was accounted to be 19.11 per cent.

Significant interaction with respect to reducing sugar content was observed between variety and storage period. The per cent increase in the reducing sugar was found to be higher for varikka bars (20.76 per cent) as compared to koozha bars (17.48 per cent).

Interaction was also observed with respect to reducing sugar content between variety and treatments. The reducing sugar content of bars formulated from varikka variety were 12.30, 11.88 and 12.54 respectively in T_1. T_2 and T_3 while it was 12.53 per cent in T_1, 12.55 in T_2 and 12.46 in T_3 of koozha bars.

β-carotene

Table 39 represents the changes in the β-carotene content of bar and its interaction between variety treatments and storage condition.

Table 39 Changes in the β-carotene content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	206.53	166.74	147.90	248.40	347.58	186.64
P_1 (Final)	145.50	108.34	46.80	64.43	85.57	126.92
Mean V/T	**176.02**	**137.54**	97.35	**156.41**	**216.57**	**156.78**
T_1	184.20	165.80				
T_2	221.53	201.53				
T_3	320.72	328.72				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,24}$ V = 709.47** CD (V) = 2.982
$F_{2,24}$ T = 3205.96** CD (T) = 3.653
$F_{1,24}$ P = 1709.34** CD (P) = 2.987
$F_{1,24}$ VP = 0.83 CD (TP) = 5.162
$F_{2,24}$ TP = 7215.52** CD (VT) = 5.163
$F_{2,24}$ VT = 34.62**

*Significant at 5 per cent level, **Significant at 1 per cent level

β-carotene content present in jackfruit bars was analysed. A significant difference was observed in the β-carotene content of fruit bars of both the varieties. The mean value for β-carotene content of the bars formulated from the two varieties was found to be 176.02 and 137.54 μg respectively in varikka and koozha.

The β-carotene content of fruit bars was found to vary significantly between the various blends formulated. The β-carotene content was found to be highest for mango blended bar (216.57 μg) followed by papaya blended bar (156.41 μg) and control jackfruit bar (97.35 μg).

With storage β-carotene content decreased and the decrease was significant. As inferred from CDvalue (2.987) the overall decrease in β-carotene content was accounted to be 32.00 per cent over a storage period of 180 days.

No interaction was observed with respect to β-carotene content between variety and storage period. However significant interaction was observed with respect to β-carotene between variety and treatment. The β-carotene content of fruit bars formulated from varikka variety was 184.20, 221.53 and 320.72 in V_1T_1, V_1T_2 and V_1T_3 respectively, whereas it was 165.80, 201.53 and 328.72 respectively in V_2T_1, V_2T_2 and V_2T_3 of koozha variety.

Significant interaction was also observed with respect to β-carotene content between treatments and storage period.

Vitamin C

Table 40 represents the changes in the vitamin C content of fruit bars and its interaction between variety, treatments and storage period.

Table 40 Changes in the vitamin C content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	7.64	6.90	6.92	7.58	7.32	7.27
P_1 (30 day)	6.04	5.80	5.72	6.02	6.03	5.92
P_2 (60 days)	4.86	4.07	4.40	4.52	4.47	4.46
P_3 (90 days)	2.70	2.11	2.47	2.57	2.18	2.41
P_4 (120 days)	0.99	0.72	0.80	0.88	0.88	0.86
P_5 (150 days)	0.00	0.00	0.00	0.00	0.00	0.00
P_6 (180 days)	0.00	0.00	0.00	0.00	0.00	0.00
Mean V/T	**3.18**	**2.80**	**2.90**	**3.08**	**2.98**	**2.98**
T_1	3.10	2.70				
T_2	3.31	2.85				
T_3	3.12	2.85				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,84}$ V = 367.41** CD (V) = 0.042
$F_{2,84}$ T = 28.40** CD (T) = 0.053
$F_{6,84}$ P = 12825.67** CD (P) = 0.072
$F_{6,84}$ VP = 41.01** CD (VP) = 0.103
$F_{12,84}$ TP = 10.89** CD (TP) = 0.132
$F_{2,84}$ VT = 7.81** CD (VT) = 0.072

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference in the vitamin C content was observed in the jackfruit bars of both the varieties. The mean vitamin C content of the fruit bars formulated from varikka and koozha variety was found to be 3.18 and 2.80 mg/100 g respectively.

Vitamin C content of the jackfruit bars formulated also showed significant difference between the various blends attempted in the study. The vitamin C content was found to be highest for papaya blended fruit bar (3.08 mg/100 g) closely followed by mango blended bar (2.98 mg/100 g) and control jackfruit bar (2.90).

With storage vitamin C content of formulated jackfruit bars decreased significantly (CD 0.07). The decrease was significant after 30 days of storage and it was practically nil at the end of the storage period.

Analysing the interaction effect it was found that vitamin C content was affected between variety and storage period. The percentage decrease in vitamin C content was higher for koozha bars (89 per cent) as compared to varikka bars (87 per cent).

Significant interaction was also observed between variety and treatment. The vitamin C content for fruit bars formulated from varikka variety was 3.10 in T_1, 3.31 in T_2 and 3.12 in T_3 against 2.70 in T_1, 2.85 in T_2 and 2.85 in T_3 of koozha variety.

Treatments and storage period also influenced vitamin C content. As inferred from CD value (0.132) a significant decrease in vitamin C content was observed for all the three types of fruit bars after a storage period of 30 days.

Polyphenols

Table 41 represents the changes in the polyphenol content of bar and its interaction between variety, treatments and storage period.

Table 41 Changes in the polyphenol content of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	30.07	28.14	28.25	29.12	30.98	29.11
P_1 (Final)	28.47	27.44	26.55	28.08	28.20	27.96
Mean V/T	**29.27**	**27.79**	**27.48**	**28.77**	**29.59**	**28.53**
T_1	29.67	27.70				
T_2	29.42	28.12				
T_3	28.72	27.57				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,24}$ V = 142.69** CD (V) = 0.252
$F_{2,24}$ T = 10.12** CD (T) = 0.313
$F_{1,24}$ P = 87.04** CD (P) = 0.252
$F_{1,24}$ VP = 13.31** CD (VP) = 0.361
$F_{2,24}$ TP = 180.51** CD (TP) = 0.443
$F_{2,24}$ VT = 4.14* CD (VT) = 0.441

*Significant at 5 per cent level, **Significant at 1 per cent level

Significant difference was observed in the polyphenolic content of fruit bars of both the varieties. The mean value for polyphenolic content of the fruit bars formulated from the two varieties (Varikka and koozha) over a period of 180 days was found to be 29.27 and 27.79 g/100 g respectively.

The polyphenolic content of fruit bars varied significantly between the various blends formulated. Mango blended fruit bars recorded highest value (29.59) while control fruit bar showed lowest polyphenolic content (27.48). Polyphenolic content decreased significantly with a storage period of 180 days. The overall decrease in polyphenolic content was 3.95 per cent.

Significant interaction was observed with respect to polyphenols between variety and storage period.

Interaction was also observed with respect to polyphenols between variety and treatment. The polyphenolic content for bars formulated from varikka variety were 29.67 (V_1T_1), 29.42 (V_1T_2) and 28.72 (V_1T_3) g/100 g) compared to 27.70 in V_2T_1, T28.12 in V_2T_2 and 27.57 in V_2T_3 in koozha variety.

Significant interaction was observed with respect to polyphenols between treatments and storage period.

As inferred from the above results, most of the chemical constituents analysed with the fruit bars depicted difference with respect to variety of jackfruit. However, TSS was not found to be influenced by the variety. All the chemical constituents exhibited changes with storage of six months, however the changes do not seem to intervene the quality of the fruit bars standardized. All the fruit bars formulated remained intact upto two months thereafter minor alterations were observed. These changes were apparent only towards the end of the storage period of six months. The per cent moisture, per cent acidity, TSS, total sugar and reducing sugar were found to increase significantly with storage whereas pH, β-carotene, vitamin C and polyphenols decreased significantly with storage period.

4.2.3.4 Changes in the Organoleptic Features of Fruit Bars with Storage

The fruit bars formulated from jackfruit individually and by blending with other fruit pulps were subjected to organoleptic evaluation by a panel of judges periodically once in a month in terms of appearance, colour, flavour, taste, texture and overall acceptability on a five point scale.

The results obtained are presented below.

Appearance

Table 42 represents the changes in the appearance of fruit bar and its interaction between variety, treatments and storage periods.

Table 42 Changes in the appearance of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	4.13	4.20	4.10	4.25	4.15	4.17
P_1 (30 day)	4.13	4.20	4.10	4.25	4.15	4.17
P_2 (60 days)	4.10	4.17	4.00	4.25	4.15	4.13
P_3 (90 days)	4.03	4.13	4.00	4.20	4.05	4.08
P_4 (120 days)	4.03	4.13	4.00	4.20	4.05	4.08
P_5 (150 days)	4.00	4.07	4.00	4.10	4.00	4.03
P_6 (180 days)	3.90	3.97	3.90	4.00	3.90	3.93
Mean V/T	**4.05**	**4.12**	**4.01**	**4.18**	**4.06**	**4.08**
T_1	4.01	4.01				
T_2	4.10	4.26				
T_3	4.03	4.10				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 6.23*
$F_{6,378}$ P = 4.22**
$F_{2,378}$ T = 10.14**
$F_{6,378}$ VP = 0.04
$F_{12,378}$ TP = 0.21
$F_{2,378}$ VT = 2.21

CD (V) = 0.062
CD (P) = 0.113
CD (T) = 0.075

*Significant at 5 per cent level, **Significant at 1 per cent level

The mean appearance score of the fruit bars formulated from the two varieties of jack fruit over a period of 180 days of storage was found to be 4.05 and 4.12 respectively in varikka and koozha varieties. Significant difference was observed in the appearance attribute of fruit bars between the varieties. In appearance attribute, koozha fruit bars were found to be superior to varikka fruit bars and their blends through the entire storage period.

Among the various blended fruit bars tried out, papaya blended bar scored highest for appearance (4.18) followed by mango blended (4.06) and control jackfruit bars (4.01) of both varieties. As inferred from CD(0.075) significant difference was observed in appearance attribute between the mango blended and papaya blended fruit bars formulated from the two varieties.

Significant decrease in the appearance score was observed over a storage period of 180 days in the formulated fruit bars. As indicated by CD value (0.113) significant decrease in appearance score of bars was observed only after a period of 120 days of storage. However, the overall decrease in the appearance score over a period of 180 days was only 5.75 per cent.

Colour

Table 43 represents the changes in the colour of fruit bars and its interaction between variety, treatments and storage periods.

The mean colour score of the bars formulated from the two varieties of jackfruit over a period of 180 days of storage was found to be 4.09 and 4.12 respectively in varikka and koozha varieties. No varietal difference was shown in the fruit bars formulated.

Table 43 Changes in the colour of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	4.17	4.23	4.10	4.30	4.20	4.20
P_1 (30 day)	4.17	4.23	4.10	4.30	4.20	4.20
P_2 (60 days)	4.13	4.13	4.10	4.20	4.10	4.13
P_3 (90 days)	4.10	4.13	4.05	4.20	4.10	4.12
P_4 (120 days)	4.10	4.13	4.05	4.20	4.10	4.12
P_5 (150 days)	4.03	4.03	4.00	4.10	4.00	4.03
P_6 (180 days)	3.93	3.93	3.90	4.00	3.90	3.93
Mean V/T	**4.09**	**4.12**	**4.04**	**4.19**	**4.09**	**4.10**
T_1	3.99	4.10				
T_2	4.19	4.19				
T_3	4.10	4.07				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 0.78
$F_{6,378}$ P = 4.88** CD (P) = 0.122
$F_{2,378}$ T = 6.84** CD (T) = 0.081
$F_{6,378}$ VP = 0.12
$F_{12,378}$ TP = 0.12
$F_{2,378}$ VT = 1.82

*Significant at 5 per cent level, **Significant at 1 per cent level

Among the various blended fruit bars tried out papaya blended bars scored highest for colour (4.19) followed by mango blended (4.09) and control jackfruit bar (4.04) of two varieties. Significant difference was observed in colour attribute between mango blended and papaya blended fruit bars (CD 0.081).

Colour scores were observed to be affected with storage. As indicated by CD value (0.122) a significant decrease in colour scores of fruit bars was observed after a period of 150 days. The overall decrease in colour score of a period of 180 days accounted to be only 6.4 per cent.

Flavour

Flavour is a perceived attribute that results from our integrated response to complex mixtures of stimuli on several senses including smell, taste, sight, touch etc. Flavour is commonly defined as being the sensation arising from the integration or interplay of signals produced as a consequence of sensing smell, taste and irritating stimuli from a food or a beverage (Shankaracharaya, 2002).

Table 44 represents the changes in the flavour of fruit bar and its interaction between variety, treatments and storage period.

The mean flavour score of the fruit bars formulated from the two varieties of jackfruit over a period of 180 days of storage was found to be 3.86 and 3.82 respectively in varikka and koozha varieties. Variety of the jackfruit seemed to be less affected with regard to flavour profile of fruit bars with storage.

Table 44 Changes in the flavour of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	4.07	4.07	4.00	3.95	4.25	4.07
P_1 (30 day)	3.97	3.97	3.90	3.85	4.15	3.97
P_2 (60 days)	3.90	3.83	3.85	3.70	4.05	3.87
P_3 (90 days)	3.80	3.77	3.80	3.60	3.95	3.78
P_4 (120 days)	3.80	3.77	3.80	3.60	3.95	3.78
P_5 (150 days)	3.80	3.73	3.77	3.60	3.85	3.77
P_6 (180 days)	3.70	3.63	3.75	3.50	3.75	3.67
Mean V/T	**3.86**	**3.82**	**3.83**	**3.69**	**3.99**	**3.84**
T_1	3.84	3.86				
T_2	3.70	3.67				
T_3	4.04	3.94				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 0.98
$F_{6,378}$ P = 7.09**
$F_{2,378}$ T = 21.33**
$F_{6,378}$ VP = 0.09
$F_{12,378}$ TP = 0.44
$F_{2,378}$ VT = 0.75

CD (P) = 0.142
CD (T) = 0.098

*Significant at 5 per cent level, **Significant at 1 per cent level

Among the various blended fruit bars tried out, mango blended bar scored highest for flavour (3.99) followed by control jackfruit bar (3.83) and papaya blended bar (3.69) of both varieties. As inferred from CD value (0.098) significant difference was observed in the flavour attribute between the three treatments attempted in the study.

Significant decrease in the flavour scores was observed over a storage period of 180 days. As indicated by CD value (0.142) a significant decrease in flavour score was witnessed after a period of 60 days of storage in all the fruit bars and the decrease in flavour score was found to be 9.82 per cent.

Taste

Table 45 represents the changes in the taste of fruit bars and its interaction between variety, treatments and storage period.

Table 45 Changes in the taste of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	4.10	4.07	4.00	3.90	4.35	4.08
P_1 (30 day)	4.00	3.97	3.90	3.80	4.25	3.98
P_2 (60 days)	3.90	3.83	3.85	3.65	4.10	3.87
P_3 (90 days)	3.80	3.77	3.75	3.60	4.00	3.78
P_4 (120 days)	3.73	3.70	3.65	3.60	3.90	3.72
P_5 (150 days)	3.73	3.60	3.60	3.55	3.85	3.67
P_6 (180 days)	3.63	3.50	3.50	3.45	3.75	3.57
Mean V/T	**3.84**	**3.78**	**3.75**	**3.65**	**4.03**	**3.81**
T_1	3.80	3.70				
T_2	3.67	3.63				
T_3	4.06	4.00				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 2.56
$F_{6,378}$ P = 10.83** CD (P) = 0.152
$F_{2,378}$ T = 29.60** CD (T) = 0.101
$F_{6,378}$ VT = 0.18
$F_{12,378}$ TP = 0.21
$F_{2,378}$ VT = 0.17

*Significant at 5 per cent level, **Significant at 1 per cent level

The mean taste score of the fruit bars formulated from the two varieties of jackfruit over a period of 180 days of storage was found to be 3.84 and 3.78 respectively in varikka and koozha varieties. No significant difference in the taste scores was observed between the two varieties of jackfruit with storage though the varikka fruit bars scored high compared to koozha bars.

Among the various blended bars tried out, mango blended bar scored highest for taste (4.03) followed by control bar (3.75) and papaya blended bar (3.65) of two varieties of jackfruit. As inferred from CD value (0.101) significant difference in taste parameter was observed between the blended fruit bars tried in the study.

Taste scores decreased significantly over a period of 180 days in the fruit bars standardized. As indicated by CD value (0.152) decrease in taste score was witnessed after a period of 60 days of storage though the decrease in taste score over a period of 180 days was accounted to be only 12.5 per cent.

Texture

Table 46 represents the changes in the texture of fruit bars and its interaction between variety, treatments and storage period.

Table 46 Changes in the texture of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	3.90	3.87	3.85	4.00	3.80	3.88
P_1 (30 day)	3.90	3.87	3.85	4.00	3.80	3.88
P_2 (60 days)	3.87	3.80	3.85	4.00	3.65	3.83
P_3 (90 days)	3.83	3.77	3.85	4.00	3.55	3.80
P_4 (120 days)	3.83	3.77	3.85	4.00	3.55	3.80
P_5 (150 days)	3.73	3.73	3.80	3.90	3.50	3.73
P_6 (180 days)	3.63	3.63	3.70	3.80	3.40	3.63
Mean V/T	**3.81**	**3.78**	**3.82**	**3.96**	**3.61**	**3.79**
T_1	3.86	3.79				
T_2	3.96	3.96				
T_3	3.63	3.59				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 1.04
$F_{6,378}$ P = 3.21**
$F_{2,378}$ T = 29.75**
$F_{6,378}$ VP = 0.09
$F_{12,378}$ TP = 0.60
$F_{2,378}$ VT = 0.31

CD (P) = 0.142
CD (T) = 0.097

*Significant at 5 per cent level, **Significant at 1 per cent level

The mean texture score of the fruit bars formulated from the two varieties of jackfruit over a period of 180 days of storage was found to be 3.81 and 3.78 respectively in varikka and koozha varieties. Varietal difference was not reflected in the texture of quality of fruit bars formulated from two varieties of jackfruit in the present study.

Significant difference was observed with respect to texture of fruit bars formulated, when other fruit pulps were blended. Among the various blended bars tried out papaya blended fruit bars exhibited superior textural qualities (3.96) followed by control jackfruit bars (3.82) and mango blended bars (3.61) of both varieties.

Texture scores of the fruit bars decreased significantly with storage period of 180 days. However as inferred from CD value (0.142) significant decrease in textural score was witnessed only after a period of 150 days of storage. The overall decrease in texture score for a period of 180 days was 6.44 per cent.

Overall acceptability

Table 47 represents the changes in the overall acceptability of fruit bars and its interaction between variety, treatment and storage period.

Table 47 Changes in the overall acceptability of jackfruit bar and its interaction between variety, treatments and storage period

Storage period (P) days	Variety (V)		Treatments (T)			Storage period (P)
	V_1 (Varikka)	V_2 (Koozha)	T_1	T_2	T_3	Days (Mean)
P_0 (Initial)	4.22	4.21	4.12	3.97	4.34	4.14
P_1 (30 day)	4.19	4.14	4.10	3.95	4.33	4.13
P_2 (60 days)	4.12	4.10	4.07	3.93	4.31	4.10
P_3 (90 days)	4.08	4.07	4.03	3.89	4.26	4.06
P_4 (120 days)	4.04	4.02	4.01	3.87	4.24	4.04
P_5 (150 days)	3.98	3.96	4.00	3.86	4.23	4.03
P_6 (180 days)	3.96	3.94	3.98	3.84	4.21	4.01
Mean V/T	**4.15**	**4.00**	**4.04**	**3.90**	**4.27**	**4.07**
T_1	4.17	3.92				
T_2	3.91	3.89				
T_3	4.37	4.17				

T_1 = Control jackfruit bar
T_2 = Papaya blended jackfruit bar
T_3 = Mango blended jackfruit bar

$F_{1,378}$ V = 18.46**
$F_{6,378}$ P = 35.69**
$F_{2,378}$ T = 1.14
$F_{6,378}$ VP = 0.02
$F_{12,378}$ TP = 0.62
$F_{2,378}$ VT = 3.99*

CD (V) = 0.363
CD (P) = 0.032
CD (VT) = 0.012

*Significant at 5 per cent level, **Significant at 1 per cent level

The mean overall acceptability scores of the fruit bars formulated from the two varieties of jackfruit over a period of 180 days was found to be 4.15 and 4.00 respectively in varikka and koozha varieties. Significant difference was observed in the overall acceptability scores of fruit bars between the two varieties of jackfruit.

Among the various blended fruit bars tried out. highest acceptability was found for mango blended bar (4.27) followed by control jackfruit bars of two varieties (4.04). Papaya blended bars of two varieties scored 3.90 for overall acceptability. However difference was not observed in overall acceptability between all the treatments attempted.

Overall acceptability of fruit bars formulated under present investigation was not found to be affected with storage of six months. A slight decrease in overall acceptability score was noticed with storage (3.23 per cent) in the fruit bars.

Significant interaction was observed in fruit bars between variety and treatment. The mean overall acceptability score for varikka fruit bars was found to be 4.17 in V_1T_1, 3.91 in V_1T_2 and 4.37 in V_1T_3 respectively as against 3.92 in V_2T_1, 3.89 in V_2T_2 and 4.17 in V_2T_3 respectively in koozha bars.

Based on the results obtained it can be concluded that appearance attribute of the product and overall performance were influenced by the variety of jackfruit. The other sensory attributes *viz.*, colour, flavour, taste, texture remained unaffected by the variety of jackfruit.

The above finding support the fact that both varieties of jackfruit could be utilized for product development. Blending papaya pulp rendered in better appearance, colour and textural qualities to the fruit bars. While blending with mango pulp resulted better flavour, taste and overall performance to the product. It is worth mentioning that fruit bars without blending stood next to blended products and all the fruit bars with both varieties were acceptable to the fruit bars with both varieties were acceptable to the judges with overall acceptability score of 82.00 per cent. With storage, scores for all the attributes declined gradually, but still the products were acceptable and relished by the judges and a period of five could be suggested as the shelf life of the fruit bars.

From the above results it can be concluded that appearance and overall acceptability of the bars was influenced by the variety of jackfruit, whereas the other attributes *viz*., colour, flavour, taste and texture of bars remained unaffected by variety of jackfruit. It was also concluded that among the various treatments applied, appearance and colour attribute was preferred for papaya bar, whereas taste and flavour was preferred for mango blended and control fruit bars. The storage period influenced all the attributes of the bars. The mean scores of all the attributes including the overall acceptability declined with storage over a period of 60 days.

4.3 STANDARDIZATION OF PRODUCTS FROM SEED FLOUR

4.3.1 Standardization of Health Drinks from Jackfruit Seed

Jackfruit seeds left after the utilization of bulbs are considered as a source of nutrients, and as pointed out by Kumar *et al*. (1988) jackfruit seeds are a rich source of proteins (6.75 per cent), carbohydrates (28.01 per cent) and energy (146.00 KCal/100 g). In the present investigation seeds were put to effective utilization by converting them to flour and incorporating flour in formulating nutrient rich health mixes.

In the present study two types of health drink mixes were formulated *viz*., malted health drink mix and spiced health drink mix. Makhal *et al*. (2003) remarked that health foods/formulated foods serve as an important vehicle to meet the nutritional requirements of normal individuals and of those who need special diets.

The malted health drink mix was prepared by incorporating malted wheat. Malting improves the overall flavour and reduces the viscosity of the food substances. The spiced health drink mix was formulated by adding variety of spices so as to introduce a different taste and flavour to the base mix. Plate 4 depicts the two types of health drink mixes standardized from jackfruit seed along with ingredients used.

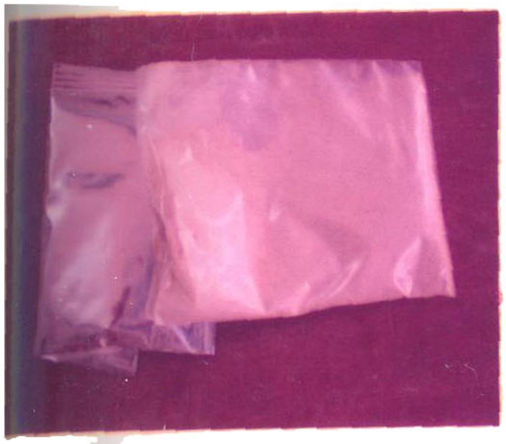
4.3.1.1 Chemical Characteristics of Health Drink Mixes

Table 48 explains the chemical characteristics of health drink mixes formulated from jack seed flour. The moisture content of the two health drink mixes standardized in the present investigation was found to be significantly different (CD 0.061) from each other. The moisture content of the malted health drink mix was 4.25 per cent whereas that of spiced health drink mix was 6.21 per cent. The acidity of the health drink mixes was 0.74 per cent and 0.81 respectively with significantly higher level in spiced health drink mix. A higher pH was observed for spiced health drink mix (7.16) when compared to malted health drink mix (6.33).

Table 48 Chemical characteristics of health drink mixes

Chemical characters	Malted health drink mix	Spiced health drink mix	F value	CD value
Moisture (per cent)	4.25	6.21	116.47**	0.061
Acidity (per cent)	0.74	0.81	1153.41**	0.004
pH	6.33	7.16	79464.00**	0.006
TSS (°Brix)	40.92	46.14	341665.40**	0.018
Total sugar (per cent)	32.44	35.57	122518.70**	0.018
Reducing sugar (per cent)	9.09	10.74	232824.00**	0.006
Pectin (g / 100 g)	26.34	29.10	159.26**	0.447
Starch (per cent)	7.55	9.67	9255.58**	0.044
Acid value (per cent)	0.01	0.141	3842.84**	0.004
Peroxide value (meq)	0.016	0.089	1650.36**	0.003
Polyphenols (g/100 g)	5.57	7.23	32924.24**	0.018

*Significant at 5 per cent level, **Significant at 1 per cent level



Malted health drink mix

Ingredients used for formulating malted health drink mix

Spiced health drink mix

Ingredients used for formulating spiced health drink mix

Plate 4. Health drink mixes standardised from jackfruit seed flour

In order to impart sweetness glucose was added to the health drink mixes while standardizing. TSS of the mixes analysed indicated that malted drink mix depicted a significantly higher TSS (40.92 °Brix) than the spiced drink mix (46.14 °Brix).

Total sugar and reducing sugar content was found to be 32.44 per cent and 9.09 per cent in malted health drink mix as against 35.57 per cent and 10.74 per cent in spiced health drink mix formulated from jackfruit seed flour. Both the constituents *viz.*, total sugar and reducing sugar were significantly different in the two products (CD value 0.018 and 0.006).

Starch content of the health mixes contribute thickness to the drink when mixed with hot milk or water. Starch content of the mixes were found to be 7.55 per cent and 9.64 per cent respectively in malted and spiced drink mixes.

Since the jackfruit seeds contains pectin and polyphenols, both the constituents were analysed in the health mixes developed. The results indicated that malted health drink mix contain 26.34 per cent pectin and 5.57 g/100 g polyphenols whereas spiced drink mix contain 29.10 per cent pectin and 7.23 g/100 g polyphenols.

The acid value and peroxide value give and indication of the keeping quality of the products. The acid value and peroxide value was found to be 0.01 per cent and 0.016 meq for malted drink mix as against 0.141 per cent and 0.089 meq in the spiced health drink mix formulated in the present investigation from jackfruit seed flour.

Nutritional characteristics of health drink mixes formulated from jackfruit seed flour

Table 49 represents the nutritional features of the health drink mixes formulated. Among the nutritional characteristics assessed in the health drink mixes energy content of malted health drink mix was found to be 318.00 KCal as against in spiced health drink mix 314 KCal.

Table 49 Nutritional characteristics of health drink mixes

Nutritional characteristics	Malted health drink mix	Spiced health drink mix	t value
Energy (KCal)	318.00	314.00	4.78**
Protein (g/100 g)	19.13	19.25	7.75**
Fat (g/100 g)	4.10	4.61	8.02**
Phosphorus (mg/100 g)	302.00	380.12	6.08**
Potassium (mg/100 g)	170.00	287.12	47.75**
Calcium (mg/100 g)	299.70	327.47	32.37**
Iron (mg/100 g)	4.20	4.01	8.09**

*Significant at 5 per cent level, **Significant at 1 per cent level

Protein was found to be sufficiently high in both the health drink mixes and was found to be 19.25 g in the spiced health drink mix and in the malted drink mix it was 19.13 g.

The fat content was almost similar for spiced health drink mix (4.61 g) and malted health drink mix (4.10 g).

The minerals were significantly higher in the spiced health drink mix as compared to malted health drink mix. The phosphorus, potassium calcium and iron content in the spiced health drink mix were found to be 380.12 mg/100 g, 287.12 mg/100 g, 327.47 mg/100 g and 4.01 mg/100 g as against 302.0 mg/100 g, 170.0 mg/100 g, 299.70 mg/100 g and 4.20 mg/100 g for malted health drink mix.

As indicated by the results both the health drink mixes formulated varied significantly with respect to all the chemical and nutritional features ascertained. However both the mixes were equally nutritious and comparable to the market products.

4.3.1.2 Organoleptic Features of Health Drink Mixes Standardized from Jackfruit Seed Flour

The organoleptic features of the two types of health drink mixes *viz.*, malted and spiced formulated from jack seed flour were assessed by a panel of judges selected for the purpose on the five point scale.

The Table 50 represents the organoleptic features of the health drink mixes standardized from jack seed flour. A significant difference (CD 0.112) was observed in the appearance scores between the two health drink mixes formulated. The appearance score obtained for malted health drink mix was 4.17 and was higher when compared to spiced health drink mix (4.06). Mean colour score also found to vary significantly (CD 0.141) between the two mixes developed and a higher score was secured for malted health drink mix (4.29) as compared to its counterpart (4.07).

Table 50 Organoleptic features of health drink mixes standardized from jackfruit seed flour

Organoleptic attributes	Malted health drink mix	Spiced health drink mix	F value	CD value
Appearance	4.17	4.06	4.17*	0.112
Colour	4.29	4.07	8.84**	0.141
Flavour	4.19	4.11	1.14	-
Taste	4.20	4.11	1.67	-
Clarity	4.16	4.10	1.20	-
Overall acceptability	4.20	4.10	1.75	-

*Significant at 5 per cent level, **Significant at 1 per cent level

The scores for flavour, taste, clarity and overall acceptability was almost alike in both the mixes developed from jackfruit seed flour. The flavour and taste score being 4.19 and 4.20 respectively in malted drink mix and 4.11 and 4.11 for spiced health drink mix.

Clarity of the drink mixes when mixed with milk was assessed and found that judges appreciated both the mixes almost alike and the drinks were found to be clear without any suspended particles. The mean clarity scores for the malted health drink mixes was 4.16 as against 4.10 for spiced drink mix.

Overall acceptability of mixes standardized was found to be 4.20 in malted health drink mix and 4.10 in spiced health drink mix, which indicates good acceptance of the products among the judges.

From the above results highlighted, it can be concluded that the two health drink mixes formulated from jackfruit seed flour were acceptable to the judges. Significant difference was observed in appearance and colour attributes, whereas the other features *viz.*, flavour, taste, clarity and overall acceptability were almost alike. On the whole, malted health drink mix excelled the spiced health drink for all the sensory parameters.

4.3.1.3 Changes in the Chemical Constituents of Health Drink with Storage

Changes in the chemical constituents of health drink with storage. Health drink mixes when stored in laminated pouches undergo changes with respect to chemical constituents, which will be an indication of the deteriorative changes occurring in the product. Hence these changes were periodically ascertained upto six months in the formulated health drink mixes.

Following Table 51 responses for detailed description of the changes occurring in the constituents of health drink mixes.

Moisture

A significant difference in the moisture content was observed between the two health drink mixes with storage. The mean value for moisture for the malted health drink mix was 4.25 per cent as against 6.21 per cent in spiced health drink mix.

The moisture content of the health drink mixes increased significantly with storage. As inferred from the CD value (0.122) significant increase in moisture content was observed after one month of storage irrespective of the products.

A significant interaction was observed with respect to moisture content between storage period and products. The increase in moisture content was found to be significant for malted health drink mix by the end of two months whereas for spiced health drink mix significant difference was observed after six months storage only.

Table 51 Changes in the chemical characteristics of health drink mixes and interaction between storage period and treatments

Storage period	Moisture (%)		Storage period (P) (mean)	Acidity (%)		Storage period (P) (mean)	pH		Storage period (P) (mean)	TSS (°Brix)		Storage period (P) (mean)	Total sugar (%)		Storage period (P) (mean)
	T_1	T_2		T_1	T_2		T_1	T_2		T_1	T_2		T_1	T_2	
P_0 (Initial)	4.00	6.11	4.82	0.71	0.77	0.74	6.40	7.30	6.85	40.00	46.00	43.00	32.39	35.47	33.93
P_1 (30 days)	4.16	6.15	5.07	0.71	0.79	0.75	6.37	7.27	6.82	40.00	46.00	43.00	32.41	35.49	33.95
P_2 (60 days)	4.20	6.21	5.18	0.72	0.81	0.76	6.34	7.21	6.77	41.20	46.10	43.65	32.42	35.53	33.97
P_3 (90 days)	4.30	6.23	5.26	0.73	0.81	0.77	6.31	7.14	6.72	41.26	46.10	4.368	32.45	35.60	34.02
P_4 (120 days)	4.34	6.25	5.28	0.74	0.83	0.78	6.30	7.10	6.70	41.30	46.16	43.73	32.47	35.62	34.04
P_5 (150 days)	4.38	6.26	5.30	0.77	0.84	0.80	6.29	7.07	6.68	41.30	46.26	43.78	32.48	35.63	34.06
P_6 (180 days)	4.39	6.28	5.33	0.79	0.85	0.82	6.28	7.03	6.65	41.40	46.36	43.88	32.49	35.65	34.07
Mean (T)	**4.25**	**6.21**	**5.17**	**0.74**	**0.81**	**0.77**	**6.33**	**7.16**	**6.74**	**40.92**	**46.14**	**43.53**	**32.44**	**35.57**	**34.00**
	$F_{1,28}$ (T) = 116.47** $F_{6,28}$ (P) = 679.516** $F_{6,28}$ (TP) = 679.516** CD (T) = 0.061 CD (P) = 0.122 CD (TP) = 0.173			$F_{1,28}$ (T) = 1153.41** $F_{6,28}$ (P) = 92.38** $F_{6,28}$ (TP) = 2.88* CD (T) = 0.004 CD (P) = 0.008 CD (TP) = 0.012			$F_{1,28}$ (T) = 79464.00** $F_{6,28}$ (P) = 356.88** $F_{6,28}$ (TP) = 58.22** CD (T) = 0.006 CD (P) = 0.011 CD (TP) = 0.016			$F_{1,28}$ (T) = 341665.4** $F_{6,28}$ (P) = 987.77** $F_{6,28}$ (TP) = 516.44** CD (T) = 0.018 CD (P) = 0.034 CD (TP) = 0.049			$F_{1,28}$ (T) = 122518.7** $F_{6,28}$ (P) = 23.33** $F_{6,28}$ (TP) = 1.55 CD (T) = 0.018 CD (P) = 0.034		

T_1 - Malted health drink mix, T_2 - Spiced health drink mix
*Significant at 5 per cent level, **Significant at 1 per cent level

Table 51 Continued

Storage period	Reducing sugar (%)		Storage period (P) (mean)	Acid value (%)		Storage period (P) (mean)	Peroxide value (meq)		Storage period (P) (mean)
	T_1	T_2		T_1	T_2		T_1	T_2	
P_0 (Initial)	9.06	10.64	9.88	0.01	0.04	0.02	0.00	0.00	0.00
P_1 (30 days)	9.09	10.66	9.88	0.01	0.06	0.03	0.00	0.00	0.00
P_2 (60 days)	9.10	10.68	9.89	0.01	0.13	0.07	0.00	0.03	0.01
P_3 (90 days)	9.10	10.73	9.91	0.02	0.15	0.08	0.01	0.08	0.04
P_4 (120 days)	9.10	10.74	9.94	0.02	0.16	0.09	0.02	0.11	0.06
P_5 (150 days)	9.11	10.82	9.94	0.02	0.20	0.11	0.03	0.18	0.11
P_6 (180 days)	9.12	10.87	9.96	0.02	0.23	0.12	0.04	0.20	0.12
Mean (T)	**9.09**	**10.74**	**9.91**	**0.01**	**0.14**	**0.07**	**0.01**	**0.08**	**0.04**
	$F_{1,28}$ (T) = 232824** $F_{6,28}$ (P) = 53.33** $F_{6,28}$ (TP) = 147.33** CD (T) = 0.006 CD (P) = 0.013 CD (TP) = 0.018			$F_{1,28}$ (T) = 3842.84** $F_{6,28}$ (P) = 187.93** $F_{6,28}$ (TP) = 145.56** CD (T) = 0.004 CD (P) = 0.007 CD (TP) = 0.091			$F_{1,28}$ (T) = 1650.36** $F_{6,28}$ (P) = 156.66** $F_{6,28}$ (TP) = 196.46** CD (T) = 0.003 CD (P) = 0.006 CD (TP) = 0.009		

T_1 - Malted health drink mix, T_2 - Spiced health drink mix
*Significant at 5 per cent level, **Significant at 1 per cent level

Acidity

Mean value of acidity for malted health drink mix was found to be 0.74 per cent as against 0.81 per cent in spiced health drink mix. Significant increase in acidity was observed for both the health drink mixes when stored.

The acidity was found to increase significantly along with storage. The increase in acidity for the two products was accounted to be 10.81 per cent. Significant increase in acidity was observed after one month irrespective of the products.

No significant interaction was observed with respect to acidity between the storage period and products.

pH

Significant difference was observed in the pH of the two health drink mixes formulated along with a storage period of 180 days. The mean value for pH of the malted health drink mix and spiced health drink mix with storage was found to be 6.33 and 7.16 respectively. The decrease in pH was found to be significant after one month of storage irrespective of the two products. In the case of malted health drink mix there was a significant decrease in pH during the first three months after which the pH remains stable.

Significant interaction was observed between the storage period and products. As inferred from CD value (0.016) a significant decrease in pH was observed after one month of storage in the two health drink mixes.

TSS

The mean value for TSS content of malted and spiced health drink mixes were 40.92 and 46.14°Brix respectively. A significant difference in the TSS content was observed between the two health drink mixes.

The TSS of the health drink mixes increased significantly with storage. As inferred from the CD value (0.034) significant increase in TSS content was observed after two months of storage irrespective of the two mixes developed. The increase in TSS was not significant between 120 – 150 days in malted health drink mix and between 60 – 90 days in spiced health drink mix.

Significant interaction was observed with respect to TSS between products and storage period. A significant increase in TSS was observed in both the health drink mixes after a storage period of two months.

Total sugar

Significant difference in the total sugar content was observed between the two health drink mixes. The mean value of total sugar for malted health drink mix and spiced drink was 32.44 per cent and 35.57 per cent respectively.

The total sugar content of health drink mixes increased significantly with storage. As inferred from CD value (0.034) a significant increase in total sugar content was observed after two months of storage irrespective of the two health drink mixes. However the increase in total sugar remained more or less same between 90 – 180 days in both the health drink mixes along with storage.

Reducing sugar

Significant difference in the reducing sugar content was observed between the two health drink mixes. The mean value of reducing sugar content of the malted and spiced health drink mixes were 9.09 per cent and 10.74 per cent respectively.

The reducing sugar content of health drinks increased significantly with storage. As inferred from CD value (0.013) significant increase in reducing sugar content was observed after one month of storage irrespective of the products.

Significant interaction was observed with respect to reducing sugar between products and storage period. The reducing sugar content increased for both the products significantly after one month of storage.

Acid value

Acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat (Sharma, 1993). The free fatty acids in the products generated increased during storage. With respect to products, a significant difference was observed between the two health drink mixes formulated. A higher acid value was observed for the spiced health drink mix (0.14 per cent) as compared to malted health drink mix (0.01 per cent).

The acid value increased significantly with storage. As inferred from CD value (0.007) a significant increase in acid value was observed after one months of storage.

Significant interaction was observed with respect to acid value between products and storage period. The acid value increased significantly for malted health drink mix after a period of 60 days whereas increase in acid value was observed after 30 days in the spiced health drink mix.

Peroxide value

Peroxide value gives a measure of oxidative rancidity occurring in the products. The extent of peroxide formation is measured in milli equivalents of oxygen combined with a kg of oil or fat so as to produce fat peroxides of obnoxious odour and taste (Sharma, 1993). Peroxides were quantified in the health drinks as skimmed milk powder and soya flour were added.

Significant difference was observed with respect to peroxide value of health drink mixes. The mean peroxide value obtained for the two products were 0.01 and 0.08 meq respectively for malted and spiced health drink mix.

The peroxide value increased significantly with storage of six months. As inferred from CD (0.006) a significant increase in the peroxide value was observed after a storage period of 60 days irrespective of the products.

Significant interaction was observed with respect to peroxide value between products and storage period. The peroxide value increased significantly for the malted health drink mix after a period of three months as compared to spiced health drink mix where the increase was noticed after two months of storage.

Changes in the nutritional characteristics of health drink mixes with storage

Table 52 represents the changes in the nutritional characteristics of health drink mixes with storage. The nutritional characteristics in the health drink mixes remained unchanged with storage. The protein and fat content remained unchanged as reflected by t value for both the health drink mixes (t 0.86 and 1.06 for malted and spiced health drink mixes). In the malted health drink mix phosphorus decreased whereas in spiced health drink mix, phosphorus and iron decreased with storage however the decrease was not significant. Calcium was found to decrease by the end of six months storage (t 8.34) for malted health drink mix as well as for spiced health drink mix (t 2.80). Potassium content decreased in the spiced health drink mix significantly along with storage (t 2.180*).

Table 52 Changes in nutritional characteristics of health drink mixes with storage

Parameters	Malted health drink mix			Spiced health drink mix		
	Initial	Final	t value (Malted)	Initial	Final	t value (Spiced)
Protein (g)	19.13	19.11	0.86	19.25	19.22	1.06
Fat (g)	4.10	4.10	0.86	4.61	4.60	0.88
Phosphorus (mg/100 g)	302.00	300.00	0.76	380.12	380.00	0.86
Potassium (mg/100 g)	170.00	170.00	0.90	287.12	284.00	2.18*
Calcium (mg/100 g)	299.70	286.00	8.34**	327.47	320.47	2.80*
Iron (mg/100 g)	4.20	4.20	0.80	4.01	4.00	0.70

*Significant at 5 per cent level, **Significant at 1 per cent level

From the results highlighted above, it can be concluded that all the chemical constituents analysed in the two health drink mixes formulated from seed flour increased with storage, except for pH which was found to decrease. The nutritional constituents *viz.*, protein, fat and energy remained unchanged with storage. However coming onto mineral content of health drink mixes phosphorus and iron content decreased, however the decrease was insignificant, whereas other minerals *viz.*, calcium and iron decreased significantly in both the health drink mixes whereas potassium was observed to decrease significantly in the spiced health drink mix.

4.3.1.4 Changes in the Organoleptic Qualities of Health Drink with Storage

The organoleptic qualities of the health drink mixes formulated from jackfruit seed flour were assessed to ascertain the shelf stability of the products.

The following table gives detailed description of the organoleptic changes occurring in the health drink mixes including the effect of products and storage period.

Table 53 represents the changes in the organoleptic attributes *viz.*, appearance, colour, flavour, taste, clarity and overall acceptability of health drink and its interaction between treatments and storage period.

Table 53 Changes in the organoleptic attributes of health drink mixes and its interaction between treatments and storage period

Storage period	Appearance			Colour			Flavour			Taste		
	Treatments (T)		Storage period (P) (mean)	Treatments (T)		Storage period (P) (mean)	Treatments (T)		Storage period (P) (mean)	Treatments (T)		Storage period (P) (mean)
	T_1	T_2		T_1	T_2		T_1	T_2		T_1	T_2	
P_0 (Initial)	4.30	4.10	4.20	4.30	4.20	4.25	4.30	4.30	4.30	4.40	4.30	4.35
P_1 (30 days)	4.30	4.10	4.20	4.30	4.20	4.25	4.30	4.30	4.30	4.30	4.20	4.25
P_2 (60 days)	4.30	4.10	4.20	4.30	4.20	4.25	4.30	4.20	4.25	4.30	4.20	4.25
P_3 (90 days)	4.30	4.10	4.20	4.30	4.10	4.20	4.30	4.20	4.25	4.20	4.20	4.20
P_4 (120 days)	4.00	4.10	4.05	4.30	4.10	4.20	4.10	4.10	4.10	4.10	4.10	4.10
P_5 (150 days)	4.00	4.00	4.00	4.30	4.00	4.15	4.00	4.00	4.00	4.10	4.00	4.05
P_6 (180 days)	4.00	3.90	3.95	4.20	3.70	3.95	4.00	3.70	3.85	4.00	3.80	3.90
Mean (T)	**4.17**	**4.06**	**4.11**	**4.29**	**4.07**	**4.17**	**4.19**	**4.11**	**4.15**	**4.20**	**4.11**	**4.15**
	$F_{6,126}$ (P) = 2.24* $F_{4\backslash 1,126}$ (T) = 4.17* $F_{6,126}$ (PT) = 0.67 CD (P) = 0.211 CD (T) = 0.112			$F_{6,126}$ (P) = 1.27 $F_{1,126}$ (T) = 8.84** $F_{6,126}$ (PT) = 0.59 CD (T) = 0.141			$F_{6,126}$ (P) = 3.84** $F_{1,126}$ (T) = 1.14 $F_{6,126}$ (PT) = 0.89 CD (P) = 0.255			$F_{6,126}$ (P) = 2.97* $F_{1,126}$ (T) = 1.67 $F_{6,126}$ (PT) = 0.15 CD (P) = 0.244		

T_1 - Malted health drink mix, T_2 - Spiced health drink mix, *Significant at 5 per cent level, **Significant at 1 per cent level

Table 53 Continued

Storage period	Clarity			Overall acceptability		
	Treatments (T)		Storage period (P) (mean)	Treatments (T)		Storage period (P) (mean)
	T_1	T_2		T_1	T_2	
P_0 (Initial)	4.20	4.20	4.20	4.28	4.26	4.27
P_1 (30 days)	4.20	4.20	4.20	4.28	4.24	4.26
P_2 (60 days)	4.20	4.20	4.20	4.26	4.22	4.24
P_3 (90 days)	4.20	4.20	4.20	4.24	4.22	4.23
P_4 (120 days)	4.15	4.10	4.10	4.20	4.20	4.20
P_5 (150 days)	4.10	4.00	4.10	4.20	3.96	4.08
P_6 (180 days)	4.10	3.80	3.95	4.08	3.74	3.91
Mean (T)	**4.16**	**4.10**	**4.13**	**4.22**	**4.12**	**4.17**
	$F_{6,126}$ (P) = 1.24 $F_{1,126}$ (T) = 1.20 $F_{6,126}$ (PT) = 0.53			$F_{6,126}$ (P) = 1.15 $F_{1,126}$ (T) = 1.75 $F_{6,126}$ (PT) = 0.53		

Appearance

The mean appearance score of the two health drink formulated, was found to be 4.17 and 4.06 over a storage period of 180 days. As inferred from the CD value (0.112), significant difference was observed in the appearance attribute after a period of 90 days in malted health drink mix whereas after 150 days in spiced health drink mix.

As far as the appearance attribute of two products are concerned significant decrease in appearance score (CD– 0.211) was observed after a period of 150 days.

However no significant interaction was observed between storage period and treatments.

Colour

Another important attribute which influences the acceptability of the product is colour. The mean colour score of the health drink mixes formulated was found to be 4.29 and 4.07 which were found to be significantly different.

Significant difference in the colour attribute was observed along with storage for the two health drink mixes. The colour scores remained intact for a period of 180 days for the malted health drink mix whereas for spiced health drink mix a significant decrease was observed after 150 days of storage.

No significant interaction was observed between storage period and treatments.

Flavour

The mean flavour scores of the two health drink mixes formulated was found to be 4.19 and 4.11.

Significant difference in flavour attribute was observed throughout the storage period (CD 0.255). Flavour scores declined significantly after

120 days of storage. No significant interaction was observed between the treatments and storage period with respect to flavour.

Taste

Taste of the food product is one of the major attribute which influences the acceptance of the product. The mean taste score of the two health drink mixes formulated was found to be 4.20 and 4.11. As inferred from the CD value (0.244) significant difference in the taste attribute was observed after a period of 120 days of storage in the health mixes. However no significant difference was observed between the two products formulated along with storage.

No significant interaction was observed between the storage period and products in taste attributes.

Clarity

The mean clarity scores of the two health drink mixes formulated was found to be 4.16 and 4.10. However no significant difference was observed in the clarity attribute of health drink mixes between the two products during storage period of 180 days.

No significant difference was observed along with storage within the products.

Similarly no significant interaction was observed with respect to health drink mixes between the storage period and products in clarity attribute.

Overall acceptability

The mean overall acceptability scores for the two health drink mixes formulated over the storage period were 4.22 and 4.12 respectively and no significant difference was observed in the two mixes formulated during storage period.

No significant difference was observed within the products in overall acceptability with storage.

Hence it can be concluded that appearance, flavour and taste of health drink mixes developed varied between the products whereas no difference was observed in other attributes *viz.*, colour, clarity and overall acceptability scores within the two products formulated from the seed flour through out the storage period.

The storage period influences the attributes *viz.*, appearance, flavour and taste whereas the other attributes *viz.*, colour, clarity and overall acceptability remained unaffected with storage.

Based on the above findings shelf stability of the products could be recommended for five months preserving all the organoleptic features.

4.3.2 Standardization of Biscuits from Jackfruit Seed Flour

Baking is a convenient, time saving and profitable cooking method that can be taken up by the cottage industries. Biscuits, cookies and crackers represent the largest category of snack items among the baked foods in India (Singh *et al.*, 1996).

Under the present investigation biscuits were standardized from jackfruit seed flour adding other ingredients and food adjuncts. Plate 5 depicts the biscuit and confectionary items standardized from jackfruit seed flour.

4.3.2.1 Chemical and Nutritional Characteristics of Biscuits Standardized from Jackfruit Seed Flour

The biscuits standardized under the present investigation were assessed for chemical and nutritional characteristics.

As indicated in the table 54 moisture content of the biscuit was found to be 6.01 per cent with a pH of 4.06 and acidity 0.63 per cent. The TSS, total sugar, reducing sugar of the formulated biscuit from jackfruit

Plate 5. Bakery and confectionary products from jackfruit seed flour

seed flour was estimated as 38.05°Brix, 31.56 per cent and 7.78 per cent respectively.

Table 54 Chemical and nutritional characteristics of biscuit

Parameters	Mean values
Moisture (per cent)	6.01
Acidity (per cent)	0.63
pH	4.06
TSS (°Brix)	38.05
Total sugar (per cent)	31.56
Reducing sugar (per cent)	7.78
Acid value (per cent)	0.04
Peroxide value (meq)	0.01
Ash (per cent)	0.052
Protein (g/100g)	8.01
Fat (g/100g)	19.88
Phosphorus (mg/100 g)	208.6
Potassium (mg/100 g)	203.8
Calcium (mg/100 g)	58.5
Iron (mg/100 g)	3.94
Energy (Kcal/100 g)	395

Acid value and peroxide value which are two determinants of keeping quality of the biscuits were analysed and found to be 0.04 per cent and 0.01 meq. Ash content of the biscuits was 0.052 per cent.

Among the nutritional characteristics, energy content of the biscuit was found to be 395 Kcal/100 g, while protein content of the biscuits was found to be 8.01 g. Fat was found to be 19.88 g. The minerals analysed in the biscuit were phosphorus, potassium and calcium which was accounted to be 208.6 mg/100 g, 203.8 mg/100 g and 58.5 mg/100 g. The iron content of seed flour biscuit was also analysed and found to be 3.94 mg.

4.3.2.2 Organoleptic Features of the Biscuits Standardized from Jackfruit Seed Flour

Sensory qualities of the biscuit standardized from seed flour was assessed in terms of appearance, colour, flavour, taste and doneness assigning scores.

As indicated in the Table 55 average score for appearance attribute was found to be 4.34, whereas the mean colour score was 4.20. The flavour and taste scores were found to be 4.18 and 4.14 respectively. The score for doneness and crispness obtained for biscuit was found to be 4.06.

Table 55 Organoleptic features of biscuit standardized from jackfruit seed flour

Organoleptic attributes	Mean scores
Appearance	4.34
Colour	4.20
Flavour	4.18
Taste	4.14
Crispness	4.06
Overall acceptability	4.18

Based on the individual score of different attributes, overall acceptability of biscuit was ascertained and found to be 4.18 out of 5. The result indicate that, acceptance of the bisçuit developed from seed flour above 80 per cent for each of the sensory attributes and also for overall acceptance indicate excellent acceptance of the product among judges.

4.3.2.3 Changes in the Chemical Constituents of Biscuits with Storage

Biscuit formulated from seed flour was sealed in laminated covers and analysed for keeping quality fortnightly for a period of two months.

Following Table 56 gives the detailed description of the changes occurring in the constituents of biscuits including the effect of storage period.

Moisture

Moisture content of biscuit varied significantly with storage. The moisture content increased with storage and the increase was found to be significant after 15 days of storage (CD 0.007). The moisture content of biscuit ranged from 5.99 – 6.04 over a storage period of 60 days.

Acidity

Significant difference was observed in the per cent acidity of the biscuit along with a storage period of 60 days. The per cent acidity

Table 56 Changes in the chemical constituents of biscuit with storage

Days	Moisture (%)	Acidity (%)	pH	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Ash (%)	Acid value (%)	Peroxide value (meq)
Initial	5.99	0.61	4.09	38.01	31.48	7.73	0.04	0.00	0.00
15 days	6.01	0.61	4.08	38.03	31.54	7.77	0.05	0.05	0.00
30 days	6.02	0.63	4.08	38.05	31.58	7.79	0.05	0.05	0.00
45 days	6.02	0.64	4.05	38.06	31.60	7.81	0.06	0.05	0.02
60 days	6.04	0.66	4.03	38.09	31.61	7.82	0.06	0.06	0.04
Mean	6.01	0.63	4.06	38.05	31.56	7.78	0.052	0.04	0.01
$F_{4,11}$	49.16**	56.23**	65.47**	15.00*	1.7	1.7	11.75*	10.33*	16.99**
CD	0.007	0.008	0.011	0.022	-	-	0.006	0.005	0.004

*Significant at 5 per cent level, **Significant at 1 per cent level

increased significantly (CD 0.008) after a period of 30 days of storage. The per cent acidity of biscuit ranged from 0.61-0.66 per cent over a storage period of 60 days.

pH

Significant difference was observed in the pH of the biscuit along with a storage period of 60 days. The pH decreased significantly (CD 0.011) after a storage period of 15 days. The pH content of biscuits ranged from 4.09 – 4.03 over a storage period of 60 days.

TSS

As far as TSS content of biscuit is concerned a significant difference in TSS content of biscuits was observed along with storage. The TSS content decreased significantly (CD 0.022) after a period of 15 days of storage. The TSS content of biscuit ranged from 38.01 – 38.09 over a storage period of 60 days.

Total sugar

The total sugar content increased with storage, however the increase was found to be insignificant. The total sugar content ranged from 31.48 – 31.61 per cent along with storage of 60 days.

Reducing sugar

The reducing sugar content though increased with storage, the increase was not found to be significant. The reducing sugar content ranged from 7.73 –7.82 per cent along over a storage of 60 days.

Ash

Significant increase in per cent ash was observed for biscuits after 15 days of storage. The per cent ash ranged from 0.04 per cent – 0.06 per cent along with storage of 60 days.

Acid value

The acid value for biscuit was nil initially which increased to 0.06 per cent. A significant increase was observed in acid value after 15 days of storage.

Peroxide value

Peroxide value was observed to be nil upto 30 days of storage, after which a significant increase was recorded in peroxide value.

Changes in the nutritional characteristics of biscuits with storage

As reflected from Table 57 negligible changes were noted in the nutritional characteristics, such as potassium (t2.38*) and calcium (8.01*) while protein, fat, phosphorus, iron and energy content remained unchanged with storage.

Table 57 Changes in the nutritional composition of biscuit with storage

Nutritional characters	Initial	Final	t value
Energy (Kcal/100 g)	395	395	-
Protein (g/100 g)	8.01	8.01	-
Fat (g/100 g)	19.88	19.88	0.89
Phosphorus (mg/100 g)	208.6	207.6	1.88
Potassium (mg/100 g)	203.8	200.7	2.38*
Calcium (mg/100 g)	58.5	49.4	8.01**
Iron (mg/100 g)	3.94	3.01	1.72

*Significant at 5 per cent level, **Significant at 1 per cent level

From the above results it can be concluded that a significant difference was observed for the parameters *viz.*, moisture, acidity, pH, TSS, peroxide value, acid value and ash along with storage. Negligible changes were found in total and reducing sugar. The per cent acidity, moisture total and reducing sugar, peroxide value, acid value and per cent ash increased along with storage whereas pH was found to decrease. However the above changes do not affect the quality of biscuit formulated.

Nutritional characteristics assessed revealed negligible changes and the biscuits remained excellent in quality even after two months of storage.

4.3.2.4 Changes in the Organoleptic Qualities of Biscuits with Storage

The organoleptic qualities of the biscuits formulated form jackfruit seed flour were assessed so as to ascertain the shelf stability of the biscuits. The biscuits were organolepticaly evaluated by a panel of 10 judges after every 15 days.

Table 58 represents the changes in organoleptic attributes *viz.*, appearance, colour, flavour, taste, doneness and overall acceptability of biscuits and its interaction with storage.

The mean appearance score of the biscuits was found to be 4.34 over a storage period of 60 days. The appearance score reduced along with storage from 4.6 – 4.0. However, no significant difference was observed with respect to appearance attribute over a storage period of 60 days.

The mean colour score of the biscuit was found to decrease along with storage from 4.3 – 4.0. However, no significant difference was observed with respect to colour attribute over a storage period of 60 days.

The mean flavour score of the biscuit was found to be 4.18 over a storage period of 60 days. The flavour score decreased significantly with storage (CD0.382) after a period of 45 days. The decrease in flavour score accounted to be 15.55 per cent over a storage period of 60 days.

The mean taste score of the biscuit was found to be 4.14 over a storage period of 60 days. The taste scores decreased significantly with storage (CD0.377) after a period of 30 days and the decrease was accounted to be 17.77 per cent.

The mean doneness/crispness of the biscuit was found to be 4.06 over a storage period of 60 days. The mean doneness score decreased

Table 58 Changes in the organoleptic attributes of biscuit with storage

Storage period (P) days	Appearance	Colour	Flavour	Taste	Crispness	Overall acceptability
	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)
P_0 (0 day)	4.6	4.3	4.5	4.5	4.6	4.5
P_1 (15 days)	4.5	4.3	4.4	4.4	4.4	4.4
P_2 (30 days)	4.4	4.3	4.2	4.1	4.0	4.2
P_3 (45 days)	4.2	4.1	4.0	4.0	3.8	4.0
P_4 (60 days)	4.0	4.0	3.8	3.7	3.5	3.8
Mean T	4.34	4.20	4.18	4.14	4.06	4.18
$F_{4,45}$	1.54	1.24	4.55**	5.86**	10.01**	4.15**
CD	-	-	0.382	0.377	0.400	1.981

*Significant at 5 per cent level, **Significant at 1 per cent level

significantly (CD0.40) with storage after a period of 30 days and the decrease was accounted to be 23.91 per cent.

The mean overall acceptability score of the biscuits was found to be 4.18 over a storage period of 60 days. The overall acceptability score decreased significantly (CD 1.98) after a period of 45 days. The overall decrease in the score was 4.5 – 3.8 and accounted to be 15.55 per cent.

The above results reflect that the appearance and colour of the biscuits were not affected with storage. However, the other attribute *viz.*, flavour, taste, doneness and overall acceptability score decreased during storage.

4.3.3 Standardization of Laddus from Jackfruit Seed Flour

The possibility of jack seed flour for developing confectionary product was explored, and seed flour was mixed with other food adjuncts to formulate laddus.

4.3.3.1 Chemical and Nutritional Characteristics of Laddus Standardized from Jackfruit Seed Flour

Under the present study, confectionary food product *viz.*, seed four laddus was standardized utilizing jackfruit seed flour. Table 59 gives the chemical and nutritional characteristics of Laddus standardized from jackfruit seed flour. The moisture content of the Laddus standardized was 23.8 per cent whereas pH and acidity was 4.06 and 1.42 per cent respectively. TSS of the product developed was found to be 23.32 °Brix whereas total sugar and reducing sugar was 11.80 per cent and 6.89 per cent respectively. The acid and peroxide value was found to be 0.176 per cent and 0.22 meq respectively. Protein content of the laddus was found to be 14.67 g whereas the fat content was 47.00 g. The energy content of the laddus was found to be 903 KCal per 100 g.

Table 59 Chemical and nutritional characteristics of laddus

Parameters	Mean values
Moisture (per cent)	23.80
Acidity (per cent)	1.42
pH	4.06
TSS (°Brix)	23.32
Total sugar (per cent)	11.80
Reducing sugar (per cent)	6.89
Acid value (per cent)	0.176
Peroxide value (meq)	0.22
Protein (g/100 g)	14.67
Fat (g/100 g)	47.00
Energy (Kcal/100 g)	903

4.3.3.2 Organoleptic Features of the Confectionary Product Standardized from Jackfruit Seed Flour

The confectionary product *viz.*, laddus standardized from seed flour was organoleptically assessed to test its acceptance.

As reflected from Table 60 the average score attained for appearance of the product was 4.6/5 whereas for colour the average score was 4.45/5 Flavour and texture score of laddus was found to be 3.90 and 3.92 whereas taste score was 4.02 out of 5.00.

Table 60 Organoleptic features of laddus standardized from jackfruit seed flour

Organoleptic attributes	Scores
Appearance	4.60
Colour	4.45
Flavour	3.90
Taste	4.02
Texture	3.92
Overall acceptability	4.17

Based on all sensory attributes, overall acceptability of the confectionary product formulated from jack seed flour was ascertained and accounted to be 4.17 /5 and adjudged to be above 80 per cent acceptable among the judges.

4.3.3.3 Changes in the Chemical and Nutritional Constituents of the Confectionary Product with Storage

Laddus formulated from seed flour was sealed in polypropylene covers and stored under ambient condition and evaluated after every five days for a period of 15 days. Following table gives the detailed description of the changes occurring in the constituents of laddus.

Table 61 represents the changes in the chemical constituents of laddus with storage of 15 days.

Significant increase in moisture content was observed in laddus with storage. Moisture content increased significantly after a period of five days (CD 1.74). The moisture content of laddus ranged from 19.39 to 27.11 per cent.

Significant difference was observed in the per cent acidity of the laddus along with storage. The mean value of acidity of laddus was found to be 1.42 per cent. Acidity increased significantly (CD 0.120) after a period of five days and the increase ranged from 1.06 – 1.80 per cent over a storage period of 15 days.

Significant difference was observed in the pH of the laddus along with storage of 15 days. The mean value of pH for laddus was found to be 4.06. The pH decreased significantly after a period of five days. The pH content of laddus ranged from 4.20-3.92 over a storage period of 15 days and the decrease was accounted to be 6.66 per cent.

Similarly a significant increase in the TSS content was observed in laddus with storage. The mean TSS content of laddus was found to be 23.32°Brix. The increase in TSS was noted after five days and the increase was from 23.03 to 23.53°Brix.

Total sugars also increased with storage and the increase was accounted to be 13.66 per cent after 15 days.

Table 61 Changes in the chemical constituents of laddus with storage

Storage period (P) Days	Moisture (%)	Acidity (%)	pH	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Peroxide value (meq)	Acid value (%)
P_0 (0 day4)	19.39	1.06	4.20	23.03	11.20	5.63	0.12	0.09
P_1 (5 days)	27.99	1.28	4.11	23.31	11.31	6.02	0.19	0.14
P_2 (10 days)	25.99	1.57	4.01	23.43	11.99	7.23	0.23	0.20
P_3 (15 days)	27.11	1.80	3.92	23.53	12.73	8.59	0.35	0.27
Mean T	23.80	1.42	4.06	23.32	11.80	6.89	0.22	0.176
$F_{3,8}$	273.6**	77.07**	40.65**	101.33**	427.56**	1622.59**	27.95**	31.11**
CD	1.740	0.120	0.024	0.070	0.111	0.108	0.057	0.108

*Significant at 5 per cent level, **Significant at 1 per cent level

Reducing sugar content of laddus was found to be 6.89 per cent. A significant increase (CD 0.108) in the reducing sugar content of laddus was observed after a period of five days. Increase in reducing sugar content of laddus was observed to be 52.57 per cent over a period of 15 days.

The increase in peroxide and acid value with a storage of 15 days was accounted to be 1.91 per cent and 2.0 per cent respectively.

The nutritional characteristics *viz.*, protein, fat and energy remained unchanged with storage.

To summarize the changes occurring in the confectionary products, a significant difference was observed in chemical constituents ascertained in the product with storage. Moisture, acidity, TSS, total sugar, reducing sugar, peroxide and acid value increased significantly with storage whereas pH declined with storage. It is also worth mentioning that the changes in the product does not interfere the quality of the product till 10 days.

4.3.3.4 Changes in the Organoleptic Qualities of Laddus with Storage

The organoleptic qualities of the laddus formulated from jackfruit seed flour were assessed so as to ascertain the shelf stability of the laddus.

Table 62 represents the changes in the organoleptic attributes *viz.*, appearance, colour, flavour, taste, texture and overall acceptability of laddus and its interaction with storage.

The mean appearance score of the laddus was found to be 4.60 with a storage period of 15 days. The mean appearance score decreased significantly (CD 0.411) after a period of 10 days. The decrease was found to be 20 per cent.

The mean colour score of the laddus was found to be 4.55 when stored for 15 days. The colour score decreased, with storage, however, the difference was not found to be significant.

Table 62 Changes in the organoleptic attributes of laddus with storage

Storage period (P) days	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)	Treatment (T)
P_0 (0 day)	5.0	4.8	4.7	4.7	4.4	4.74
P_1 (5 days)	4.9	4.6	4.2	4.4	4.1	4.30
P_2 (10 days)	4.5	4.6	3.7	4.0	3.5	4.08
P_3 (15 days)	4.0	4.2	3.0	3.0	3.7	3.58
Mean T	4.60	4.55	3.90	4.02	3.92	4.17
$F_{3,36}$	10.05**	2.28	13.73**	15.81**	7.40**	26.87**
CD	0.411	0.478	0.562	0.534	0.425	1.335

*Significant at 5 per cent level, **Significant at 1 per cent level

The mean flavour score of the laddus was found to be 3.90 when stored for 15 days. After five days mean flavour score decreased significantly (CD 0.562). The flavour loss was accounted to be 36.17 per cent.

The mean taste score of the laddus was found to be 4.02 when stored for 15 days. The mean taste score decreased significantly (CD 0.534) after a storage period of 10 days and the decrease was accounted to be 36.17 per cent.

The mean texture score of the laddus was found to be 3.92 when stored for 15 days. The mean texture score decreased significantly (CD 0.425) after 10 days and decrease in score was 15.90 per cent.

The mean overall acceptability score of the laddus was found to be 4.17. The mean overall acceptability score decreased significantly (CD 1.335) after a storage period of five days. The overall acceptability scores of laddus ranged from 4.74 – 3.58 respectively over a storage period by 15 days.

Generally the sensory features of the product decreases as the storage period advances. In the case of laddus also sensory character such as appearance, flavour, taste, texture and overall acceptability scores decreased with storage. Colour of the product was unchanged whereas as flavour loss was observed at an early period when compared to other features.

Although the above product was short lived but the taste was highly preferred.

4.4 ASSESSMENT OF MICROBIAL PROFILE OF THE PRODUCTS DEVELOPED FROM JACKFRUIT

Microbial population in the processed foods is an important factor, which determines the quality and safety of the product. Microbial contamination of the products standardized in the study were ascertained to determine the keeping quality of the products. Processing methods and addition of preservatives were assumed to reduce the microbial load of the products, which would enhance the keeping quality of the products.

When foods are processed, there are chances of contamination through various means and during the storage of the products. these microbes multiply and cause spoilage of the products. Hence assessment of microbial population of the products is an essential step in the development of new products.

The microbial contamination of various food products developed from jackfruit were monitored at regular interval depending upon the type of products.

Microbial Assessment of jackfruit nectars

Jackfruit nectars formulated from the two varieties of jackfruit and its blends were assessed for microbial contamination soon after it was prepared and thereafter fortnightly till two months. The results revealed that no microbial contamination was detected in any of the samples stored at refrigerated condition till two months of storage. In the case of nectars stored at ambient temperature, contamination was nil upto 45 days. However, when analysed at the end of two months, negligible contamination was observed.

Table 63 represents the microbial growth detected in the nectars. Bacterial growth was observed towards the end of storage period in the samples stored at ambient condition. Bacterial growth was observed in the control varikka and koozha nectars (4.0 and 3.0 x 10^2 cfu/ml). Among the blended nectars bacterial growth was observed in papaya blended varikka nectar (4.2 x 10^2 cfu/ml) whereas for koozha variety microbial growth was observed in pineapple and papaya blends (4.5 and 6.0 x 10^2 cfu/ml). Fungal spore count was observed in all the three blends of varikka *viz.*, pineapple, papaya and mango (2.2, 3.1 and 3.0 x 10^2 cfu/ml) whereas in koozha nectars fungal count was observed only in control koozha nectar (2.1 x 10^2 cfu/ml).

Table 63 Microbial assessment of the products developed from jackfruit

Jackfruit nectar (60 days)	Bacterial count at the end of storage period (60 days) 10^2 cfu/ml	Fungal count at the end of storage period (60 days) (10^2 cfu/ml)
Control jackfruit nectar (V_1)	4.0×10^2	-
Pineapple jackfruit nectar (V_1)	-	2.2×10^2
Papaya jackfruit nectar (V_1)	4.2×10^2	3.1×10^2
Mango jackfruit nectar (V_1)	-	3.0×10^2
Control jackfruit nectar (V_2)	3.0×10^2	2.1×10^2
Pineapple jackfruit nectar (V_2)	4.5×10^2	
Papaya jackfruit nectar (V_2)	6.0×10^2	
Mango jackfruit nectar (V_2)	-	
Jackfruit bar (180 days)		
Control varikka bar	2.2	-
Papaya blended varikka bar	-	2.0
Mango blended varikka bar	-	1.2
Control koozha bar	6.0	2.2
Papaya blended koozha bar	7.5	
Mango blended koozha bar	-	
Health drink mixes (180 days)		
Malted health drink	3.0	2.2×10^2
Spiced health drink	3.5	-
Confectionary product (15 days)		
Laddus	0	5×10^2

V_1 – Varikka jackfruit V_2 – Koozha jackfruit

Specific identification (Table 64) of the microbes in jackfruit nectars were carried out which revealed the presence of *Acetobacter*. The bacteria revealed positive results when biochemical tests were conducted *viz*., catalase, carbohydrate fermentation and gas from glucose, whereas gave a negative motility test.

Table 64 Test for identification of bacteria in jackfruit products

Morphological tests	Characters		
Gram test	Negative	Positive	Positive
Shape	Rod	Spherical chain	Rod
Pigment	Brown		Off white
Biochemical test Catalase	+	+	+
Carbohydrate fermentation	+	+	-
Motility test	-	-	+
Gas from glucose	+	-	-
Bacteria identified	Acetobacter	Streptococcus	Bacillus serratia

The yeast identified was *Saccharomyces* and *Candida*, and the mould *Penicillium*. It is encouraging to note that microbial count detected in the nectars stored at ambient condition was very low. Taking into account of all the parameters ascertained, the shelf stability recommended for the jackfruit nectars is one month.

Microbial Assessment of Jackfruit bar

Microbial assessment of the jackfruit bar standardized in the present investigation was carried out at monthly interval upto six months since the product is a dehydrated one with low moisture content, shelf stability is expected more.

No contamination was detected in any of the fruit bars prepared from the two varieties of jackfruit till five month. However towards the end of six months some organisms made its appearance.

Negligible bacterial count was found in the control varikka bar (2.0 x 10^2 cfu/ml) whereas slightly higher bacterial load was recorded in control koozha bar and in papaya blended koozha bar. Negligible fungal growth was observed in mango and papaya blended varikka bars (1.2 and 2.0 x 10^2 cfu/ml). Fungal count was observed in control koozha bar (2.2 x 10^2 cfu/ml) which was also very low.

The morphological and biochemical test performed, confirmed the presence of *Streptococcus* and *Bacillus*. The yeast identified was *Candida* and mould – *Mucor* species. Based on the microbial analysis conducted the shelf life recommended for jackfruit bars was 150 days.

Microbial Assessment of Jackfruit Seed products

Seed four was utilized for the formulation of two health drink mixes which were in the dry powder form. In order to assess the keeping quality, the products were subjected to microbial analysis at monthly interval upto six months.

No contamination was detected in the health drink mixes formulated till five months. However when analysed at the end of sixth month, negligible contamination was noticed, the bacterial population was recorded as 3.0 x 10^2 cfu/ml in malted health drink mix and 3.5 x 10^2 cfu/ml in spiced health drink mix. Mild fungal growth was also observed in malted health drink mix (2.2 x 10^2 cfu/ml).

The morphological and biochemical tests revealed the presence of *Streptococcus* bacteria whereas the fungal spores of *Mucor* and *Penicillium* were recorded.

On account of the above, shelf stability recommended for the health drink mix is five months.

Microbial Assessment of Biscuits

Biscuits formulated from jackfruit seed flour were also assessed monthly for a period of two months. It is encouraging to note that no contamination was detected in the biscuits upto two months of storage.

Microbial assessment of laddus

Confectionary products generally have short life. Jackfruit seed flour based laddus standardized were analysed for microbial examination every fifth day upto a period of fifteen days. Fungal contamination was detected in laddus after 15^{th} day. The fungal count was recorded to be (5.0 x 10^2 cfu/ml). The mould identified was *Rhizopus*. Based on the different parameters ascertained, shelf stability of the product recommended is 10 days.

4.5 ASSESSMENT OF THE PRODUCTS FOR FPO STANDARDS

According to Sharma (1995) formulation of food standards is a dynamic activity, involving the co-operation of many experts in the field. Kapoor (1993) is of the opinion that food laws are essential for food safety. The Bureau of Indian Standards (BIS) has specified certain type tests for food products to maintain quality of processed products. Table 65 represents the assessment of products for FPO standards.

Table 65 Assessment of products for FPO standards

Type of products	Parameter	FPO standards	Levels in the standardized products
*Beverage Fruit nectar	Juice content	> 20 per cent	50 – 60 per cent
	TSS	> 15 per cent	18.06°Brix – 24.72°Brix
	Organoleptic quality	Free from taints	Free from objectionable taints
	Fermentation test	No sign of bacterial growth on incubation at 37°C for 7 days	Absent
	Preservatives SO_2	< 70 ppm	50 – 60 ppm
*Fruit bar	Moisture	<20 per cent	9.15 – 11.79 per cent
	KMS	<750 ppm	480 – 510 ppm
	Visible mould	Absent	Absent
	Insector larvae	Absent	Absent

*FPO specifications as quoted by Ranganna (1986)

♦Biscuit	Moisture	<6.0 per cent	5.99
	Ash	<0.06	0.05
	Peroxide value	<0.05	0.04
	Acid value	<0.05	0.05

♦BIS specification IS 1011: 2002

Health drink mixes Malted	Moisture	<10 per cent	4.00 – 4.40
Spiced	Moisture	<10 per cent	6.09 – 6.29
	Visible mould	Absent	Absent

In the present investigation test specified by Bureau of Indian Standards (BIS) were carried in the products developed incorporating jackfruit. FPO prescribe more than 20 per cent juice content and 15 per cent TSS for fruit nectars. Under the present study the juice content of the various nectars formulated with jackfruit and its blends ranged from 50-60 per cent and TSS ranged between 18.06°Brix – 24.472°Brix. Nectars were organoleptically assessed by a panel of judges and found to be free from any sort of off flavours and objectionable taints. Microbial examination of nectars revealed no sign of bacterial growth when incubated at 37°C for seven days. The amount of SO_2 in the products prescribed is less than 70 ppm and in the developed products the SO_2 ranged from 50 – 60 ppm.

Hence the nectars formulated from jackfruit individually and blended with other fruit pulps were found to be in conformity with the prescribed FPO standards.

With respect to fruit bars, which is a dehydrated fruit product, FPO has specified moisture content less than 20 per cent and SO_2 level less than 750 ppm. Moisture content of all the fruit bars formulated in the present study ranged between 9.15 to 11.79 per cent, which itself is an indicator of good shelf stability. It is encouraging to record that over a period of six months also, the moisture content was not more than 12.5 per cent in all the fruit bars developed. The SO_2 level estimated in the products ranged between 480-510 ppm, which are well within the level suggested.

Visible mould, fungi, insects or larvae were not seen in the fruit bars with storage. Hence it can be confirmed that the fruit bars developed under study confirm to the prescribed standards of FPO.

Health drink mixes formulated from jackfruit seed, were found to contain less moisture. The moisture content for malted health drink mix was found to be 4.00 per cent initially which increased to 4.40 per cent with the storage of six months whereas spiced health drink mix had a higher moisture content 6.09 per cent initially, and enhanced to 6.29 per cent by the end of six months. The prescribed moisture content for health drink mixes by BIS is 10 per cent. Moreover, no microbial contamination was detected in the health drink mixes till the end six months. Thus the health drink mixes developed also keep well with the BIS standards suggested.

Prime factors taken into account for good shelf stability of biscuit are moisture content, ash, acid and peroxide value. Prescribed moisture level of baked products is less than six per cent in and ash content less than 0.06 per cent. Peroxide and acid value recommended should not exceed 0.05 meq and 0.05 per cent in the finished products.

Under the present study the biscuit standardized from jackfruit seed flour had a moisture content of 5.99 per cent. the percentage ash was 0.05 per cent and peroxide and acid value were found to be 0.04 meq and 0.05 per cent respectively. The peroxide value was nil during the initial period, however after two months stôrage the value was found to be 0.04 meq. Similarly acid value was found to 0.05 per cent towards the end of storage period. Thus the jackfruit seed biscuit developed under investigation also satisfy the standards suggested.

Comparison of the data with the prescribed standards indicated that the recipes were properly adjusted for its essential contents to meet the recommended standards. Products developed satisfy the FPO requirements and thus it could be concluded that products developed from jackfruit had been properly formulated and procedures were well carried out during standardization process, and thus meet the specified requirements.

4.6.1 Consumer Acceptance of Jackfruit Products

Today's consumers have increased concern regarding food safety and sensory features of the food products. Any new food products are to be consumer tested, before it reaches the market. Hence the consumer

Table 66 Assessment of consumer acceptance of jackfruit products

Jackfruit nectar	Appearance		Colour		Flavour		Taste		Consistency		Overall acceptability	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Control jackfruit nectar	3.64	3.62	3.32	3.06	3.12	2.70	3.18	2.46	3.16	2.80	3.18	2.72
Pineapple blended jackfruit nectar	2.98	3.06	3.36	3.00	4.00	3.88	3.90	3.20	3.00	2.88	3.44	3.00
Papaya blended jackfruit nectar	3.96	3.76	4.08	3.72	2.76	2.58	2.44	2.26	3.36	2.78	3.32	3.22
Mango blended jackfruit nectar	3.80	3.64	3.68	3.60	3.70	3.46	4.02	3.52	3.52	3.00	3.68	3.48
CD value (variety)	-		0.179		0.172		0.163		-		0.125	
CD value (treatments)	0.256		0.243		0.244		0.235		0.232		0.263	

V_1 – Varikka variety V_2 – Koozha variety

Jackfruit bar	Appearance		Colour		Flavour		Taste		Texture		Overall acceptability	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Control jackfruit bar	4.16	4.00	4.14	3.66	3.76	3.72	4.00	3.62	4.00	3.88	3.91	3.81
Papaya blended jackfruit bar	4.28	3.98	4.34	3.86	3.86	3.32	3.60	3.12	3.76	3.68	3.90	3.56
Mango blended jackfruit bar	4.04	4.00	3.60	3.84	4.16	4.10	4.18	4.14	3.66	3.06	4.01	3.96
CD value (variety)	-		-		-		0.202		-		-	
CD value (treatments)	-		-		0.232		0.243		-		0.252	

Health drink mixes	Appearance	Colour	Flavour	Taste	Clarity/ Consistency	Overall acceptability
Malted health drink mix	4.06	4.04	4.00	4.02	4.04	4.14
Spiced health drink mix	3.62	3.52	3.02	3.04	3.62	3.90
CD value	0.373	0.339	0.310	0.292	0.332	0.203

Bakery and Confectionary products	Appearance	Colour	Flavour	Taste	Crispness/ doneness/ texture	Overall acceptability
Biscuit	4.80	4.81	4.82	4.58	4.50	4.86
Laddu	4.80	4.78	4.77	4.60	4.44	4.90

acceptance of the products developed under the present investigation was undertaken.

Assessment of consumer acceptability of different types of products developed was tested among 50 consumers selected at random. Freshly prepared products were distributed among the consumers and were asked to record their acceptance on a five point scale. The results are presented in Table 66.

Among the various nectars standardized from jackfruit, varikka variety nectars were found to excel for all the organoleptic features as compared to koozha nectars. Among the various sensory attributes, general appeal of the products which account both colour and appearance of the products were found to be highly preferred, when papaya fruit pulp was blended with jackfruit pulp.

For appearance and colour attributes score of papaya blended nectars of both varieties of jackfruit were most acceptable to the consumers. Other organoleptic attributes *viz.*, flavour, taste, consistency and overall acceptability of pineapple and mango blended nectars of both jackfruit varieties were better accepted when compared to other nectars.

Flavour was well appreciated when pineapple pulp was blended and the score was highest in both varieties of nectars by the consumers.

The taste of mango blended nectars of both the varieties were well appreciated by the consumers by scoring 4.02 and 3.52 respectively for varikka and koozha nectars. Consistency of the nectars was adjudged to be best in mango blended nectars and found to be lowest for papaya blended koozha nectar (2.78).

Taking into account of overall acceptability of nectars, mango blended nectars of both varieties were the best acceptable nectars for the consumers with a score of 3.68 in varikka nectars and 3.48 in koozha nectars.

Data on consumer acceptance of jackfruit bar revealed a similar trend. Appearance and colour features were higher for papaya blended fruit bars of both varieties. The acceptance score for appearance attribute was 4.28 and 3.98 and that of colour score was 4.34 and 3.86 respectively in varikka and koozha variety. Taking into account of flavour and taste parameters mango blended fruit bars of both varieties scored highest by the consumers.

Plain fruit bars were found to be well acceptable to the consumers for textural qualities. The scores obtained were 4.00 for varikka and 3.88 for koozha fruit bars.

Based on the overall acceptability scores, it was observed that mango blended fruit bars formulated from two varieties of jackfruit topped (4.01 and 3.96) closely followed by control fruit bars (3.91 and 3.81).

Among the two heath drink mixes standardized from jackfruit seed flour, consumer acceptance was better for malted health drink mix as compared to spiced health drink mix. The acceptance for appearance, colour, flavour, taste and clarity were higher for malted health drink mix. On the whole malted health drink mix (4.14) was better appreciated by the consumers, when compared to spiced health drink mix (3.90).

Biscuit standardized from jackfruit seed flour was found to be highly acceptable to the consumers as indicated by the acceptability scores attained. Overall acceptability of biscuit was found to be 97.2 per cent among the consumers. Confectionary item formulated *viz.*, laddus from jack seed flour was also found to be highly appreciated by the consumers. The overall acceptability score was 4.90 out of 5 which indicate 98 per cent acceptance for the product among the consumers.

4.6.2 Consumer Preference of the Products

Preference studies are designed to determine consumers subjective reactions to external phenomena and their reasons for having them.

Table 67 Consumer preference of the products developed based on hedonic point scale

Classification of products	Products	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike
Nectars	Control jackfruit nectar (V_1)	6	30	40	16	8
	Pineapple jackfruit nectar (V_1)	8	28	28	24	12
	Papaya jackfruit nectar (V_1)	8	16	28	30	18
	Mango jackfruit nectar (V_1)	12	30	16	14	28
	Control jackfruit nectar (V_2)	-	12	26	24	38
	Pineapple jackfruit nectar (V_2)	4	8	32	22	34
	Papaya jackfruit nectar (V_2)	2	12	32	22	32
	Mango jackfruit nectar (V_2)	12	22	26	24	16
Fruit bar	Control varikka bar	8	36	34	18	4
	Papaya blended varikka bar	12	14	34	20	20
	Mango blended varikka bar	16	30	30	12	12
	Control koozha bar	8	22	46	14	10
	Papaya blended koozha bar	6	20	44	14	16
	Mango blended koozha bar	10	28	36	14	12
Seed flour products	Malted health drink	8	18	40	12	22
	Spiced health drink	2	10	22	18	48
	Jackfruit seed flour biscuit	50	36	14	-	-
	Jackfruit seed flour laddu	62	24	12	2	-

V_1 – Variakka, V_2 – Koozha

According to Lundahal (1983) most consumers have fairly fixed ideas and know what to expect in terms of sensory quality of a given processed food. Consumer's reaction towards a new product are of great importance in the product. development, which would help in market promotion of the products.

Consumer preference of the products was ascertained for all the 18 products formulated from jackfruit, for this purpose, 50 consumers were selected at random, from different categories of people *viz.*, teachers, students and labourers.

Results are presented in Table 67 which indicate that among different nectars formulated from jackfruit control varikka nectar was lived extremely by six per cent of the consumers, whereas 30 per cent liked it very much, 40 per cent liked it moderately and 16 per cent liked it slightly and remaining eight per cent neither liked nor disliked.

The pineapple blended jackfruit varikka nectar was liked extremely by eight per cent of the consumers, 28 per cent liked it very much, another 28 per cent liked it moderately, 24 per cent liked it slightly and 12 per cent neither liked or disliked. In the case of papaya blended jackfruit varikka nectar eight per cent liked it extremely whereas 16 per cent and 28 per cent liked it very much and liked moderately. Thirty per cent of the consumers liked the papaya blended jackfruit varikka nectar slightly and 18 per cent neither liked nor disliked the nectar. The highest preference was observed for mango blended varikka nectar, 12 per cent consumers liked extremely, 30 per cent liked it very much, 16 per cent liked it moderately 14 per cent liked it slightly.

For control koozha jackfruit nectar none of the consumer liked it extremely, 12 per cent liked it very much, 26 per cent consumers liked it moderately, 24 per cent liked it slightly while 38 per cent consumers neither liked nor disliked.

The pineapple blended koozha nectar was liked extremely by four per cent consumers, whereas eight per cent liked it very much, 32 per cent liked it moderately, 22 per cent liked it slightly and remaining 34 per cent consumers neither liked nor disliked.

The papaya blended koozha nectar was liked extremely by two per cent of the consumers, 12 per cent liked it very much, 32 per cent liked it moderately, 22 per cent liked it slightly and remaining 32 per cent neither liked nor disliked. The preference was higher for mango blended koozha nectar, 12 per cent of the consumers liked it extremely, 22 per cent liked it very much, 26 per cent liked moderately, 24 per cent liked it slightly.

In the case of jackfruit bars, varikka control bars were liked extremely by eight per cent consumers, 36 per cent liked it very much, 34 per cent liked it moderately, 18 per cent liked it slightly and 4.00 per cent neither liked nor disliked. The papaya blended varikka bar was liked by 12 per cent consumers, 14 per cent liked it very much, 34 per cent liked it moderately, 20 per cent liked it slightly and 20 per cent consumers neither liked nor disliked. The mango varikka bar was preferred the highest. Sixteen per cent consumers liked it extremely, 30 per cent liked it very much, 30 per cent liked it moderately, 12 per cent liked it slightly and remaining 12 per cent neither liked nor disliked.

The control koozha bar was liked extremely by 8.00 per cent consumers, 22 per cent liked it very much, 46 per cent liked it moderately, 14 per cent liked it slightly and 10 per cent consumer neither liked nor disliked. The papaya blended koozha bar was liked extremely by 6.00 per cent consumers 20 per cent liked it very much, 44 percent liked it moderately, 14 per cent liked it slightly and 16 per cent consumers neither liked nor disliked. The mango blended koozha bar was liked extremely by 10 per cent consumers, 28 per cent consumers liked it very much, 36 per cent liked it moderately, 14 per cent liked it slightly and 12 per cent neither liked nor disliked.

The products formulated from seed flour were health drink mixes, biscuits and laddus. Among the three products laddu was preferred most. The malted health drink was liked extremely by 8.00 per cent consumers, 18 per cent liked it very much, 40 per cent liked it moderately, 12 per cent liked it slightly and remaining 22 per cent neither liked nor disliked.

For the spiced health drink 2.00 per cent consumers liked it extremely, 10 per cent liked it very much, 22 per cent liked it moderately, 18 per cent liked it slightly and 48 per cent neither liked nor disliked.

The biscuits formulated from jackfruit seed flour were liked extremely by 50 per cent consumers, 36 per cent liked it very much and 14 per cent liked it moderately, whereas jackfruit seed flour laddu were liked extremely by 62 per cent consumers, 24 per cent liked it very much and 12 per cent liked it moderately.

4.6.3 Consumer Preference Scores of the Products Developed from Jackfruit with respect to 'Rank Orders'

Based on the consumer's preference, the products developed under the present investigation were ranked. Per cent score of preference is the ratio of the aggregate score given by 50 consumers to the maximum score of five. Table 68 represents the rank order of the jackfruit products based on the consumer percentage score.

Out of the eight nectars standardized from the two varieties of jackfruit, consumers preferred control varikka nectar (62.0 per cent), followed by pineapple blended varikka nectar (59.2 per cent) and mango blended koozha nectar (58.0 per cent).

Among the fruit bars standardized from jackfruit control varikka bar and mango blended varikka bar were preferred by consumers (65.2 per cent each) followed by mango blended koozha bar (62.0 per cent) and control koozha bar (60.8 per cent). It is also worth mentioning that control

Table 68 Consumer preference scores of jackfruit products as per 'Rank Orders'

Classification of products	Products	Percentage score	Rank order
Nectars	Control jackfruit nectar (V_1)	62.0	4
	Pineapple jackfruit nectar (V_1)	59.2	6
	Papaya jackfruit nectar (V_1)	53.2	12
	Mango jackfruit nectar (V_1)	56.8	9
	Control jackfruit nectar (V_2)	40.0	15
	Pineapple jackfruit nectar (V_2)	45.2	14
	Papaya jackfruit nectar (V_2)	46.0	13
	Mango jackfruit nectar (V_2)	58.0	7
Fruit bar	Control varikka bar	65.2	3
	Papaya blended varikka bar	55.8	10
	Mango blended varikka bar	65.2	3
	Control koozha bar	60.8	5
	Papaya blended koozha bar	57.2	8
	Mango blended koozha bar	62.0	4
Seed flour products	Malted health drink	55.6	11
	Spiced health drink	40.0	15
	Jackfruit seed flour biscuit	87.2	2
	Jackfruit seed flour laddu	89.2	1

V_1 – Varikka jackfruit V_2 – Koozha jackfruit and mango blended varikka bar was the highly preferred food product among all the products standardized and stood third in rank.

In the case of seed flour products, consumers preferred laddus with percentage preference score of 89.2 per cent. Laddus was the most preferred product among all the products standardized and obtained the first rank order.

Biscuits standardized from jackfruit seed flour acquired second rank with a per cent score of 87.2 per cent.

Preference of the products by the consumers in the rank order of 3rd, 4th, 5th and 6th were control and mango blended varikka bar, control varikka nectar and mango koozha bar, control koozha bar and pineapple blended varikka nectar.

4.7 ECONOMIC VIABILITY OF THE PRODUCTS DEVELOPED WITH JACKFRUIT

Table 69 gives the detail of the cost of production of the finished products formulated from jackfruit. The cost of production of one litre of jackfruit nectars was found to range between Rs. 12 to Rs. 21, being highest for mango blended varikka nectar (Rs. 21.00) and lowest for plain koozha nectar (Rs. 12.00).

Clarified juice standardized from varikka jackfruit was comparatively expensive as the cost of the enzyme used for extraction is more. The cost of production was found to be Rs. 131 / litre of clarified juice. This is a concentrated juice which can be diluted and used for making various types of beverages.

Among the fruit bars standardized from jackfruit pulp the cost of one kg of fruit bars ranged from Rs. 23 – 40. Highest cost was accounted for mango blended varikka bar Rs. 40/- while the lowest for plain koozha bar Rs. 23. Cost of production of health drink mixes indicated that cost of

Table 69 Cost of jackfruit products developed

Name of the product	Cost of the finished product (inclusive of 10 % overhead charges) (Rs.)
Jackfruit nectars	Cost per litre
Plain varikka nectars	14.00
Plain koozha nectars	12.00
Pineapple blended varikka nectar	18.00
Pineapple blended koozha nectar	15.00
Papaya blended varikka nectar	15.00
Papaya blended koozha nectar	13.00
Mango blended varikka nectar	21.00
Mango blended koozha nectar	18.00
Clarified juice (varikka jackfruit)	131.00
Jackfruit bars	Cost per kg
Plain varikka bar	25.00
Plain koozha bar	23.00
Papaya blended varikka bar	29.00
Papaya blended koozha bar	27.00
Mango blended varikka bar	40.00
Mango blended koozha bar	38.00
Jackfruit seed flour products	
Malted health drink mix	72.00
Spiced health drink mix	88.00
Baked product	
Biscuit	50.00
Confectionary product	
Laddu	90.00

half kg malted health drink mix was Rs. 72 as against Rs. 88 per kg for spiced health drink mix.

Confectionary product formulated from jack seed flour was found to be Rs. 90 / kg while seed flour biscuit was Rs. 50/ kg.

Product Yield Ratio of Jackfruit Products

The factors that determine the cost of the final product is the turn over of the finished product obtained from the raw materials used. Knowledge of the product yield of any product developed is essential in deciding the economic feasibility of the product. Hence product yield ratio of each of the product standardized under the present investigation was determined.

Results are presented in Table 70. All the raw material used for obtaining the finished products is taken into account while ascertaining the product yield. Assessment of product yield of the clarified juice from jackfruit was found to be 1: 1.3.

Among the nectars standardized from the two varieties of jackfruit, the yield was recorded highest for pineapple blended koozha and varikka nectars (1 : 1.4 / 1 : 1.3), followed by mango blended nectars of varikka and koozha variety (1 : 1.2 / 1 : 1.3). Comparatively low yield was recorded for plain nectars of both varieties (1 : 1/1) and was found to be similar.

In the case of fruit bars standardized from jackfruit the highest yield was recorded for mango blended bars of both varieties (1 : 0.90/ 1: 0.85) closely followed by plain fruit bars of varikka and koozha variety (1 : 0.85 / 1 : 0.88). The lowest yield for fruit bars was observed for papaya blended bars of both varieties (1 : 0.80 / 1 : 0.85). Product yield of jackfruit seed flour was also accounted. Product yield was slightly more for malted health drink mix (1 : 0.95) as compared to spiced health drink mix (1 : 0.90). Product yield of biscuit and laddu was 1 : 0.97 and 1 : 0.99 respectively.

Table 70 Product yield ratio of jackfruit products

Name of the product	Product yield ratio
Jackfruit nectars	
Clarified juice	1 : 1.3
Plain varikka / koozha nectar	1 : 1.1 / 1 : 1.1
Pineapple blended varikka/koozha nectar	1 : 1.3 / 1: 1.4
Papaya blended varikka/koozha nectar	1 : 1.1 / 1: 1.2
Mango blended varikka/koozha nectar	1 : 1.2 / 1 : 1.3
Jackfruit bars	
Plain varikka/koozha bar	1 : 0.85 / 1 : 0.88
Papaya blended varikka/koozha bars	1 : 0.80 / 1 : 0.85
Mango blended varikka/koozha bars	1 : 0.90 / 1 : 0.85
Jackfruit seed flour products	
Malted health drink mix	1 : 0.95
Spiced health drink mix	1 : 0.90
Baked product	
Biscuit	1 : 0.97
Confectionary product	
Laddu	1 : 0.99

4.8 BYPRODUCT RECOVERY FROM JACKFRUIT WASTE AND ITS QUALITY ANALYSIS

Kalsi and Dhawan (2001) stated that fruit wastes are generated at various stages in the process of their harvesting, handling, transport, storage, marketing, processing or even during their use in kitchen. Tandon and Garg (1999) remarked that utilization of waste for the extraction of useful byproducts is important from economical as well as environmental point of view.

Under the present investigation waste arising after processing of jackfruit was subjected to recover useful byproducts. Pectin and starch are the two byproducts extracted from the jackfruit waste in the present investigation. Krishnamurthy and Giri (1949) and Bhatia *et al.* (1956) had found that pectin can be recovered from jackfruit waste.

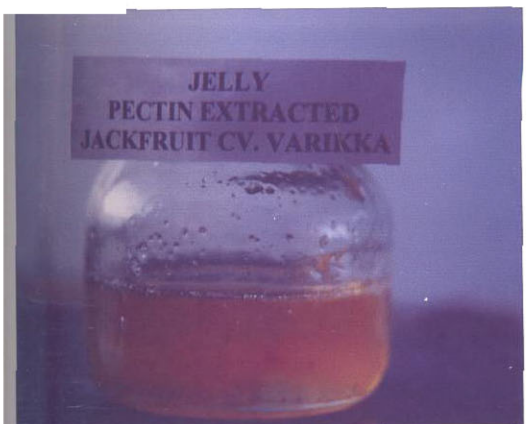
Roy and Mitra (1970) and Bobbio *et al.* (1978) reported that the jackfruit seeds being a rich source of starch were used for extracting starch.

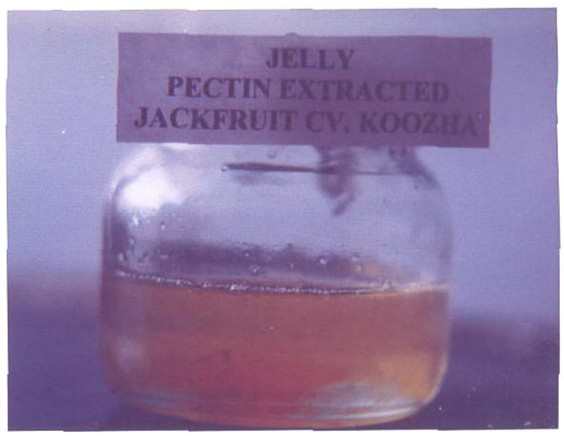
Quality evaluation of pectin and the starch extracted from jackfruit waste was undertaken in order to substantiate its quality. Plate 6 depicts the pectin and starch extracted from jackfruit waste.

4.8.1 Quality Analysis of Pectin Recovered from Jackfruit Waste

Pectin is a natural component found in most of the plants, in combination with other structural components such as cellulose. It acts as a strengthening and cementing material giving texture to the tissues. It is an extremely versatile ingredient which is used to improve the quality of food and pharmaceutical products (Citrus Colloids Ltd., 1996).

Sudhakar and Maini (1995) has the opinion that pectins isolated from plant material, play a significant role in the manufacture of fruit products like jams, jellies, marmalades, preserves etc. and thus are indispensable to the fruit processing industry.





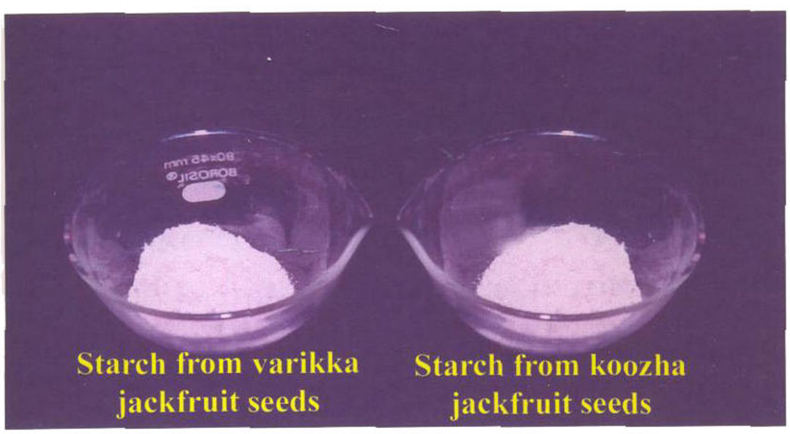


Plate 6. Byproducts extracted from jackfruit

Table 71 gives a detailed picture of the quality parameters analysed in the pectin extracted from jackfruit waste. The quality parameters ascertained were moisture, equivalent weight, methoxyl content, viscosity and jelly grade.

Table 71 Quality analysis of pectin extracted from jackfruit waste

Parameters	Varikka	Koozha	t value
Equivalent weight	499.66	331.73	136.56**
Methoxyl content (per cent)	12.26	15.26	24.05**
Viscosity (relative)	1.08	1.00	26.00**
Jelly grade	180.00	160.00	1.70
Jellying capacity (minutes)	20.00	20.00	-
Cost (Rs. / 100 g)	1290.00	1290.00	-
Yield (per cent dry weight)	3.68	2.88	12.48**

*Significant at 5 per cent level, **Significant at 1 per cent level

Ranganna (1986) pointed out that the equivalent weight is used for calculating the anhydrouronic acid content and the degree of esterification. The anhydrouronic acid content of the pectin indicates the percentage of other organic material present, generally neutral polysaccharides, while ash content represents the amount of inorganic impurities. Equivalent weight obtained in the pectin extracted from the two varieties of jackfruit was 499.66 in varikka fruit as against 331.73 in koozha. Significant difference was observed with respect to equivalent weight (136.56**) of pectin extracted from the two varieties of jackfruit.

The methoyxyl content or degree of esterification is an important factor in evaluating the setting time of pectins, their combining ability with metallic ions and the ability of the pectin to form gels (Francis and Bell, 1975). The methoxyl content of the pectin extracted from jackfruit waste of the two varieties of jackfruit was found to be 12.26 and 15.26 respectively in varikka and koozha variety. Significant difference (24.05**) was observed in the methoxyl content of the pectin isolated between the two varieties.

The molecular weight of pectin which is related to the length of polysaccharide chain is another important parameter contributing to the jelly formation, viscosity and the firmness of the texture of many food products. The relative viscosity was found to be higher for varikka variety (1.08) as compared to koozha variety (1.00). Significant difference was observed with respect to relative viscosity of pectin extracted from the two varieties (26.00**) of jackfruit.

The jelly grade for the pectin obtained was found to be 180 from varikka variety while for koozha the jelly grade was 160. The jelly grade of the pectin extracted from waste varied between the varikka and koozha varieties, however the difference was not significant.

The jellying capacity of the pectin extracted from jackfruit was ascertained and found that the time taken for setting was 20 minutes which indicate that the jellying capacity is rapid setting.

The yield of pectin (dry weight basis) from the jackfruit waste was worked out, and was found to be 3.68 per cent for varikka as against 2.88 per cent in koozha variety. A significant difference was also observed in the per cent yield of pectin between the two varieties (12.48**).

The cost of extraction of pectin from the jackfruit waste was accounted to be very expensive. The cost of extraction was accounted to be Rs. 1290 for obtaining 100 g pectin from 1 kg of fruit waste.

4.8.2 Quality Analysis of Starch Recovered from jackfruit

Starches are generally added to foods not as a source of nutrient, but for the functional properties they contribute. Some of the desirable traits starch contributes are textural qualities, mouth feel, thickening, gelling, binding and offer stability to food products (Dias *et al.*, 1997).

Tandon and Kalra (1989) stated that besides tubers, seeds, kernels also serve as a potential source of starch. Roy and Mitra (1970) and Bobbio *et al.* (1978) had reported that jackfruit seeds contain 25 -52 per cent of starch.

The starch extracted from jackfruit was analysed for amylose content, alkali number, granule size, relative viscosity, gelatinization temperature, yield and cost benefit ratio (Table 72).

Table 72 Quality analysis of jackfruit seed starch

Parameters	Varikka	Koozha	t value
Amylose content (per cent)	32.36	22.53	18.56**
Alkali number	2.15	3.82	23.33**
Granule size (μm)	8.17	7.21	13.88**
Viscosity	2.05	1.06	119.03**
Gelatinization temperature (°C)	80.20	67.90	28.72**
Cost analysis (Rs./100g)	55.00	55.00	24.60**
Yield (per cent dry fruit)	6.9	6.1	2.25*

*Significant at 5 per cent level, **Significant at 1 per cent level

The common starches contain about 20-30 per cent amylose and 70-80 per cent amylopectin. The gelling property of starch depends upon the amylose content (Kaur *et al.*, 2002). The amylose content present in varikka seeds was found to be 32.36 per cent as against 22.53 per cent of koozha seeds. Significant difference was observed with respect to amylose content of the seeds of two varieties (18.56**).

Alkali test was performed which indicated that the alkali number was 2.15 for varikka seed starch as against 3.82 for koozha seed starch.

The size and shape of starch granules vary depending upon their origin (www.ontrackindia.com). The granule size for varikka seeds was found to be 8.17 µm as against 7.21 µm of koozha seeds.

Starch do not form a true solution and yield heavy stringy and viscous dispersions. The analysis of viscosity of jackfruit seeds revealed a higher viscosity 2.05 for varikka seeds as compared to 1.06 for koozha seeds.

Gelatinization temperature is one of the important parameters with respect to starch granules, which clearly indicates its dispersion ability with water. Starch granules gradually hydrolyse when mixed with water and form a colloidal dispersion forming a paste. The gelatinization temperature for varikka seed starch was found to be 80.2°C as against 67.9°C in koozha seeds.

The starch obtained from the jackfruit seeds were anlaysed (dry weight basis) and the yield was found to be 6.9 per cent and 6.1 per cent respectively in varikka and koozha seeds. The cost incurred for extracting starch was accounted and found to be Rs. 55 per 100 g.

A significant difference was observed between the starch extracted from jackfruit seeds with respect to alkali number (23.33**), granule size (13.88**), viscosity (119.03**), gelatinization temperature (28.72**) and percentage yield (2.25*).

Discussion

5. DISCUSSION

Discussion pertaining to the present investigation entitled "Utilization of jackfruit for product development and byproduct recovery" is presented under the following lines.

5.1 Assessment of physico-chemical characteristics of jackfruit

5.2 Standardisation and product development utilizing jackfruit bulbs and assessing the chemical, nutritional, organoleptic and shelf stability features of developed products

5.3 Standardisation and product development utilizing jack seed flour and assessing the chemical, nutritional, organoleptic and shelf stability features of developed products

5.4 Assessment of microbial profile of the products standardized

5.5 Comparison of the products developed with FPO standards

5.6 Assessment of consumer acceptance and consumer preference of the products standardized

5.7 Economic viability of the jackfruit products developed

5.8 Byproduct recovery from jackfruit and its quality evaluation

5.1.1 Assessment of Physical Characteristics of Jackfruit

As early as in 1965, Morton reported that the jackfruit is hardly regarded as a commercial fruit crop although it is widely cultivated in Southern Asia, East Indies and other warm areas of both hemispheres. The fruit appears in the market in spring and continues until summer, and enjoys a high premium price (Samaddar and Yadav 1970). Roy (1994) reported that several varieties of jackfruit are found and they vary widely in size, shape, appearance and taste. The information pertaining to the physical attributes of jackfruit is scattered throughout the literature and hence observations on the physical attributes of the fruit such as colour, inter spine distance, number of spines per unit area, peduncle length, weight of fruit, length of fruit, number of fruits per plant and yield per plant were recorded.

The colour of the fruit was observed to be green when unripe but as the fruit matures the colour turned to be yellow. Berry and Kalra (1987) opined that the fruit is pale green to yellow brown in colour, formed by a number of conical horny protuberances.

Sharma (1964) reported that the fruit constitutes, fruit axis, persistent perianth and true fruit. The perianth is the most important part and constitutes major bulk of the fruit. It has lower free and fleshy edible region and the upper free and horny non-edible region. Bose and Mitra. (1990) reported that as the fruit ripens the length of the spines decrease, the distance between the spines increase and the spines per unit area of fruit decreases.

Interspine distance and the spines per unit area was recorded in the two varieties of jackfruit under study. The inter spine distance was found to be more for varikka fruit (1.26 cm) as compared to koozha fruit (0.99 cm). The number of spines per unit area decreased as the fruit matures and the spines flatten. Significant difference was observed in the number of spines /unit area in the two varieties of jackfruit (14.04**) and was recorded more for varikka variety (5.07) as compared to koozha (4.23). No significant difference was observed in the peduncle length of the two varieties of jackfruit, however length was recorded higher for varikka fruit (60.70 cm) compared to koozha (60.10 cm).

Significant difference (9.67** and 56.85** respectively) was observed in weight and length of the fruits of the two varieties. The koozha fruit was found to be heavier (6.61 kg) and larger in size (100.04 cm) as compared to varikka fruit (5.45 kg weight and 80.12 cm length). As early as in 1953, Hayes reported that fruit attains greater size when fully mature and the large fruits may weigh as much as 40 kg. Hossain and Haque (1977) reported average fruit weight as 3.24 - 7.39 kg, the weight of the pulp and seed being 0.57 and 0.39 kg respectively in the smallest fruit and 2.70 and 1.01 kg in the largest fruit. Srinivsan (1971) reported that the average weight of the newly evolved cultivar named Muttan varikka as 7.0 kg with 46 cm length and 23 cm width.

Significant difference was observed in the number of fruits in varikka (51) as compared to koozha variety (46). Varietal difference (14.44**) was also reflected in the yield / plant, which was recorded lower for varikka variety (276.77 kg) as compared to koozha variety (298.87 kg).

5.1.2 Assessment of Cut Jackfruit

In order to get information regarding the bulbs of the jackfruit, the fruit was opened and analysed for colour, length and weight of the bulbs and length and weight of the seeds. The colour of the bulbs was found to be bright yellow in varikka variety as against pale yellow in koozha bulbs.

Significant difference was found between the two varieties of jackfruit with respect to length and weight of bulbs (29.75**, 9.84**) as well as length and weight of seeds (16.21**, 20.59**). Similarly length and weight of koozha seeds (6.96 cm and 4.43 g) was more compared to varikka seeds (5.77 cm and 3.20 g respectively). The number of seeds was also found to be more for koozha as compared to varikka. Bhatia *et al.* (1955) reported that the bulbs constitute 29 per cent, while the seeds and the rind constitutes 12 and 54 per cent respectively in the ripe fruit.

From the observations enlightened above, it can be concluded that weight and length of varikka bulbs were lower than koozha fruits, however bulbs were more attractive and bright in varikka variety though the varikka fruits were smaller in size compared to koozha variety. Varietal difference was also reflected in the number of fruits and yield per plant, which was in favour of varikka variety.

5.1.3 Assessment of Chemical Constituents in Jackfruit Bulbs

The chemical composition of the jackfruit with respect to moisture, acidity, pH, TSS, total sugar, reducing sugar, fibre, pectin, β-carotene, vitamin C and polyphenol was assessed in the two varieties of jackfruit.

Under the present investigation moisture level observed was almost similar, however, moisture content of koozha variety was found to be higher (78.10 per cent) than varikka variety (76.56 per cent). Berry and Kalra (1987) and Anon (1979) reported 77.2 per cent moisture in ripe jackfruits. Acidity was also found to be higher for koozha variety (2.63 per cent) as against 2.64 per cent for varikka variety. Siddappa and Bhatia as early as in 1955 found acidity of jackfruit bulbs as 2.34 per cent. The pH of the fruit was found to be higher for koozha variety (4.13) as compared to its counterpart (3.96).

Significant difference in TSS content was found between the two varieties of jackfruit, being higher for koozha (25.10°Brix) as against 21.96°Brix in varikka.

Significant difference in total sugar and reducing sugar was also observed in the two varieties of jackfruits under study. The total sugar and reducing sugar content of koozha variety was higher, 22.83 per cent and 3.66 per cent respectively as against 19.86 per cent and 5.71 per cent in varikka variety. Results obtained was in tune with the observation reported by Siddappa and Bhatia (1955). The author reported 20.63 per cent total sugar and 5.03 per cent reducing sugar in jackfruit pulp. However, Chan and Hen (1975) reported 11.45 per cent total sugar in ripe jackfruit which is lower than the total sugar value observed in the two varieties of jackfruit under study. The fibre content in the jackfruit was more or less same for both the varieties (1.03 and 1.22 per cent respectively for varikka and koozha fruits). Siddappa and Bhatia (1955) found 2.89 per cent fibre in jackfruit while, Tojal (1975) reported 0.68 per cent fibre in jackfruit. Anon (1979) reported fibre content of ripe jackfruit as 1.10 g. Samaddar and Yadav (1970) was of the opinion that varietal difference, climatic and soil conditions may influence the chemical composition of jackfruit.

Jackfruit is considered as a cheap but valuable source of β-carotene and is very popular among the population of lower income group. Carotene content was found to be more in koozha variety (178.36 μg) compared to varikka (163.66 μg). Gopalan *et al.* (1999) reported β-carotene content of ripe jackfruit as 175 μg, while Hossain and Haque (1979) had reported β-carotene content between 250-1740 μg/100 g in jackfruit. Anon (1979) had reported β-carotene in ripe fruit as 162 μg.

Vitamin C content was observed to be low in both the varieties of jackfruit studied (10.36 and 9.70 μg/100 g respectively in varikka and koozha). The values recorded was on par with the values reported by earlier researchers. Bhatia *et al.* (1955), Gopalan *et al.* (1999) and Hossain and Haque (1979) reported vitamin C content in jackfruit as 10.08 per cent, 7.00mg/100g and 2.64-11.77 mg/100g respectively.

5.1.4 Assessment of Jackfruit Pulp

The bulbs from the two varieties of jackfruit were utilized for the preparation of pulp which was further used for product development. Chemical composition of the fruit pulp was analysed.

The moisture content of the varikka and koozha pulp was significantly different and was found to be 77.98 per cent and 79.03 per cent respectively. Siddappa and Bhatia (1955) had reported moisture content of jackfruit pulp as 72.51 per cent.

The acidity of varikka pulp was higher (3.03 per cent), as a reflection of higher acidity of varikka fruit when compared to koozha (2.93 per cent). Siddappa and Bhatia (1955) had reported 2.34 per cent acidity in the jackfruit pulp. The pH of the pulp from the two varieties of jackfruit was found to be quite similar.

The total sugar content of varikka pulp was lower (21.92 per cent) while that of reducing sugar content was higher (5.1 per cent) then found in koozha pulp (3.20 per cent). Siddappa and Bhatia (1955) reported total sugar content of jackfruit pulp as, 20.63 per cent and reducing sugar content as 5.03 per cent.

5.1.5 Assessment of Jackfruit Seeds

Jackfruit seeds encased in the soft cream coloured pulp are edible. The seeds were assessed for moisture, acidity, total sugar, reducing sugar, protein, total carbohydrates, fibre and total minerals.

The moisture content of jackfruit seeds was observed to be higher for koozha variety (63.43 per cent) as compared to varikka variety (60.02 per cent). The moisture content of jackfruit seeds reported by Tojal (1975) was comparatively higher (70.35 per cent). However, Kumar *et al.* (1988) reported moisture content as 63.19 per cent and 64.87 per cent in Kathari and Bharat Baramasi variety.

Significant variation was observed in moisture content (200.82**), acidity (20.00**), total sugar (10.96**), reducing sugar (13.00**), total carbohydrates (9.87**), protein (5.42*) and total minerals (4.24*) between the seeds of two varieties. However no significant difference was observed in starch and fibre content in the two varieties of jackfruit seeds.

The protein content of the seeds was observed to be higher for varikka variety (5.80 g) compared to that of koozha variety (5.10 g). Tojal (1975) reported protein content in jackfruit seeds as1.609 g which is comparatively lower than the protein content estimated in the varikka and koozha seeds under investigation. However, Novis and Coutinho (1952) reported protein value as 9.4 per cent in jackfruit seeds. Protein content reported by Kumar *et al.* (1988) in jackfruit seeds was 6.75 per cent for Kathari and 6.25 per cent for Bharat Baramasi variety.

The total carbohydrate content of the seeds was observed as 12.70 per cent for varikka and 13.83 per cent for koozha. Tojal (1975) found carbohydrate content of Jackfruit seeds as 12.45 per cent. Kumar *et al.* (1988) reported total carbohydrate content of the two varieties of jackfruit as 28.01 per cent for Kathari and 6.83 per cent for Bharat Baramasi.

The starch content in varikka and koozha seeds was found to be 14.13 and 13.86 per cent respectively. Roy and Mitra (1970) and Bobbio *et al.* (1978) found the starch content of seeds of jackfruit as 25–52 per cent which is quite higher as compared to the starch content observed in the two varieties under present investigation. However, Kumar *et al.* (1988) reported 15.50 per cent starch in Kathari variety and 14.35 per cent in Bharat Baramasi variety.

The fibre content of the seeds of varikka and koozha variety under observation was found to be 1.40 per cent which is higher than the fibre content (0.68 per cent) reported by Tojal (1975).

Total mineral content of jackfruit seeds was estimated to be 1.46 per cent and 1.26 per cent respectively in varikka and koozha which was on par with the values reported by Tojal *et al.* (1975) (1.5 per cent). Kumar *et al.* (1988) reported total mineral content as 1.27 per cent for Kathari and 1.16 per cent for Bharat Baramasi variety of jackfruit.

Assessment of the chemical constituents of jackfruit bulbs and seeds of both varieties, revealed that they could be considered as a valuable source of various nutrients. Significant difference was observed in the nutrients and chemical constituents between the two varieties of jackfruit bulbs and seeds.

5.2 STANDARDIZATION AND PRODUCT DEVELOPMENT UTILIZING JACKFRUIT BULBS

Standardization is a prerequisite of any food based industry. Singh and Gopalakrishnan (2002) have opined that product diversification is the need of the hour due to rapid changes in socio-economic and living styles of the people dwelling in the rural and urban areas. As a result more and more convenient foods are entering in the market. In the present study. jackfruit is taken as a resource for product development

5.2.1 Standardization of Clarified Juice from Jackfruit Pulp

Expression of juice from the jackfruit is difficult and juice yield is comparatively low. In the present study enzymatic treatment was applied to obtain clear juice from jackfruit. The standardization of clarified juice indicated that maximum juice yield was obtained when jackfruit pulp was treated with one per cent enzyme, incubated at 40°C for two hours. Juice obtained was sparkling clear and was free from any suspended particles.

5.2.1.1 Assessment of Chemical and Nutritional Characteristics of Clarified Juice Standardized from Jackfruit

The clarified juice obtained from jackfruit after enzymatic treatment was found to have a acidity 1.86 per cent, pH of 5.02, TSS 15.03°Brix, total sugar 8.89 per cent, reducing sugar 7.56 per cent, pectin 0.00/100 g, β-carotene 121.70 and vitamin C 1.02 mg/100 g whereas the jackfruit juice obtained without enzyme treatment had acidity 2.05 per cent, pH of 5.60, TSS 11.12°Brix, total sugar 8.42 per cent, reducing sugar 6.73 per cent, pectin 0.16 g/100 g, β-carotene 136.16 μg and vitamin C 2.01 mg/100 g.

Significant difference was observed in the pH of the clarified juice between the treated and untreated sample (23.59**). pH was found to be low in the clarified juice when compared to control sample. Ahmed (1996) reported the effect of liquid pectolytic enzyme on different varieties of Banana fruit and found, that the juice obtained had a pH ranging from 4.27 – 4.67. Joshi *et al.* (1991) reported that addition of pectinols to the pulps of plum, peach and apricot caused slight decrease in pH. Treated pulp under the present investigation also depicted same trend.

Significant difference (8.85**) was observed between the treated and control juice with respect to acidity and was higher in untreated juice. Similar observation was reported by Joshi *et al.* (1991) in the juices extracted from pulps of peaches, plums and apricot after enzymatic treatment. Ahmed (1996) reported that the acidity of clarified juice from banana varieties subjected to enzyme treatment ranged between 0.45 – 0.51 per cent. Sandhu *et al.* (1988) reported a higher acidity in the clarified juice obtained from apple pomace subjected to enzymatic treatment.

The enzyme treatment resulted in significant increase in TSS (35.27**), total sugar (13.40**) and reducing sugar (6.69**) in the jackfruit juice when compared to control juice. In support of the above, Sandhu (1988) reported an increase in total soluble solids, reducing and total sugar in the enzyme treated juice. Devaraju *et al.* (2002) reported the comparative efficacy of pectinase enzymes in the juice recovery from Ber fruit. The results revealed that quality parameters like TSS (14.78°Brix) and total sugar (10.27 per cent) improved when compared with untreated sample. Ahmed (1996) found TSS of clarified juice of enzyme treated banana varieties as 17-25°Brix.

Pectin content was found to be nil in the enzyme treated sample as compared to control sample (0.16 g/100 g). When the juice was treated with pectinase enzyme, the insoluble fraction was converted to soluble fraction and as a result no pectin is left in the treated mass. Sandhu *et al.* (1988) supported the above finding.

The nutrient content was found to alter due to enzyme treatment with the significant reduction in β-carotene and vitamin C content (4.59** and 149.00** respectively) in the enzyme treated sample. Vitamin C gets oxidized rapidly when subjected to enzyme treatment and hence easily destroyed. The results are on par with the earlier work carried out by Sandhu *et al.* (1988) where the ascorbic acid decreased in the enzyme treated apple pomace juice. Joshi *et al.* (1991) reported low vitamin C content in the juices extracted from peaches, plums and apricots subjected to enzyme treatment. However, Devaraju *et al.* (2002) reported an increase in vitamin C content in enzyme treated Ber juice (59.55 mg/100 g) as compared to control juice (57.55 mg/100 g).

The enzyme treated juice obtained from jackfruit was sparkling clear with no suspended impurities. This is an important quality required for the clarified juice. The present investigation confirm that, enzyme treatment enabled to obtain the above criteria for the jackfruit juices. The above finding was in line with Sandhu *et al.* (1988) who obtained clear juice from apple pomace after enzyme treatment. Similar results were also reported by Joshi *et al.* (1991) where clear and less viscous juice was obtained from pulps of plum, peach and apricot.

Slight browning was detected in the enzyme treated juice (0.10) as compared to control. Sandhu *et al.* (1988) reported browning at the rate of 0.015 for the apple pomace juice subjected to enzyme treatment. Similarly, Ahmed (1996) reported the effect of pectolytic enzyme on the different varieties of banana fruit and found that the colour of the juices was different for different varieties of banana. Brown colour was more intense for Singapuri variety of banana followed by Chapa, Kathali and Martamam.

The juice yield was found to be significantly (38.44**) higher in the enzyme treated sample and the increase was accounted to be 31 per cent.

Similar results were reported by Sandhu *et al.* (1988). He found 20.07 per cent increase in juice yield in the Maharaji variety and 9.79 per cent increase in the Red Delicious variety of apple. Devaraju *et al.* (2002) reported an increase in the juice yield as 55.37 per cent in the enzyme treated ber fruit. Bhalla and Chatanta (2000) reported an increase in the juice yield in the ripe fruit of plum as 18 per cent, peaches 35.5 per cent and in apricot 33.7 per cent.

The results obtained clearly establish that enzyme treatment in jackfruit influence the juice yield and the clarity of the juice and does not bring forth any undesirable qualities.

5.2.2 Standardization of jackfruit nectars

Manan *et al.* (1992) stated that fruit Beverages and juices are not only rich in minerals, vitamins and nutritive factors but are also delicious and have an universal appeal. In the present study nectars were standardized from the two varieties of jackfruit *viz.*, varikka and koozha individually and by blending with other fruit pulps.

5.2.2.1 Chemical and Nutritional Characteristics of Nectars Standardized from Jackfruit

Significant difference in the acidity was observed between various nectars standardized. The lowest acidity was observed in papaya blended koozha nectar (0.33 per cent) and the highest for pineapple blended varikka nectar (0.59 per cent). Kumar and Manimegalai (2003) reported 0.3 per cent acidity for whey based pineapple RTS, whereas Raj and Khurdiya (2003) reported 0.29 per cent acidity in RTS prepared from pulp of culled apple pomace. In another study, Kumar and Manimegalai (2002a) found 0.3 per cent acidity in soy milk whey blended papaya RTS. In this context, acidity of the nectars standardized was in tune with the earlier findings reported.

Significant difference was observed with respect to pH between the various nectars standardized. The pH of the nectars standardized ranged from 5.71 to 4.11 being highest for papaya blended koozha nectar and lowest for pineapple blended varikka nectar. Irene (1997) reported pH as 4.60 for mango based RTS beverage. While, Diju (1995) reported pH of RTS beverage formulated from passion fruit as 3.50.

No significant difference was observed with respect to TSS between the nectars standardized. Mango blended varikka nectar recorded highest TSS whereas pineapple blended koozha nectars recorded the lowest. TSS of the product can be adjusted depending upon preference of the consumers and FPO prescribe a minimum of 15°Brix TSS in nectars. In this context the nectars formulated stand ideal and satisfy the requirements. Diju (1995) reported TSS of RTS beverage formulated from passion fruit as 12.45° Brix while, Beena (1998) reported TSS of mango blended nectar as 15°Brix. RTS beverage developed by Kumar and Manimegalai (2002) from soya milk whey blended with papaya was found to have a TSS of 15° Brix.

Significant difference was observed with respect to total sugar content between the various nectars and the highest total sugar was observed in mango blended varikka nectar however, comparatively low total sugar (5.89 per cent) was reported in citrus juices by Mehta and Bajaj (1983). Jackfruit contains various sugars and hence the total sugars present in the nectars were comparatively high.

Reducing sugar content was found to vary in various nectars standardized under the present study. The highest reducing sugar was observed in papaya blended koozha nectar (3.83 per cent) and the lowest in control varikka nectar (2.51 per cent). Pandey *et al.* (2003) reported reducing sugar content in carrot juice as 3.4 per cent.

Significant difference was observed with respect to all the nutritional constituents analysed between the various nectars standardized. The highest β-carotene content was observed in mango blended varikka nectar (400.72 μg) and lowest in control varikka nectar (121.61 μg) which indicate that, β-carotene content was enhanced when mango pulp was blended with jackfruit. The blending improved the nutritional content of the nectars.

The highest vitamin C content was observed in papaya blended koozha nectar (11.43) and the lowest in control varikka nectar (7.70).

Significant difference was found between the various nectars standardized. Vitamin C content of RTS beverage formulated from whey based mango fruit was 1.40 mg/100 g (Kumar and Manimegalai , 2001) whereas, Kumar and Manimegalai (2002a) reported vitamin C content as 5.60 mg / 100 g in RTS beverage prepared from soy milk whey blended with papaya. Kumar and Manimegalai (2003) reported vitamin C content as 3.50 mg per cent for whey based pineapple RTS. In another study, Teortia *et al.* (1997) reported vitamin C content as 10.89 mg for muskmelon RTS. Diju (1995) reported a vitamin C content of 15.5 mg/100 g in passion fruit beverage.

Polyphenolic content of nectars was also found to vary significantly between the nectars formulated. Polyphenolic content was highest in mango blended varikka nectar (98.85 g/100 g) and the lowest in control varikka nectar (23.45 g/100 g).

5.2.2.2 Organoleptic Features of the Nectars Standardized from Jackfruit

Christienson (1985) reported that organoleptic assessment stands essential for the development of new products. According to Potter (1986) parameters such as appearance, colour and taste determine the quality and also function as a common index of spoilage.

On assessing the sensory attributes of nectars formulated, it was found that appearance score of the nectars ranged between 3.96–4.30 out of 5, indicating 70–86 per cent acceptance for appearance attribute. The highest score for appearance was secured by Papaya blended varikka nectar (4.30) and the lowest score for control koozha nectars (3.96). The colour scores of jackfruit nectars ranged between 4.04 – 4.29 with the lowest score for control varikka nectar and highest for papaya blended nectars. However no significant difference with respect to appearance and colour scores was observed between the various nectars formulated.

The colour and appearance attribute of the nectars was found to be highly favourable when papaya pulp was blended with jackfruit. The reddish orange colour of ripe papaya gave good appeal to the finished products.

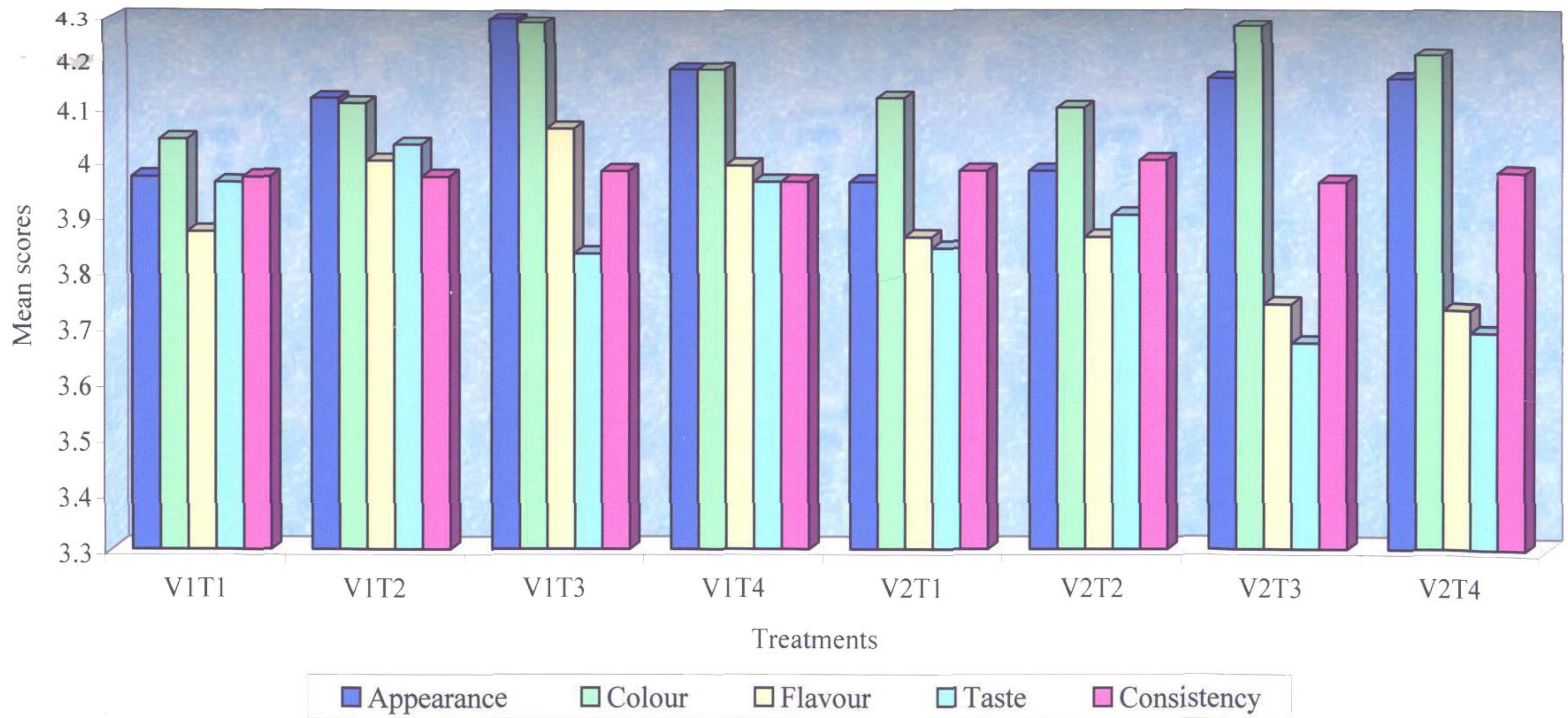
Bajaj *et al.* (2002) is of the opinion that flavour imparts recognizable character in the food products. The flavour scores of the nectars formulated ranged from 4.06 – 3.73. Pineapple blended varikka nectar was adjudged to be the best while mango blended koozha nectar, the lowest in flavour. The pineapple pulp blends well with jackfruit pulp and improved the flavour of the finished product. Significant difference was observed with respect to flavour between the various nectars standardized. Neelofer (2004) reported that when pineapple juice was blended with tender coconut water, appeal of the RTS beverage enhanced considerably.

In taste parameter also, pineapple blended nectars were superior, closely followed by mango blended varikka nectar. Papaya blended jackfruit nectar was found to be poor in taste attribute. However no significant difference was observed with respect to taste scores between the various nectars formulated.

The consistency attribute scored best for pineapple blended koozha nectar (4.00), closely followed by mango blended koozha nectar (3.98) and the lowest score was secured by mango blended varikka nectar (3.96). The overall acceptability score of the nectars standardized ranged between 3.97–3.88 out of 5 indicating 77–79 per cent acceptability among the panel members. Fig. 7 represents the organoleptic features of jackfruit nectars.

5.2.2.3 Assessment of Changes in the Physico-chemical Characteristics of Nectars During Storage

Monitoring the storage behaviour is as important as its acceptability testing in formulation of any new product. Potter (1986)



V_1T_1 – Control varikka jackfruit nectar
V_1T_2 – Pineapple blended varikka jackfruit nectar
V_1T_3 – Papaya blended varikka jackfruit nectar
V_1T_4 – Mango blended varikka jackfruit nectar

V_2T_1 – Control koozha jackfruit nectar
V_2T_2 – Pineapple blended koozha jackfruit nectar
V_2T_3 – Papaya blended koozha jackfruit nectar
V_2T_4 – Mango blended koozha jackfruit nectar

Fig. 7. Organoleptic features of jackfruit nectars

considered that the knowledge of the constituents of food and their proportions is the basis of the understanding of product quality. Shelf life quality of the nectars was assessed by monitoring the changes occurring in chemical and organoleptic qualities with storage.

Acidity

According to Ashurst (1986) acidity gives flavour and offer antimicrobial activity to the beverages. Significant increase in acidity was observed between the nectars formulated from two varieties of jackfruit with storage. Similar findings was reported by Raj and Khurdiya (2003) in RTS beverage formulated from apple pomace stored for six months. The reason for increase in the product may be due to the accelerated degradation of pectin (Conn and Stump, 1976) or due to the formation of organic acids from ascorbic acid degradation (Prasad and Mali 2000). The increase in acidity was found to be 0.50 per cent in varikka variety and 0.39 per cent for koozha variety. Varikka variety itself is more acidic as compared to koozha variety which might have contributed for the higher increase in acidity of the nectars with storage.

Among the four treatments attempted highest increase in acidity was recorded in pineapple blended nectar (0.50 per cent) followed by mango blended nectar (0.49 per cent). Significant difference was observed with respect to acidity between the various blended nectars tried out during storage.

Influence of storage condition on the acidity of nectars indicated that lesser changes were noted in the nectars stored under refrigerated condition though the changes were apparent. The increase in acidity of the nectars stored under ambient condition ranged between 0.40 – 0.51 per cent while under refrigerated condition it ranged between 0.40 – 0.46 per cent.

Influence of storage period on the acidity of the nectars indicated that acidity was found to increase significantly when stored for two months. Considerable increase in acidity was observed after two weeks of storage though the increase was not found to affect the quality of the nectars. Increase in acidity was reported in whey based mango RTS by Kumar and Manimegali (2001). Similar findings were reported by Kumar and Manimegalai (2002a) for soy milk whey blended papaya RTS. Sethi and Malini (1989) noticed an increase of 2.08 per cent acidity in tomato concentrate stored for eight months. Pandey *et al.* (2003) also reported increase in acidity in the carrot juice concentrate stored for a period of three months. Increase in acidity was also reported by Irene (1997) in mango based RTS beverage stored for eight months and in passion fruit RTS stored for six weeks by Diju (1995). Increase in acidity was also reported by Beena (1998) in nectars formulated from papaya pulp.

Overall increase in acidity in the nectars with the storage was found to be 22.5 per cent. Significant interaction was noted in acidity between variety and storage period, variety and storage condition ,treatment and storage condition and between variety and treatment.

pH

Significant difference in pH was observed in the nectars standardized from two varieties of jackfruit with storage, though the changes were minimum to bring out deteriorative changes. The highest decrease in pH was observed in papaya blended nectar (1.30 per cent) followed by control nectar (1.17 per cent), pineapple blended (1.09 per cent) and mango blended (0.6 per cent) nectars.

Influence of the storage condition with respect to pH indicated that the nectars stored under refrigerated condition depicted minimum changes in pH when compared to nectars stored under ambient condition. Similar results were reported by Neelofer (2004) in tender coconut water RTS stored under two storage conditions.

pH of the nectars were stable till two weeks of storage after which gradual decline in pH was noted in the nectars stored under the two storage conditions and the decrease was significant. Decrease in the pH was reported by Kumar and Manimegalai (2001) in the mango blended RTS after 90 days of storage whereas, Kumar and Manimegalai (2002a) reported decrease in pH after 90 days of storage in soy milk whey RTS.

Irene (1997) reported decrease in pH in mango based RTS beverages stored for eight weeks under ambient conditions. Diju (1995) also reported decrease in pH in passion fruit RTS standardized by her. So also Kumar and Manimegalai (2003) reported decrease in pH in the whey based pineapple RTS beverage.

The overall decrease in the pH in the nectars was accounted to be 2.99 with storage. Significant interaction with respect to pH was found between variety and storage period (0.012), variety and storage condition (CD 0.012) and variety and treatment (CD 0.015).

TSS

According to Mehta *et al.* (2002) total soluble solids gives an indication of the sweetness in the product, which is an important criteria influencing the acceptability of the products.

TSS content of the nectars formulated from the two varieties of jackfruit remained constant upto two weeks in varikka nectar and one week in koozha nectar, after which the TSS content increased significantly (CD 1.746). TSS of the nectars formulated from varikka variety was found to be higher (23.25° Brix) as compared to koozha variety (19.06°Brix).

With respect to treatments, no significant difference was observed in TSS content of the nectars however the storage condition influenced the TSS content of nectars. Overall increase in TSS content was higher in nectars stored under ambient condition compared to those stored under refrigerated condition. Raj and Khurdiya (2003) reported increase in TSS in the RTS beverage prepared from apple pomace stored under ambient condition, for a period of six months.

The storage period influenced the TSS of the nectars formulated and the increase in TSS may be due to accelerated conversion of polysaccharides into sugars (Kumar and Manimegalai 2003). It is worth mentioning that increase in TSS content did not affect the taste of the nectars and they were organoleptically stable, and the overall increase in TSS was only two per cent over 60 days of storage. Mehta and Bajaj (1983) reported increase in total soluble solids in citrus juice during storage at room temperature. Sethi (1985) found that Litchi juice, showed an increase in TSS with storage.

Increase in TSS was also reported by Beena (1998) in papaya based nectars when stored for six months. However, Diju (1995) reported negligible change in the TSS content in the RTS formulated from passion fruit during six weeks storage. Kumar and Manimegalai (2001) reported no change in the TSS content of the whey based mango fruit RTS when stored for 90 days. Similar results were reported by Kumar and Manimegalai (2002a) in the soy milk whey blended papaya RTS.

Khurdiya and Roy (1984) and Saini and Baini (1994) also observed no change in the TSS in the jamun beverage and watermelon juice formulated. No significant interaction was observed with respect to TSS between the treatments, storage period and storage condition.

Total sugar

The total sugar content of the nectars standardized under the present study was found to enhance with the storage. Significant difference was found in the total sugar content of the nectars formulated from the two varieties of jackfruit (CD 0.034). The total sugar content for varikka nectars over a period of 60 days was found to be 22.65 per cent as against 19.18 per cent in koozha nectars.

Significant difference (CD0.045) was observed with respect to total sugar between the various treatments attempted in the study when stored for a period of 60 days. Increase in total sugars was found to be highest for papaya blended nectars (2.60per cent) followed by pineapple blended nectar (2.16 per cent). The possible reason for the significant difference in total sugar content of various treatments is due to the difference in the total sugar present in different fruits used for blending. The total sugar in different fruit vary from 3-18 per cent and is composed of different proportions of mixtures of sucrose, fructose and glucose (Bose and Mitra 1990).

Storage condition influenced the total sugar content of the nectars formulated under study. The nectars stored under room temperature depicted higher increase in total sugar content when compared to nectar stored under refrigerated condition. Raj and Khurdiya (2003) reported similar findings in RTS beverages formulated from culled appled pomace where total sugar enhanced to a higher level when stored at ambient condition. In contrast to the above finding, Bawa and Saini (1987) reported a decline in total sugar in carrot juice when stored at room temperature.

Storage period was found to influence the total sugar content of the nectars formulated under the study (CD 0.027). The total sugar content of nectars increased significantly after a storage of one week and the increase was accounted to be 2.02 per cent with storage period of 60 days. In support of the above finding, Mehta and Bajaj (1983) observed an increase in total sugar in citrus juices when stored for eight months. Palaniswami and Muthukrishnan (1980) also reported an increase in total sugar content in lemon juice during seven months of storage.

Significant interaction was observed with respect to total sugars in the nectars between variety and storage period (CD 0.083), storage period and storage condition (CD 0.081), variety and storage condition (CD 0.045), treatment and storage condition (CD 0.05) and variety and treatment (CD 0.053).

Reducing sugar

On assessing the qualitative changes in the reducing sugar content of the nectars indicated, an increase with storage. No significant difference was observed in reducing sugar content between the nectars standardized from two varieties of jackfruit. The reducing sugar content of nectars formulated from the two varieties of jackfruit was found to be 3.13 and 3.17 per cent respectively in varikka and koozha nectars

Significant difference was observed in reducing sugar content between the treatments applied with storage (CD 0.045). The increase in the reducing sugar content was more in mango blended nectars (25.13 per cent), followed by control nectars (23.76 per cent), pineapple blended nectars (23.07) and papaya blended nectars (19.32 per cent).

The storage condition influenced the reducing sugar content of the nectars and the increase in reducing sugar content was comparatively higher in nectars stored under ambient condition. Storage period was also found to influence the reducing sugar content of the nectars with a significant increase in all the nectars after one week of storage. Pandey *et al.* (2003) reported similar increase in the reducing sugar content in the beverage formulated from carrot during storage. Increase in reducing sugar content was also reported by Diju (1995) and Beena (1998) in the beverages formulated by them.

β-carotene

Jackfruit is a rich source of β-carotene, however during processing, major share is lost and the finished product retain only a small quantity.

Significant difference (CD 0.562) was observed in the β-carotene content of the nectars formulated from the two varieties of jackfruit nectar. The β-carotene content in the nectars was found to be 237.46 μg for varikka as against 223.99 μg in koozha nectars. Significant difference (CD 0.794) was observed with respect to β-carotene content between the various treatments applied, and was found to be highest in mango blended nectar 377.14 μg. Nectars stored under refrigerated condition retained more β-carotene as compared to nectars stored under room temperature.

As storage period advanced β-carotene content decreased and the overall decrease was accounted to be 34.25 per cent. Significant interaction was observed with respect to β-carotene content between variety and storage period ,variety and storage condition ,treatment and storage condition and variety and treatment.

Vitamin C

Significant reduction (CD 0.023) was observed in the vitamin C content of nectars formulated from the varikka and koozha variety of jackfruit over a period of 60 days and was found to be 8.43 mg and 9.30 mg /100 g respectively.

Significant difference (CD 0.024) was also observed between the various blended nectars with storage in vitamin C content. The highest decrease in vitamin C content was observed in mango blended nectar (27.61 per cent) followed by control nectars (24.50 per cent), pineapple blended nectar (23.15 per cent) and papaya blended nectar (21.59 per cent). The storage condition (CD 0.022) profoundly influenced the vitamin C content of the nectars, and the decrease was higher for nectars stored under ambient condition. Raj and Khurdiya (2003) reported rapid decrease in vitamin C content in RTS beverage prepared from culled apple pomace stored under ambient condition for a period of 90 days. The rapid decrease in vitamin C may be due to oxidation by trapped oxygen in glass bottle resulting in the formation of dehydro-ascorbic acid as stated by Kumar (1990).

Storage period was found to influence the vitamin C content of the nectars significantly (CD 0.033). Decrease in vitamin C content was observed after a period of one week of storage and the overall decrease in the vitamin C content was accounted as 24.06 per cent. Decrease in vitamin C was reported by Beena (1998) in the nectars formulated from papaya fruit, when stored for six months. Similar results were reported by Kumar and Manimegalai (2002a) in RTS prepared from soy milk whey blended with papaya, Teortia *et al.* (1997) in musk melon RTS beverage during six months storage, Diju (1995) in the RTS formulated from passion fruit while Kumar and Manimegalai (2001) also reported a decrease in vitamin C content in whey based mango RTS during 90 days of storage. Kumar and Manimegalai (2003) also reported a decrease in the vitamin C content of the whey based pineapple RTS during 90 days storage.

Significant interaction was observed with respect to vitamin C content between variety and storage period (CD 0.051), treatment and storage period (CD 0.075), variety and storage condition (CD 0.024), treatment and storage condition (CD 0.033) and variety and treatment (CD 0.039).

Polyphenols

Significant difference was observed in the polyphenolic content of the nectars formulated from two varieties of jackfruit (CD 0.283). Treatments and the storage period profoundly influenced the Polyphenol content of the nectars. The overall decrease in polyphenolic content of nectars with storage was 26.25 per cent. Significant interaction was observed with respect to polyphenols between variety and treatment (CD 0.56) and treatment and storage period (CD 0.561).

From the above data it can be concluded that variety of the fruit, treatments applied and storage condition used in the present investigation influenced all the chemical constituents in the products during storage. All the nectars formulated from jackfruit stayed well when stored under refrigerated condition. Based on all the parameters ascertained the shelf life of the product is 45 days.

5.2.2.4 *Changes in the Organoleptic Attributes of Nectars during Storage*

According to Hurst *et al.* (1993) shelf life of food varies with type of ingredients, the processing, packaging, environmental conditions and consumer holding. The quality of food also depends on the existing distribution and marketing systems and consumer food storage habits. The fruit nectars standardized from the two varieties of jackfruit were monitored fortnightly for the changes in organoleptic qualities with respect to variety, treatments, storage period and storage condition are discussed below.

Appearance : Appearance of a food acts as a gate keeper and the old saying "we eat with our eyes" is not far of the mark (Kamble *et al.*, 2004). The appearance scores decreased significantly in all the nectars formulated from the two varieties.

The appearance scores decreased significantly for varikka nectars after a period of 30 days while significant difference was noted only after 45 days in koozha nectars. The mean appearance score of nectars formulated from the two varieties of jackfruit over a period of 60 days of storage was found to be 4.14 and 4.07 respectively in varikka and koozha nectars. The varikka nectars were found to excel in appearance as the pulp of varikka was bright yellow in colour compared to koozha pulp.

Among the four treatments tried out papaya blended nectar scored highest for appearance (4.23) followed by mango blends (4.17) of both varieties during storage. Significant difference (CD 0.061) in the appearance scores was observed with respect to various treatments and the appearance of papaya blended nectar attained the highest.

It is interesting to note that, the appearance scores remained unaffected by the storage condition. However, slight decline in the appearance score was recorded and the decline was accounted to be only 4.3 per cent in the nectars stored under refrigerated condition as against 6.4 per cent in nectars stored under ambient condition. Storage period was found to influence the appearance attribute of the nectars formulated with a steady decline after 45 days of storage. Similar results were reported by Doodnath and Badriel (2000) in the nectars formulated from water melon when stored at 20 – 25°C temperature. Beena (1998) reported decrease in appearance scores in papaya based nectars when stored for six months. Irene (1997), Diju (1995) and Hema (1997) also reported similar observations in appearance attribute in the beverages formulated by them and stored for three to six weeks.

Colour

Colour of food stuff is one of the important element in determining its acceptance and enhancing delicacy of food articles. It is believed that the enjoyment of foods depends on eye appeal, colour being the first quality attribute perceived by the senses (Kamble *et al.*, 2004).

No significant difference was observed in the colour attribute of nectars of two varieties of jackfruit though the mean colour scores of koozha nectars recorded higher scores (4.80) than varikka nectars (4.16).

Colour of the fruit was significantly influenced by the treatments applied. The highest score was recorded for papaya blended jackfruit nectars (4.29) of both varieties. In this context it may be pointed out, that control jackfruit nectar of both varieties scored lesser for colour throughout the storage period. Blending of other fruit pulps thus improved the colour attribute of the nectars formulated.

The storage condition influenced (CD 0.053) the colour scores of the nectars. Nectars stored under refrigerated condition scored higher with respect to colour during storage. Raj and Khurdiya (2003) reported decrease in colour scores in the nectars formulated from apple pomace stored under ambient condition (7.17 – 6.13) during storage of six months.

It is encouraging to note that the colour scores of all the nectars remained intact upto 30 days after which scores declined significantly (CD 0.093). Overall decrease in the colour scores over the storage period of 60 days was negligible and accounted to be only 7.94 per cent. Similar results have been reported by Kumar and Manimegalai (2002a) in soy milk whey blended RTS beverage stored for 90 days under refrigerated condition. The yellowish orange colour of the RTS was maintained upto 60 days after which the colour had degraded to moderate yellowish orange. Saini and Grewal (2000) reported decrease in the colour scores in the bleached and unbleached pear juice over seven months storage. Kumar and Manimegalai (2003) reported that the light yellow colour of pineapple blended RTS beverage maintained scores upto 60 days after which the colour decreased to yellowish brown.

Beena (1998) reported decrease in colour scores in the nectars formulated from papaya during six months storage. Irene (1997), Diju (1995) and Hema (1997) reported decrease in the colour scores in the RTS beverages formulated from mango, passion fruit and jamun when stored for five to six weeks.

Flavour

Flavour is defined as the combination of taste and odour and is influenced by sensations of rain, heat ,cold and by tactile sensations. Birch and Lindley (1986) is of the opinion that flavour is total or unitary experience that arises from stimulation of the sense of taste, the sense of smell and other senses.

Significant difference was seen in the flavour attribute of nectars formulated from the two jackfruit varieties where as the flavour scores was higher in varikka nectars (3.98) as compared to koozha nectars (3.80). Significant difference was observed in flavour between the various nectars formulated.

Storage condition had a definite impact on the flavour profile of the nectars. The nectars stored under refrigerated condition had better flavour profile (3.94) as compared to those stored under ambient condition (3.84). Raj and Khurdiya (2003) reported flavour loss in RTS beverage formulated from apple pomace stored under ambient condition for a period of 90 days.

. The flavour of the nectars remained intact upto a period of 30 days after which significant decrease was recorded .Saini and Grewal (2000) reported reduction in the flavour scores of pear juice, during a storage of seven months. Volatile compounds responsible for flavour character in fruits degrade and affect the flavour of the products when stored. Kumar and Manimegalai (2003) also reported loss of flavour in pineapple RTS beverage after 60 days of storage. Beena (1998) reported reduction in flavour, scores in the nectars formulated from papaya during six months storage. Similar findings were also reported by Diju (1995), Irene (1997) and Hema (1997) in the RTS beverage formulated by them from passion fruit, mango and jamun.

Overall decrease in the flavour scores was found to be 16.64 per cent with storage, however decline in flavour was not found to affect the quality of nectars formulated drastically. Significant interaction was observed with respect to flavour between variety and treatment and storage period and storage condition.

Taste

According to Birch and Lindley (1986) taste generally implies to the characteristics such as saltiness, sweetness, acidity and bitterness. Significant difference (CD 0.063) was observed in the taste attribute of nectars prepared from two varieties of jackfruit. Varikka variety nectars were preferred over its counterparts in taste attribute. As far as the treatments are concerned significant difference was observed with respect to taste, and the taste of pineapple blended nectars of both varieties scored highest (3.97) followed by control nectars (3.90) throughout storage period. Taste parameter of the nectars was affected by storage condition applied (CD 0.062). The taste was found to be better in the nectars stored under refrigerated condition (3.91) as compared to nectars stored under non-refrigerated (3.81) condition. Analysing the effect of storage period on the taste attribute revealed that the taste of all the nectars formulated remained intact for a period of 30 days after which a significant decrease in the taste scores was observed. Similar results were reported by Kumar and Manimegalai (2003) in whey based pineapple RTS which was highly acceptable upto 45 days. Diju (1995), Irene (1997), Hema (1997) and Beena (1998) also reported reduction in taste scores in the RTS beverages and nectar formulated from different fruits.

Consistency

Varietal difference was not reflected in the consistency of the nectars standardized from jackfruit. Mean scores for the nectars formulated from varikka and koozha was almost alike (3.9) which indicate that both varieties can be utilized for formulation of nectars.

However the storage condition influenced the consistency of the nectars. The consistency scores of nectars stored under ambient condition declined at a higher pace as compared to refrigerated samples. Raj and Khurdiya (2003) reported faster decrease in consistency scores of RTS prepared from apple pomace stored under ambient condition as compared to other samples stored under lower temperature.

Consistency scores of the nectars formulated in the present study significantly decreased with storage (CD 0.078). The overall decrease in the consistency scores was found to be 10.61 per cent in the different nectars standardized. Consistency of the beverage was reported to decrease with storage in papaya nectars (Beena, 1998). Diju (1995), Irene (1997) and Hema (1997) also reported a similar decrease in consistency scores in the RTS beverages formulated from different fruits.

Overall Acceptability

It is worth mentioning that neither the variety nor the treatment affected the overall acceptability of the nectars formulated under study though, the pineapple blended jackfruit nectars were adjudged to be the best. The storage condition was also not found to influence the overall acceptability scores of the nectars. However the storage period made an impact on the overall acceptability scores of the nectars. Overall decrease in the acceptability score was found to be only 4.5 per cent with storage indicating that deterioration in the nectars was not very much. Decrease in overall acceptability scores was reported by Beena (1998) in the nectars prepared from papaya fruit where as Kumar and Manimegalai (2003) reported that the whey based pineapple RTS beverage remained highly acceptable upto 45 days.

Taking into account of the results obtained it can be concluded that varietal difference was exhibited in the sensory attributes *viz.*, appearance, flavour and taste, whereas colour, consistency and overall acceptability of the nectars remained unaffected Appearance, colour and taste of the nectars were found to be significantly influenced by the treatments whereas other sensory attributes like flavour, consistency and overall acceptability was found to be less affected. Storage condition was found to influence colour, taste, flavour and consistency of the nectars whereas appearance and overall acceptability remained unaffected.

Sensory features such as appearance and overall acceptability of the nectars were stable upto 45 days, but colour, flavour and taste of nectars were retained for a period of 30 days. Though taste and flavour scores decreased the products were organoleptically acceptable upto a period of 60 days. The pineapple and mango blended nectars was preferred for flavour and taste whereas papaya blended nectars for appearance and colour. Based on the overall performance pineapple and mango blended nectars of both the varieties were adjudged to be the best. The refrigerated samples excelled over the non-refrigerated samples with respect to all the sensory attributes.

5.2.3 Standardization of Jackfruit Bars

Fruit bar is partially dried tasty product and is popular in many parts of the country. Jackfruit bars were formulated from the two varieties of jackfruit individually and by blending with other fruits to introduce variety and taste to the product.

5.2.3.1 Chemical and Nutritional Characteristics of Bars Standardized from Jackfruit

The fruit bars formulated under the present study were evaluated in terms of chemical constituents *viz.*, moisture, acidity, pH, TSS, total sugar, reducing sugar, β-carotene, vitamin C and polyphenols.

Significant difference with respect to moisture was observed between the various fruit bars formulated (CD 0.213). The moisture content of varikka bars (11.28 per cent) was comparatively higher as compared to koozha bars (10.28 per cent). Among the various treatments employed, blending with papaya pulp resulted in higher moisture content in the fruit bars in both varieties. The lowest moisture content was recorded for control koozha bar and highest in papaya blended bars.

Moisture content of the products influence the keeping qualiy of the products and hence moisture content of the fruit bars was kept low. Mango bars developed by Jyothi (1997) was found to have a moisture content of 8.8 per cent while, Krishnaveni *et al.* (1999) reported 16.73 per cent moisture in jackfruit bars formulated by her.

The acidity of the fruit products is attributed to many organic acids present in fruits and the citric acid added while processing. The acidic nature of the product helps to enhance the shelf life of the product, besides checking the growth of microorganisms (Frazier *et al.*, 1999). Significant difference was observed with respect to acidity between the various blended fruit bars formulated and was found to be highest in mango blended bars (1.07 per cent) and the lowest in control fruit bars (0.52 per cent). Papaya blended mango fruit bars formulated by Beena (1998) was found to have an acidity of 0.49 per cent while Jyothi (1997) reported 1.19 per cent acidity in mango bars standardized by her. Krishnaveni *et al.* (1999) found 0.47 per cent acidity in jackfruit bars. The above findings indicate that the acidity of jackfruit bars developed in the present investigation is also in similar line.

Significant difference in pH was found within the various treatments tried. The highest pH was observed for mango blended bar (4.73) while the lowest for control varikka bar (4.50). Krishnaveni *et al.* (1999) reported pH of 4.8 in jackfruit bars while Kumar and Manimegalai (2002b) found pH as 3.98 in sapota fruit bars. Beena (1998) reported pH of 4.21 for papaya blended mango based fruit bars and Jyothi (1997) reported pH of 4.40 for mango bars. Results obtained in the present study are in conformity with the above findings.

TSS of the jackfruit bars standardized ranged between 65.28° Brix to 72.30 °Brix and was significantly different between the various blended fruit bars formulated . It was observed that by blending the jackfruit pulp with other fruit pulps enhanced the TSS content of the fruit bars. The highest TSS content was observed for papaya blended varikka bar and the lowest in control varikka bar .Kumar and Manimegalai. (2002b) reported TSS content of fruit bars as 68°Brix while Krishnaveni *et al.* (1999) developed jackfruit bars with TSS of 93.39 °Brix. Beena (1998) found the TSS content of papaya blended mango fruit leather as 65.17 °Brix whereas plain mango leather developed by Jyothi (1997) was found to have TSS as 29 °Brix. Earlier works support the results obtained in the present study.

Significant difference was observed with respect to total sugars between the various blended fruit bars. The highest total sugar was recorded for mango blended varikka fruit bar and the lowest for papaya blended varikka bar (56.76 per cent). Krishnaveni *et al.* (1999) reported 54.22 per cent total sugar in jackfruit bars while Beena (1998) reported total sugar of 39.53 per cent in papaya blended bar while, Jyothi (1997) reported a total sugar content of mango bar as 32.64 per cent. Kumar and Manimegalai (2002b) reported total sugar content of sapota bar as 53.35 per cent.

The reducing sugar content of the jackfruit bars was observed to be highest for papaya blended koozha bar (12.55 per cent) and lowest for papaya blended varikka bar (11.88 per cent) with a significant difference between the various treatments applied. Kumar and Manimegalai (2002b) reported reducing sugar content of sapota fruit bars as 7.29 per cent, while Krishnaveni *et al.* (1999) reported reducing sugar content of jackfruit bars as 8.55 per cent. Beena. (1998) found reducing sugar content as 34.92 per cent for papaya-mango leather and Jyothi (1997) reported reducing sugar content as 29.79 per cent in mango leather.

Among the nutritional characteristics assessed, significant difference was observed with respect to β-carotene, vitamin C and polyphenols in the various fruit bars standardized. The highest β-carotene content was estimated in mango blended koozha bar (328.72 μg) closely followed by mango blended varikka bar (320.72 μg) and lowest in control koozha bar (165.80 μg). The highest vitamin C content was observed in papaya blended varikka bar (3.31) and lowest for control koozha bar (2.70). The vitamin C content of varikka fruit bars was higher as compared to koozha fruit bars. Krishnaveni *et al.* (1999) reported a vitamin C content of jackfruit bars as 7.30 mg, while Jyothi (1997) reported a vitamin C content of mango leather as 36.73 mg. Fruit leather formulated from papaya-mango pulp by Beena (1998) was found to have vitamin C content as 17.76 mg. The highest polyphenolic content was observed for control varikka bar (29.67 g/100 g) and lowest in mango blended koozha bar (27.57 g/100 g).

The above findings confirm that all the chemical constituents analysed in the jackfruit bars formulated under the present investigation are in tune with the findings reported in similar products developed by earlier researchers.

5.2.3.2 Organoleptic Characteristics of Jackfruit Bars Standardized

Raab and Khader (1976) reported that fruit bar is a well established product manufactured by dehydrating fruit pulp into leathery sheet. Two distinct variety of jackfruit were utilized to formulate fruit bars individually and by blending with other fruits in different proportions to obtain fruit bars of varied taste and flavour. The data obtained on sensory parameters of fresh fruit bars are discussed below.

The highest score for appearance was attained by papaya blended koozha bar (4.26), closely followed and equally shared by papaya blended varikka bar and mango blended koozha bar (4.10). Plain fruit bar of both varieties remained less attractive when compared to others. No significant difference was observed with respect to appearance attribute between the various fruit bars formulated.

Regarding the colour attribute, papaya blended fruit bars of both varieties scored outstandingly higher compared to others. Plain varikka bar was found to be the poorest in colour attribute. However no significant difference in colour score was noted between the six combinations attempted in the study. In this context, it may be noted that blending of papaya improved the appearance and colour of the products formulated. Beena (1998) also reported a higher eye appeal for papaya based fruit bars due to the bright red colour of papaya.

The mango blended fruit bars formulated from the two jackfruit varieties secured the highest score for flavour. while the mean score obtained for papaya blended bars was quite low. The data discloses that the exotic flavour of mango is appealing and at the same time provide pleasing flavour to jackfruit pulp when mixed together. Beena (1998) reported that papaya pulp when blended with mango, improved the flavour of the fruit leather.

The mango blended varikka fruit bar scored highest for taste (4.06) closely followed by mango blended koozha bar (4.00). Taste character was less appreciated in papaya blended fruit bars of both varieties. Blending of mango with jackfruit improved the taste and aroma to a greater extent, besides masking the jackfruit flavour. However, no significant difference was observed between the various treatments applied.

Data showed that the texture attribute of the fruit bars was found to be more or less similar. Papaya blended fruit bars of both varieties secured highest score for texture and the lowest score was for mango blended bars. Report published by CFTRI (1977) stated that variety of the fruit and consistency of the pulp have definite impact on the quality of fruit bar. No significant difference was found between the products formulated with two varieties of jackfruit.

Taking into account of the overall acceptability of fruit bars it was indicated that the mango blended varikka bar outshine others (4.37) followed by control varikka bar (4.17). Even with better colour and appearance score, overall acceptability was found to be lowest in papaya blended fruit bars. The lowest overall acceptability score was found in papaya blended koozha bar (3.89). However, overall acceptability of all the fruit bars under investigation was found to range between 77.8-79.87 per cent, which indicate the acceptance of the products among judges with negligible difference in sensory qualities. Significant difference in overall acceptability was observed with respect to various treatments tried out. Fig 8 represents the Overall acceptability of jackfruit bars.

The findings clearly indicates that both the jackfruit varieties could be utilized for formulation of fruit bars with negligible difference in sensory qualities. Blending with other fruit pulps gave products of appreciable quality.

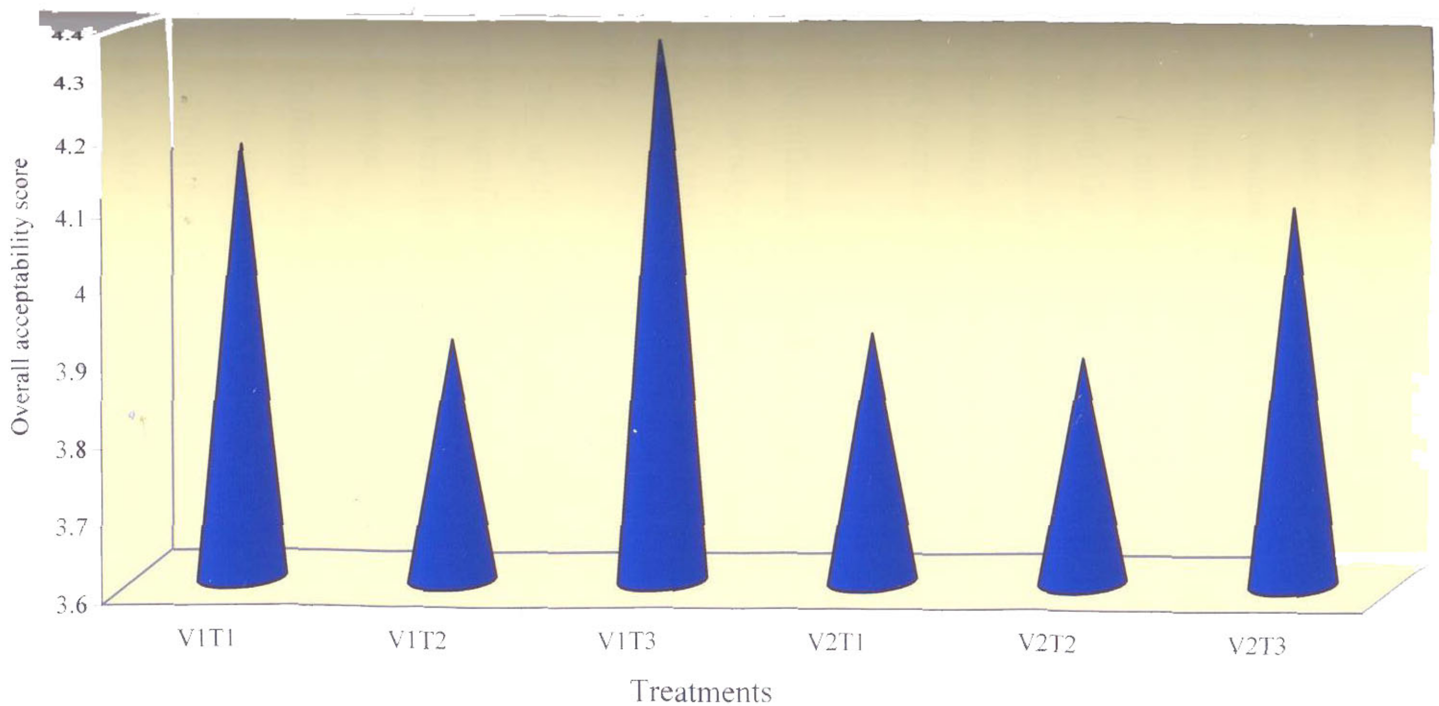
5.2.3.3 Changes in the Chemical Constituents of Fruit Bars with Storage

Stability of the original quality of any processed product is of paramount importance during storage Jackfruit bars formulated under the present investigation were stored and monitored periodically in order to ensure the shelf stability of the product. The data on changes in the chemical constituents *viz.*, moisture, pH, acidity, TSS, total sugar, reducing sugar, vitamin C, β-carotene and polyphenolic content of jackfruit bars as influenced by variety, treatments and storage period are discussed in the following tables.

Moisture

Garg *et al.* (1989) opined that the most important factor which determines the extent of deterioration in the dried products is the moisture content of the final product.

Significant difference was observed in the moisture content of the fruit bars formulated from the two varieties of jackfruit throughout storage period. Moisture content of jackfruit bars formulated by applying different treatments was found to vary and to be highest in papaya blended bars. Papaya, it self is quite watery and contribute to higher moisture level,



V_1T_1 - Control jackfruit bar

V_1T_2 - Papaya blended jackfruit bar

V_1T_3 - Mango blended jackfruit bar

V_2T_1 - Control jackfruit bar

V_2T_2 - Papaya blended jackfruit bar

V_2T_3 - Mango blended jackfruit bar

Fig. 8. Overall acceptability of jackfruit bars

when blended with other pulps. Similar results were reported by Jyothi (1997) for mango bar, which had a higher moisture content and took longer time for drying.

During the earlier period of storage, the moisture level of the jackfruit bars remained stable. However, after a period of 30 days the moisture content of all the jackfruit bars increased significantly which may attributed to the absorption of moisture from the atmosphere. The increase in moisture content for the fruit bars was accounted to be 15.06 per cent and the increase was highest in papaya blended jackfruit bars of both varieties. Mir and Nath (1993) found that moisture content of the fortified mango bars increased with storage of 90 days. Jyothi. (1997) also reported increase in moisture content in the mango fruit bars standardized by her.

Significant interaction was observed with respect to moisture between variety and storage period (CD 0.323), treatment and storage period (CD 0.401) and variety and treatment (CD 0.213).

Acidity

The acidity of the fruit bars formulated from the two varieties increased significantly with storage. The acidity was found to be higher for koozha bars (0.74 per cent) as compared to varikka bars (0.72 per cent) during storage.

Different blended jackfruit bars exhibited different levels of acidity. The highest acidity was found in mango blended bar (1.07) while plain jackfruit bars showed the lowest acidity (0.52) during storage. As pointed by Kalra *et al.* (1991) higher acidity of mango pulp (0.20 – 0.30 per cent) contributed higher acidity in the product. Acidity of jackfruit bars under study increased with storage and it was recorded to be significant after 30 days of storage.

Krishnaveni *et al.* (1999) observed increase in acidity in jackfruit bars when stored for 180 days. Similarly an increase in acidity was reported by Sarvanakumar and Manimegalai (2002) in fruit bars developed from sapota when stored for six months. Gowda and Ramanjameneya (1995) noted increase in acidity in mango bars after six months of storage. Mir and Nath (1993) also noted a significant increase in acidity in three types of mango bars when stored for 90 days. Sagar (2003) also reported increase in acidity in plum leather stored in different packaging material for a period of six months.

Beena (1998), Jyothi (1997) and Vennilla (2004) also reported increase in acidity in papaya mango fruit leather and mango bars respectively with storage.

Significant interaction was observed with respect to acidity between variety and treatments and between treatment and storage period.

pH

According to Ranganna (1986), pH is a measure of active acidity which influences the flavour or palatibiltiy of a product and affect the processing requirements. Determination of pH reveals the acidity and alkalinity of the product which in turn gives a positive indication of deteriorative change in the product.

Significant difference was observed in the pH of the fruit bars standardized from the two varieties of jackfruit with storage and was found higher for koozha bars as compared to varikka bars. As far as the treatments were concerned, the pH was observed to be highest for mango blended bars of both varieties (4.69) and the lowest in plain fruit bars of both varieties. Significant decrease in pH was observed when fruit bars were stored for six months and the overall decrease in pH was accounted to be 21.95 per cent.

Krishnaveni *et al.* (1999) recorded similar observations in jackfruit bars when stored in different packaging materials. Saravanakumar and Manimegalai (2002) reported that the fruit bars developed from sapota had an initial pH of 3.98 which decreased to 3.28 after six months of storage. Beena (1998) reported significant decrease in pH in the fruit leather prepared from papaya mango pulp. Similar results were also reported by Jyothi (1997) in mango bars during storage of six months. Vennilla (2004) also reported decline in pH in the fruit bars formulated from guava pulp.

Significant interaction was observed with respect to pH between variety and storage period, treatment and storage period and variety and treatments.

Total soluble sugars

Variety of the jackfruit was not found to influence the TSS content of the jackfruit bars formulated under the present study during storage. and was almost alike.

However significant difference in the TSS content was observed between the six types of fruit bars formulated (CD 0.02). It may be inferred that blending with other fruit pulps influences the TSS content of the fruit bars standardized. Highest TSS was recorded in papaya blended bar and the lowest in plain fruit bars.

Influence of storage period in the TSS content of jackfruit bars indicated that TSS content increased significantly with storage and was apparent after 30 days. The overall increase in TSS of the fruit bars with storage was 0.77 per cent. Saravanakumar and Manimegalai (2002) reported slight increase in TSS during storage of six months. Gradual increase in the TSS was reported in papaya based fruit bars by Sobana (1998). Krishnaveni *et al.* (1999) also reported increase in TSS content of jackfruit bars with storage. Increase in TSS content was noted in papaya – mango leather by Beena (1998) and in mango bars by Jyothy. (1997).

A significant interaction was observed with respect to TSS between variety and storage period (CD 0.04), treatment and storage period (CD 0.04) and variety and treatment (CD 0.02).

Total sugars

Accounting changes in the total sugar content of the jackfruit bars indicated that varietal variation was reflected in the total sugar content of the fruit bars formulated with storage. Total sugar content was higher in fruit bars formulated from varikka when compared to koozha bars.

Total sugar content of mango fruit bars were outstandingly higher when compared to other products. Lowest total sugar was observed in papaya blended fruit bars. In general, fruits contain total sugar from 3-18 per cent composed of a mixture of sucrose, fructose and glucose. Total sugars present in the formulated fruit bars is the reflection of total sugar content of the fruit pulp.

Total sugar content of the fruit bars was found to increase with storage and the increase was observed after 30 days of storage. Beena (1998) and Jyothy (1997) also recorded similar results in the products standardized by them.

However, Saravanakumar and Manimegalai (2002) reported a remarkable decrease in total sugar content in the fruit bar formulated from sapota. Similarly decrease was also reported by Krishnaveni *et al.* (1999) in jackfruit bars developed by her. Sagar (2003) reported decrease in total sugar content in plum leather over a period of 130 days. Vennilla (2004) also reported decrease in total sugar content in guava-papaya fruit bar with storage.

Significant interaction was observed with respect to total sugars between variety and storage period, treatment and storage period and variety and treatment.

Reducing sugar

With respect to reducing sugar content of fruit bars formulated difference was reflected in the reducing sugar content of the product. Reducing sugar was found to be higher in koozha fruit bars (12.51 per cent) as compared to varikka bar.

Treatments also influenced the reducing sugar content of the fruit bars developed. Mango blend recorded highest reducing sugar in the bars formulated from two varieties and lowest was observed in papaya blended bar. Reducing sugar increased in all the fruit bars formulated with storage and the increase was significant after a period of 30 days.

In support of the above, Saravanakumar and Manimegalai (2002) reported a remarkable increase in the reducing sugar content of fruit bars formulated from sapota fruit. Krishnaveni *et al.* (1999) also reported significant increase in reducing sugar content in jackfruit bars formulated by her. Chauhan *et al.* (1997) observed an increase in reducing sugar content of mango bar during storage. Beena (1998) and Jyothi (1997) also reported an increase in reducing sugar in the fruit bars standardized from papaya mango pulp and plain mango pulp when stored for a period of six to eight months. Under the present study the increase in reducing sugar content was 16.04 per cent with storage. Significant interaction was found with respect to reducing sugar between variety and storage period and variety and treatment

β-carotene

Significant difference was observed between the β-carotene content of fruit bars formulated from two varieties of jackfruit with storage.

Varikka variety fruit bars depicted higher β-carotene content than that of koozha bars with storage.

Significant difference was also observed between the six types of fruit bars formulated with storage, being highest for mango blended fruit bar. Kalra *et al.* (1991) reported similar findings in mango bar developed from mango pulp.

β-carotene content of the fruit bars decreased with storage. Krishnaveni *et al.* (1999) also reported a significant reduction in β-carotene content in jackfruit bars with storage. Similarly, Mir and Nath (1993) also reported significant reduction in the β-carotene content of mango bars along with storage period of 90 days.

Significant interaction was observed with respect to β-carotene between variety and storage period, treatments and storage period and variety and treatment.

Vitamin C

Changes in the nutritional characteristics of the fruit bars formulated were assessed so as to know the extent of retention of nutrients during storage. Vitamin C was monitored monthly whereas β-carotene and polyphenols were analysed initially and towards the end of the storage period.

Significant difference was observed between the vitamin C content of fruit bars formulated from two varieties of jackfruit though vitamin C content was negligible. Fruit bars formulated from varikka fruit depicted higher vitamin C content compared to koozha bars. Significant difference was also observed in the vitamin C content between the three types of fruit bars formulated from two varieties of jackfruit. Blending with papaya and mango resulted in higher vitamin C content in the fruit bars formulated.

Vitamin C content decreased remarkably with storage after a period of 30 days. The overall decrease in the vitamin C content of the fruit bar was 88.17 per cent when stored for 180 days. In support of the above finding, Krishnaveni *et al.* (1999) reported reduction in vitamin C in jackfruit bars formulated by her. Jyothy (1997) and Beena (1998) also reported significant decline in the vitamin C content in fruit bars formulated from plain mango pulp and papaya-mango pulp.

Significant interaction was found with respect to vitamin C content of the fruit bars between variety and storage period, treatment and storage period and variety and treatment.

Polyphenols

Polyphenol content of the fruit bar was analysed and significant difference was observed between the polyphenol content of fruit bars formulated from two varieties of jackfruit with storage. Varikka variety fruit bars were found to contain more polyphenolic content as compared to koozha bars.

Treatments attempted in the present study showed a significant impact on the polyphenolic content of the fruit bars throughout storage period. The mango blended fruit bars contain highest phenolic content (29.59 g/100 g) whereas the control fruit bars depicted the lowest. Significant decrease in the polyphenolic content was observed for the fruit bars along with storage.

Significant interaction was observed with respect to polyphenols between variety and storage period, treatment and storage period and variety and treatment

From the results discussed above it was depicted that variety of jackfruit influenced all the chemical and nutritional characteristics of fruit bars except TSS and varikka variety bars were found to be superior in nutritional characteristics as compared to koozha variety bars. Significant increase in the moisture, acidity, TSS, total sugar and reducing sugar in the fruit bars and a significant decrease was observed with respect to pH, vitamin C, β-carotene and polyphenols in the jackfruit bars with storage of six months. The various treatments applied also had definite impact on the chemical and nutritional characters of jackfruit bars standardized under present investigation.

5.2.3.4 Changes in the Organoleptic Attributes of Fruit Bars during Storage

The organoleptic qualities of the products assumed to change during storage. The data on changes in the organoleptic attributes of jackfruit bars as influenced by variety, treatments and storage condition are discussed below.

Appearance

Christienson (1985) reported that the consumer preference to appearance is one of the major factor leading to the increasing demand of the product, and hence it is very essential to keep the appearance of the product quite attractive. Significant difference was observed in the appearance of the fruit bars from varikka varieties after 90 days while changes were noted only after 120 days in koozha fruit bars.

A significant difference was also observed in appearance attribute of different blends formulated from two varieties during storage. As in the case of nectars, appearance of papaya blended fruit bars was more appealing to the consumers.

The appearance of the fruit bars, was found to remain stable for a period of 120 days after which a significant decrease in the appearance attribute was observed. Similar results have been reported by Beena (1998) in papaya-mango blended bars and also by Jyothi (1997) in mango blended bars with six months storage.

The overall decline in the appearance score was accounted to be only 5.75 per cent over a period of 180 days, and in no way affected the general appearance.

Colour

Peterson and Johnson (1979) is of the opinion that if the total colour of the product is judged unacceptable the food is summarily rejected.

Varietal difference of the jackfruit was not found to reflect the colour attribute of the fruit bars formulated under investigation. However, significant difference was observed in the colour of the fruit bars with respect to the various treatments applied. The highest score was secured for papaya blended bar (4.19) irrespective of the variety and maintained it throughout the storage period. Beena (1998) reported that consumers preferred papaya based blended fruit bars over others due to their colour.

Impact of the storage period on the colour attribute indicated that the colour scores of jackfruit bars remained more or less same for a period of 120 days after which a significant decline was observed. Krishnaveni *et al.* (1999) found that the colour scores of jackfruit bar developed remained intact for a period of 90 days. Beena (1998) also reported similar decrease in the colour scores along with storage period of eight months in papaya blended bars. Jyothi (1997) also supported the above finding.

Flavour

Health (1978) defined flavour as a substance which may be a single chemical entity or a blend of chemicals of natural or synthetic origin whose primary purpose is to provide all or part of particular flavour.

Variety of the jackfruit was not found to affect the flavour of the fruit bars indicating that both the varieties of jackfruit are equally good for formulating fruit bars. However, significant difference was observed in flavour with respect to various blends tried out. The mango blended bar exhibited better flavour profile followed by control bar while papaya blended fruit bars of both varieties scored less in flavour attribute.

Significant changes in the flavour profile was seen throughout the storage period and was conspicuous after 60 days. The decrease in flavour was accounted to be 9.82 per cent. The results are on par with the results reported by Beena (1998) and Jyothi (1997) where the flavour scores declined with storage. Krishnaveni *et al.* (1999) reported a decrease in flavour scores of jackfruit bars after 90 days of storage and the decrease was accounted to be 12.5 per cent.

Taste

Taste of the food product plays a major role in the acceptance of any product. Under the present study no significant difference was found between the bars formulated from the two varieties of jackfruit, with respect to taste character during storage. Treatments applied in the study alter the taste parameter of the fruit bars and the plain fruit bars were found to be lowest in taste attribute when compared to others.

Significant decrease was observed with respect to taste when kept for storage study. The changes were visible after 60 days of storage and the overall decrease in taste was accounted to be 12.5 per cent. The results are on par with research conducted by Krishnaveni *et al.* (1999) where the mean scores for taste decreased from 4.0 – 3.6 after 90 days of storage. Similar results were reported by Beena (1998) and Jyothi (1997) in papaya mango blended fruit bars and mango fruit bars.

Texture

According to Matz (1962) texture has long been recognized as an important element in the total sensory impression obtained during the consumption of the food. It is becoming increasingly evident that some form of texture measurement is highly desirable in the grading of all foods.

Under the present investigation variety of jackfruit was not found to influence the texture of the fruit bars indicating that fruit bars formulated from two varieties was almost similar in texture whereas different treatments employed in the formulation of fruit bars was found to influence the texture of the product developed. Texture of the papaya blended fruit bars of both varieties, outshine throughout the storage period, with soft and pliable texture. Plain fruit bars formulated from two varieties of jackfruit stood next while bending with mango pulp resulted in leathery fruit bars.

As in the case of other sensory attributes, texture scores of the fruit bars decreased and was significant after five months of storage. Overall decrease in texture feature was only 6.44 per cent towards the end of 180 days which indicate that, the changes do not mask the textural quality of the product. The results are on par with the earlier findings done by Krishnaveni *et al.* (1999) where the texture scores for jackfruit bar decreased with storage period of 180 days. Similar results were reported by Beena (1998) and Jyothi (1997) in the fruit bars formulated by them.

Overall acceptability

Taking into account of all the sensory attributes, overall acceptability of the fruit bars judged, gave valid conclusion that variety of the jackfruit influenced the overall acceptability of the fruit bars formulated in the study where varikka variety gave better production.

Different treatment employed improved the overall acceptability of the fruit bars formulated. Blending with mango pulp, resulted in superior quality fruit bars by masking the strong flavour of jackfruit. Results also indicate that plain fruit bars excelled in overall acceptability scores. The overall acceptability scores decreased significantly with storage after 150 days and was accounted to be 3.14 per cent.

Beena (1998) and Jyothi (1997) reported decrease in the overall acceptability scores of the fruit bars formulated from papaya and mango during storage. Krishnaveni *et al.* (1999) reported a decrease in the overall acceptability scores of jackfruit bar along with storage of 180 days.

From the above results it can be concluded that both the jackfruit varieties could be utilized for product development, though the various treatments tried out influenced the sensory appeal of the products. Papaya blended fruit bars were more appealing to eyes whereas mango blended fruit bars were found to be highly favoured in taste and flavour. Decline in sensory characters were noticed with storage. However, significant decline was observed only after 120 days in appearance and colour and after 60 days in flavour and taste. Based on the various parameters ascertained the shelf life of the jackfruit bar is five months.

5.3 STANDARDIZATION OF PRODUCTS FROM JACKFRUIT SEED FLOUR

5.3.1 Standardization of Health Drink Mixes

Functional food has a positive impact on individual's health, physical performance or state of mind, in addition to nutritive value (Varshney, 2001). Srilakshmi (2003) has opined that health foods assist the consumers in attaining enduring health in a convenient and natural way. Varshney (2001) stated that health food is to be 100 per cent natural *i.e.*, free from any additive such as synthetic colour or flavour or any type of preservatives. Taking into account of the above facts, in the present study, two types of base mixes were successfully formulated incorporating jack seed flour *viz.*, malted health drink mix and spiced health drink mix.

Srilakshmi (2003) opined that malted beverages could be made at household/community level and even at commercial level. Dahiya and Kapoor (1994) revealed that malting significantly reduced the hot paste viscosity of all other supplements in a mix and increase their nutrient density per unit volume. Pioneering work has been done at CFTRI and it was reported that addition of five per cent malted barley flour reduce the viscosity of hot paste slurry of the commercial supplementary foods upto 15 per cent (Desikachar, 1982). Malted health drink mix was standardized using wheat malt along with other ingredients.

In the formulation of spiced health drink mix, ingredients such as green gram and different spices along with jackfruit seed flour were used. Khanum *et al.* (2001) reported that spices and condiments are important ingredients in our daily diet though they are used in small quantities. Spices in foods are primarily used for their flavour and stability during storage. He was also of the opinion that spices have natural antioxidants which exhibit antimicrobial properties apart from carminative effect and helps in digestion.

5.3.1.1 Chemical Characteristics of Health Drink Mixes

The chemical and nutritional characteristics of the health drink mixes standardized in the present investigation revealed that moisture content of both the mixes were below 10 per cent and recorded comparatively very low moisture in malted health drink mix (4.25 per cent) compared to spiced health drink mix (6.21 per cent). Health drink mixes developed by Neelofer (2004) from coconut was found to have 3.58 per cent moisture in malted mix as against 9.09 per cent in therapeutic health drink mix respectively.

The acidity and the pH were observed to be higher for spiced health drink mix (0.81 per cent and 7.16) as compared to malted health drink mix (0.74 per cent and 6.33). In order to have sweetness in the health mixes glucose was added in malted drink while jaggery was added in spiced drink. The TSS of the health drink mixes was 40.92 and 46.14°Brix respectively. The total sugar, reducing sugar, pectin and starch content was higher for spiced health drink mix as compared to malted health drink mix.

The polyphenolic content was higher in the spiced health drink mix as expected when compared to malted health drink mix. Spices especially fenugreek and cumin are rich source of polyphenols, which might have contributed to higher percentage of polyphenols in the spiced health drink mix. The acid value and peroxide value which are essential criteria for maintaining keeping quality were found to be 0.01 per cent and 0.016 meq for malted health drink mix as against 0.141 per cent and 0.089 meq. for spiced health drink mix which are quite low. Hence, it can be assumed that the shelf stability will be more in the products standardized under the present study.

Peroxides reported in health drink mixes developed from coconut by Neelofer (2004) was comparatively more, when compared to mixes developed in the present study.

Nutritional characteristics of health drink mixes

Nutrients ascertained in the health drink mixes were energy, protein, fat, phosphorus, potassium, calcium and iron. Energy content of the two mixes was found to be rather high but was almost alike, 318.00 KCal in the malted health drink mix and 314.00 KCal in spiced health drink mix. Neelofer (2004) reported energy content of health drink mixes by her as 335 and 323 Kcal in malted and therapeutic health drink mix .

The protein content was observed to be more or less similar in the two health drink mixes standardized from jackfruit seed flour and accounted to be around 19.25 g and 19.13 g for spiced and malted health drink mix. Protein content of two health drink mixes standardized by Neelofer (2004) was 19.12 g and 15.66 g respectively per 100 g in malted and therapeutic health drink mixes. The protein content in the commercial health drink mixes available in the market such as boost is 18 g / 100 g whereas nutriprot is 14 g/100 g and Complan is 20 g/100 g. Hence the mixes developed with seed flour is comparable and stands excellent.

Fat content of the health drink mixes formulated was found to be slightly higher in spiced health drink mix (4.61 g) as compared to malted health drink mix (4.10 g). In support of the above. Naikare and Mabesa (1993) reported fat content of supplementary food developed from coconut as 4.90 per cent. Coconut based health drink mixes developed by Neelofer (2004) was found to have a fat content between 1.87 g -2.90 g.

Two health drink mixes formulated from seed flour was found to have good mineral content though spiced health drink was found to have comparatively higher amounts of phosphorus (380.12 mg), potassium (287.12 mg) and calcium (327.47 mg) whereas iron content was accounted to be more in malted health drink mix (4.20 mg/100 g).

Neelofer (2004) reported appreciable amounts of minerals in the coconut based health drink mixes. The calcium, phosphorus and iron content for the malted health drink mixes from coconut was 430.33 mg, 222.77 mg and 1.76 mg respectively whereas for therapeutic health drink mix it was found to be 566.37 mg, 219.32 mg and 1.95 mg. Dahiya and Kapoor (1994) reported the supplementary mixes developed by roasting and malting cereals were able to meet one third of the requirements for energy, iron and calcium for young children. Nirmala (2002) formulated supplementary food with parboiled rice with energy calcium, iron and phosphorus content as 368.00 KCal/100 g, 32.80 mg per 100 g, 3.25 mg per 100 g and 200 mg per 100 g respectively.

Thus health drink mixes developed from jackfruit seed flour were found to be excellent in nutritional quality and comparable with commercial health drink mixes available in the market and mixes developed by other researchers.

5.3.1.2 Organoleptic Characteristics of Health Drink Mixes

Sensory evaluation of health drink mixes revealed higher preference for malted health drink mix as compared to spiced health drink mix to the judges. The pleasant flavour imparted by the malting enhanced the taste and flavour of the malted health drink mix. Significant difference was observed between the two health drink mixes with respect to appearance attribute with a higher score for malted health drink mix as compared to spiced health drink mix. Similarly significant difference was also observed with respect to colour between the two health drink mixes formulated. When spices were added to the mix, the colour became dull and affected the appearance of the spiced health drink mix, whereas malting imparted a pleasing colour and fine texture to the product.

However, no difference was observed with respect to flavour, taste, clarity and over all acceptability in the two mixes developed from jackfruit seed flour. Flavour and taste of the mixes scored almost alike and were well appreciated by the judges. The mixes developed gave a clear appearance when mixed with milk/water. Both the health drink mixes scored above 80 per cent in overall acceptability which indicate that health drink mixes developed from seed flour is a better acceptable product. In this context it may be noted that Neelofer (2004) reported overall acceptability of health drink mixes developed from coconut as 70 per cent. Fig. 9 and 10 represents the organoleptic features of the two health drink mixes standardized from jackfruit seed.

5.3.1.3 Changes in the Chemical Characteristics of Health Drink Mixes with Storage

The health drinks standardized from jackfruit seed flour were stored in laminated pouches for six months and monitored monthly to understand the shelf life of the product.

The results revealed that the moisture content of the health drink mixes increased significantly after one month of storage irrespective of the treatment and the overall increase in moisture content for jackfruit health drink mix was 10.58 per cent. Neelofer (2004) also reported that moisture increased in the two health drinks formulated from coconut.

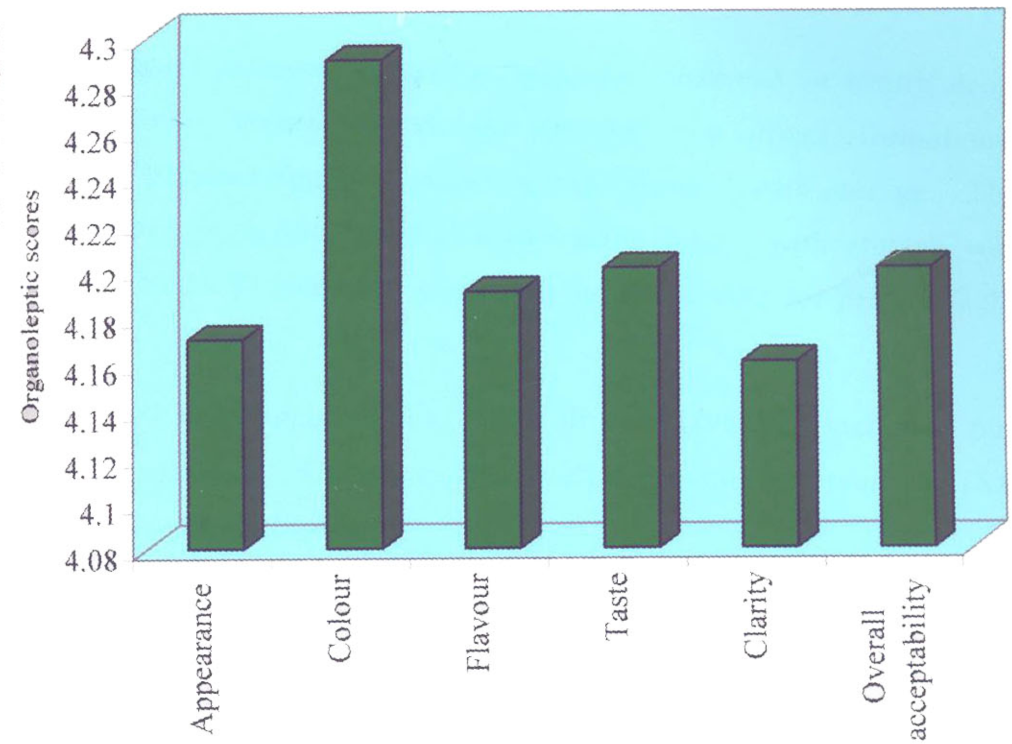


Fig. 9. Organoleptic features of malted health drink mix from jackfruit seed flour

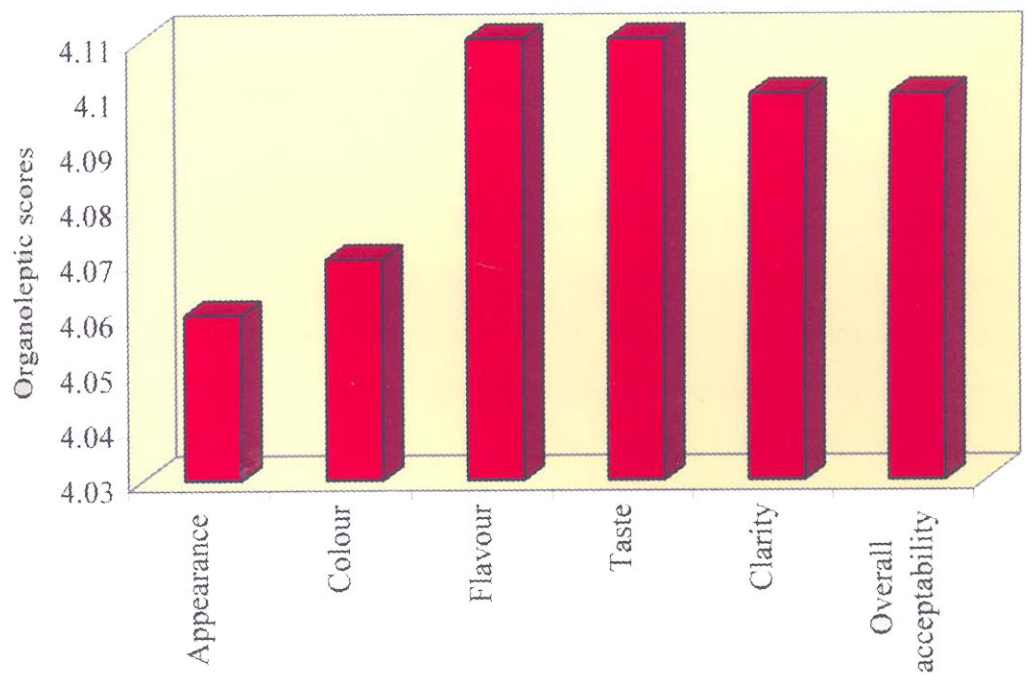


Fig. 10. Organoleptic features of spiced health drink mix from jackfruit seed flour

Significant increase in acidity was also observed in health drink mixes after one month of storage in the two mixes formulated. consequently pH was found to decrease significantly with storage. The overall increase in acidity in the health drink mixes with storage was accounted to be 10.81 per cent whereas overall decrease for pH was 2.91 per cent.

TSS and total sugar of the health drink mixes also increased but only after two months of storage. However, the overall increase in TSS and total sugar was negligible.

The reducing sugar content of the health drink mixes increased significantly after one month of storage and the overall increase was accounted to be 0.80 per cent.

Similar trend was seen for peroxide and acid value of the health drink mixes with storage. The overall increase in free fatty acid was accounted to be 12 per cent. Similar results have been reported by Neelofer (2004) in the two health drink mixes formulated from coconut.

Changes in the Nutritional Characteristics of Health Drink Mixes with Storage

As indicated from the data, there was no change in the protein and fat content of the two health drink mixes even after six months of storage. However a slight decrease was observed in the mineral content of the spiced health drink mix with storage where potassium and calcium decreased significantly with storage (t 2.180* and t 2.80*). With respect to malted health drink mix, significant decrease was observed in calcium (t 8.34**) whereas the other minerals remained intact with storage in the two mixes developed.

From the above results it can be concluded that two health drinks formulated from jackfruit seed flour had excellent appeal and shelf stability for a period of six months. The increase in moisture, acidity, TSS, total sugar, reducing sugar, peroxide and acid value in the health drink mixes was noted with storage. However the nutritional characteristics remained more or less intact. Most of the chemical changes *viz.*, moisture, acidity, TSS, total sugar and reducing sugar changed significantly after one month of storage for the health drink mixes irrespective of treatment. Based on the above parameters ascertained, the shelf stability of the product suggested is five months.

5.3.1.4 Changes in the Organoleptic Characteristics of Health Drink Mixes with Storage

As reported by Livingstone *et al.* (1993) shelf life qualities are essential parameters to be assessed since they determine the suitability of a particular product. This should be a matter of great concern in the case of health foods. Sethi and Malini (1989) has defined the quality of a food as a combination of the attributes that determine the degree of acceptability of the product which include nutritional value, microbiological safety, cost, convenience and organoleptic qualities.

Under the present investigation, the health drink mixes formulated from jack seed flour were stored for a period of six months in laminated pouches and monthly monitoring was carried out by the panel judges. The health drink mixes were mixed with hot milk and served hot for organoleptic evaluation.

Appearance

Significant difference in the appearance attribute was recorded between the two health drinks along with the storage. The appearance scores remained intact for a period of 150 days after which a significant decline in the scores was observed. A similar decrease in appearance scores was reported by Neelofer (2004) after a period of 30 days in the health drink mixes formulated from coconut. It is encouraging to note that unlike the coconut drink mixes, seed flour mix was found to have better shelf stability with respect to appearance attribute. Decrease in appearance scores was reported by Rohini (1997) in the supplementary mix developed from soya flour with other ingredients.

Colour

According to Fergus (1993) colour influences the sensory characteristics and in turn influences the food acceptability, choice and preference. When colour attribute of health drink mixes was taken into account the malted health drink mix excelled as compared to spiced health drink mix. However no significant difference in colour attribute was observed in health drink mixes developed with storage. Contrary, Neelofer (2004) reported decrease in the colour scores of the health drink mixes formulated from coconut.

Flavour

According to Birch and Lindley (1986) flavour is the mingled but unique experience of sensation produced by a material taken in the mouth perceived principally by the sense of basic smell and by other cutaneous smell in the mouth. Significant decrease in flavour scores was observed in the two health drink mixes after a period of 150 days of storage. The flavour for the malted health drink mix was preferred to spiced health drink mix, which was found to be strong due to the addition of spices. The overall decrease in flavour was accounted to be 11.7 per cent. Decrease in flavour scores was reported by Neelofer (2004) in the health drink mixes formulated for coconut and was accounted to be 41.0 per cent over a period of two months.

Taste

The taste of both the health drink mixes was equally liked by judges though significant difference in the taste attribute was observed after a period of 150 days of storage and overall decrease was accounted to be 10.34 per cent. Similar observation was reported by Neelofer (2004) in health drink mixes formulated from coconut.

Clarity

No significant difference was observed in the clarity attribute of health drink mixes even after storage of 180 days, which further confirm the stability of health drinks formulated.

Overall acceptability

According to Savithri *et al.* (1990) the overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of the food and its palatability or sensory quality. No significant difference was observed in the two mixes in overall acceptability during storage of six months. Two health drink mixes developed from jack seed flour performed well with 80 per cent acceptability among judges. Moreover, no appreciable changes were noted with sensory attributers upto five months. Overall acceptability of the two mixes were almost alike and was found equally acceptable.

5.3.2 Standardization of Biscuits from Jack Seed Flour

Biscuits, cookies and crackers represent the largest category of snack items among the baked foods in India. According to Pratima *et al.* (2000) biscuit industry has been growing at an average rate of 6 to 7 per cent during the past six years and is expected to maintain the same trend in the coming years. In the present study jackfruit seed flour was utilized along with other food adjuncts to formulate nutrient rich biscuit.

5.3.2.1 Chemical and Nutritional Characteristics of Biscuits

Chemical and nutritional characteristics of biscuit studied indicate that moisture content, one of the prime factor in determining the shelf stability of baked products was found to be 6.01 per cent. Biscuits standardized from coconut by Neelofer (2004) was also found to have a moisture less than 10 per cent. Singh *et al.* (2000) found that soy fortified biscuit contain less moisture (2per cent). Devi *et al.* (2000) reported moisture content in the biscuits formulated from green gram dhal as 5-8 per cent.

The acidity and pH of jack seed flour biscuit was accounted to be 0.63 per cent and 4.06 respectively. Whereas the TSS, total sugar and reducing sugar were 38.05°Brix, 31.56 per cent and 7.78 per cent respectively.

Singh *et al.* (2000) has reported total sugar content of soya fortified biscuits as 20.92 per cent and that of reducing sugar content as 1.93 per cent.

Free fatty acid and peroxide content present in the biscuits were also accounted, as these factors influence the keeping quality of the biscuit. Free fatty acid was 0.04 per cent whereas peroxide was accounted to be 0.01 per cent in jackfruit seed flour biscuit formulated. Free fatty acid and peroxide content of cookies reported by Neelofer (2004) was 0.41 per cent and 0.65 meq.

The calorie content of jack seed flour biscuit was 395 Kcal and protein content was 8.01 g per 100 g. Neelofer (2004) reported calorie and protein content of coconut cookies as 356 Kcal and 5.15 g, whereas Singh *et al.* (2000) reported a calorific value of soya fortified biscuits as 481 KCal and protein content as 17.30 per cent. Protein content of biscuits formulated from sweet potato flour was found to be 9.66 g as reported by Elizabeth (1999). Devi *et al.* (2000) reported protein content of biscuits formulated from green gram dhal as 14.42 per cent while Singh *et al.* (2000) reported protein content of soya fortified biscuits as 10.54 per cent. In this context seed flour biscuits stands distinct and is protein rich (8.01 g/100 g)

The fat content estimated in the jack seed flour biscuit was 19.88 g. Neelofer (2004) found fat content of coconut cookies as 25.67 g while Semwal *et al.* (1996) reported total fat content of various biscuits ranged between 1 – 2.46 per cent. Singh *et al.* (2000) reported fat content as 17.70 per cent in soy fortified biscuits. Biscuits developed by Devi *et al.* (2000) from green gram dhal contain very high fat (39.79 per cent).

The ash content of the jack seed flour biscuit was 0.05 per cent. Ash content of 1.34 per cent was reported by Singh *et al.* (2000) in soya fortified biscuits whereas, ash content of green gram dhal biscuits was reported as 1.2 percent by Devi *et al.* (2000).

The minerals analysed in the jack seed flour biscuits were phosphorus (208.6 mg/100 g), potassium (203.8 mg/100 g), calcium (58.5 mg/100 g) and iron (3.94 mg/100 g) indicating appreciable mineral status. Coconut cookies formulated by Neelofer (2004) was also rich in minerals *viz.*, calcium (60.33 mg), phosphorus (242.33 mg) and iron (1.70 mg). Semwal *et al.* (1996) stated that commercially available biscuits, contain minerals such as sodium, potassium, iron and calcium in the range of 80-495 mg/100g, 45-172 mg/100g, 3.8-23 mg/100g and 12-180 mg/100g respectively. Soya fortified biscuits standardized by Singh *et al.* (2000) was also found to contain good amounts of calcium.

5.3.2.2 Organoleptic Quality of Biscuit Developed from Jack Seed Flour

The mean scores for various sensory attributes *viz.*, the appearance, colour, flavour, taste and crispness were 4.34, 4.20, 4.18, 4.14 and 4.06 respectively. Overall acceptability of the biscuit formulated was found to be 4.18 out of 5.00 indicating 80 per cent acceptance of the product among judges. The appearance of the baked products is mainly judged by the brown hues developed on the surface. Pandey (2002) viewed that maillard reaction is important for the production of brown hues on the surface of baked products. In the present study jackfruit biscuit developed had very appealing colour as indicated by the scores, and the crispness was well appreciated. Fig. 11 represents the Organoleptic features of the jackfruit seed flour biscuit.

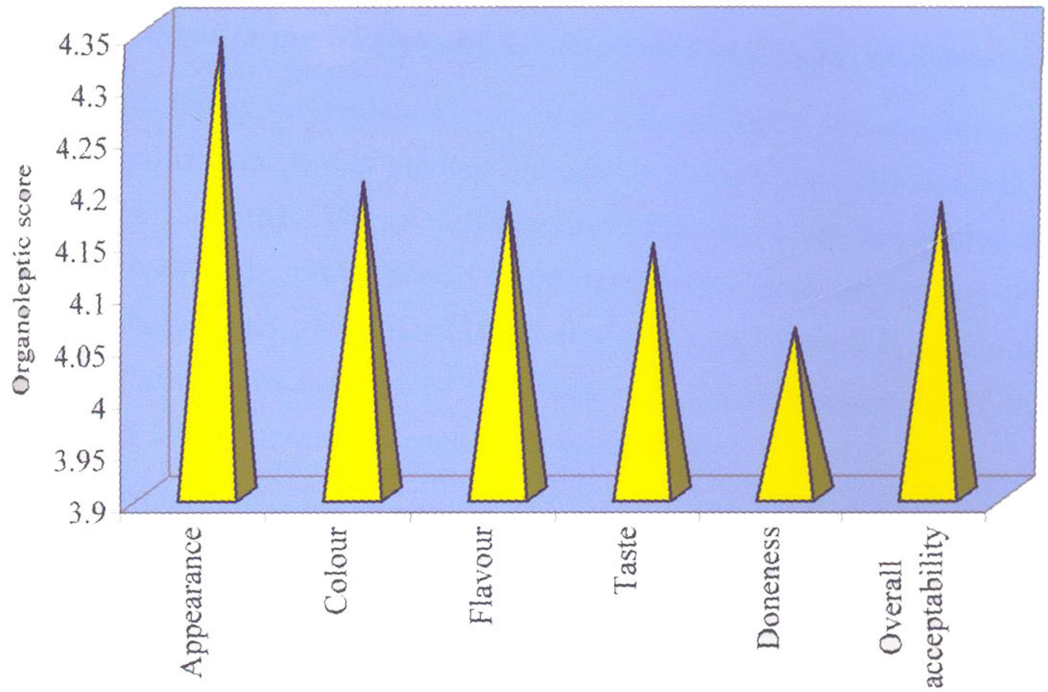


Fig. 11 Organoleptic features of biscuit from jackfruit seed flour

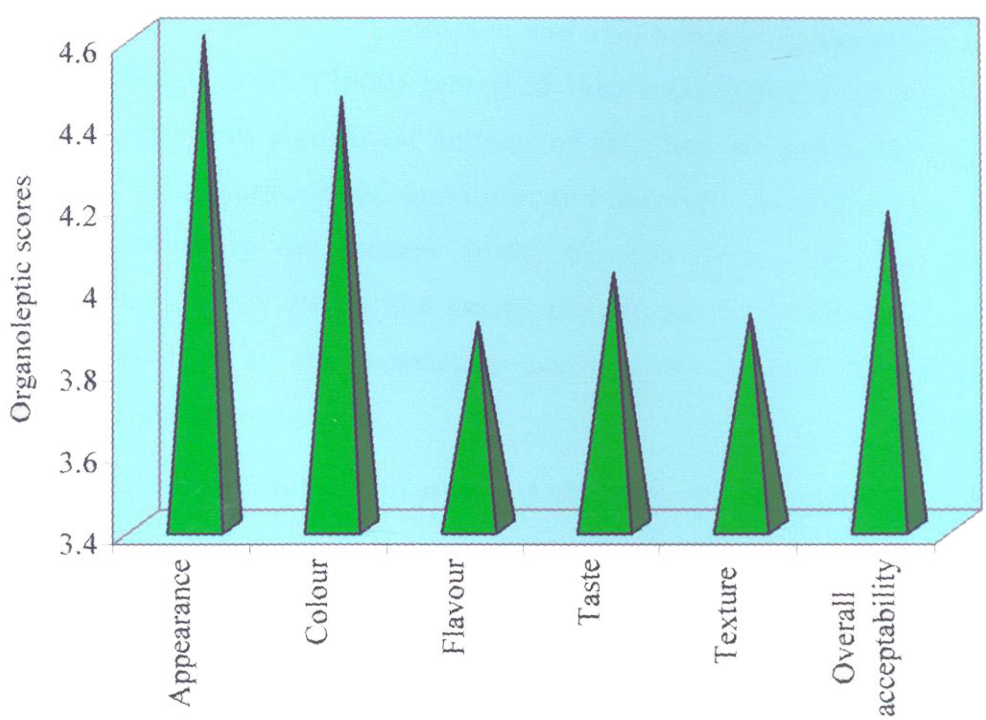


Fig. 12 Organoleptic features of confectionary product from jackfruit seed flour

5.3.2.3 Changes in the Chemical Characteristics of Biscuit with Storage

Considering the moisture content of biscuit under investigation, it was observed that there was gradual increase in the moisture content when stored for two months. The overall increase in moisture was accounted to be 0.25 per cent only over a period of 60 days which in no way affect the quality of the product. Neelofer (2004) also reported increase in moisture content in the biscuits formulated from coconut. These changes could be overcome by adopting modern packaging techniques.

Significant increase in acidity was observed in jackfruit seed flour biscuit after a storage of one month whereas significant decrease in pH was recorded after 15 days. Total sugars and reducing sugars was also found to be enhanced with storage however changes were not apparent. Increase in TSS was found to be significant after 15 days of storage.

Changes in the peroxide value was observed after 15 days of storage, whereas changes in acid value was seen after 30 days. Neelofer (2004) also reported increase in peroxide and acid value in coconut biscuit when stored. Singh *et al.* (2000) remarked that since biscuits in general have low moisture and significant amount of fat, they are prone to loose the crispness by absorption of moisture and develop rancidity due to oxidation. However in the present study, biscuits developed were not found to become rancid during the entire storage period of 60 days and were crisp. Based on all the parameters ascertained the shelf life of the biscuits suggested is two months.

Changes in the nutritional composition of the biscuits with storage

Decrease in potassium and calcium content of the biscuit was observed with storage of 60 days (t 2.38* and 8.01**), whereas the other nutrients *viz.*, energy, protein, fat, phosphorus and iron remained intact.

5.3.2.4 Changes in the Organoleptic Qualities of Biscuits with Storage

The appearance scores though decreased slightly with storage, the change was not found to be significant and the overall decrease in appearance score was 13.04 per cent. Decrease in appearance score was reported by Neelofer (2004) in the coconut biscuits with storage. Similarly a decrease in colour score was noticed and was accounted to be 6.97 per cent.

Ranganna (1986) stated that flavour is an important factor, which enriches the consumers preference to a particular product. The flavour score of the jack seed flour biscuit decreased significantly but only after a period of 30 days. The overall decrease in flavour score with storage was accounted to be 15.55 per cent. Neelofer (2004) also reported decrease in flavour scores in the coconut biscuits with storage.

As far as taste attribute is concerned a significant decrease in taste scores was noticed after a period of 30 days. The overall decrease in taste score with storage was accounted to be 17.77 per cent. Neelofer (2004) also reported similar decrease in taste score with storage in baked products developed.

Crispness of the biscuit was ascertained by pressing the crumb with fingers to see whether sticky or not. Crispness decreased with storage and the decrease was significant after 30 days. Decrease in doneness score was reported by Pratima *et al.* (2000) in the soya fortified biscuits with storage of 45 days. Similar results were also reported by Ranhotra (1980) and Sathe *et al.* (1981) in the biscuits developed from green gram dhal.

The overall acceptability of jackfruit seed biscuit was found to decrease significantly after 30 days of storage. The overall decrease in the acceptability scores was accounted to be 15.55 per cent. Decrease in overall sensory score was reported by Neelofer (2004) for coconut biscuits and by Pratima *et al.* (2000) in soya fortified biscuits.

To conclude, appearance and colour scores of the biscuits standardized from jackfruit seed flour was less affected with storage. . Other sensory features such as flavour, taste, crispness and overall acceptability scores were intact upto one month of storage after which significant decrease was observed.

5.3.3 Standardization of Laddus

Jack seed flour was utilized to formulate confectionary product *viz.*, laddu which is an energy dense snack. The seed flour was mixed with other food ingredients and adjuncts in order to get a consumer acceptable sweet product from jackfruit seed flour.

5.3.3.1 Chemical and Nutritional Characteristics of Jackfruit Seed Flour Laddu

Laddus formulated was found to have higher moisture and acidity (23.80 per cent and 1.42 per cent respectively). The pH was found to be 4.06. TSS, total sugar and reducing sugar of the laddus were 23.32°Brix, 11.80 per cent and 6.89 per cent respectively.

The nutrients *viz.*, energy, protein and fat analysed in the laddus was accounted higher as to keep them nutrient dense. Energy content of the laddus was 903 KCal, while protein and fat content was 14.67 g and 47 g respectively.

The acid value and peroxide value were ascertained as they are rancidity indicators in the products. The acid value was found to be 0.176 per cent whereas peroxide value accounted to be 0.22 meq which are comparatively low.

5.3.3.2 Organoleptic Features of Laddus Standardized from Jackfruit Seed Flour

Appearance and colour of the laddus were adjudged to be excellent as the score pertaining to the above features were 4.6 and 4.45 respectively out of five. Flavour and texture of the product developed was scored almost alike and indicated 78 and 80 per cent acceptance. The overall acceptability of the laddus was 83.4 per cent indicating a high acceptance of the product among the judges. Fig. 12 represents the Organoleptic features of confectionary product standardized from jackfruit seed flour.

5.3.3.3 Changes in the Chemical and Nutritional Constituents of Laddus with Storage

The laddus formulated from jackfruit seed flour were sealed in laminated pouches and stored in food grade containers under ambient condition.

The overall increase in moisture and acidity of laddus was accounted to be 22.74 and 36.96 per cent respectively and the changes were significant. Whereas pH was found to decrease significantly with storage.

The TSS content and total sugar of the laddus increased significantly with storage and the overall increase was accounted to be 12.59 per cent and 5.35 per cent. The reducing sugar content increased significantly with storage and the overall increase was found to be 24.67 per cent.

A significant increase in peroxide and acid value was also observed with storage indicating deteriorative changes in the product. Based on the various parameters ascertained the shelf life of the product suggested under ambient condition is 10 days.

5.3.3.4 Changes in the Organoleptic Attributes of Laddus with Storage

The results revealed decrease in appearance scores of the laddu, though was not significant.

Flavour, taste and texture scores decreased with storage and the decrease was accounted to be 36.17, 36.17 and 15.90 per cent.

The overall acceptability of laddus also decreased with storage and the decrease in overall acceptability scores of laddus was accounted to be 24.7 per cent with 15 days of storage.

From the above results it can be concluded that confectionary products is of short life though the sensory features were highly favourable.

5.4 ASSESSMENT OF MICROBIAL PROFILE OF THE PRODUCTS DEVELOPED FROM JACKFRUIT

According to Frazier *et al.* (1999) human food supply mainly depends on plants and animal source or the products from them and hence, it is obvious that foods will contain various micro-organisms. The development and type of spoilage of food products depends on several factors such as physical state of the food, its colloidal nature, types of preparation, treatments, chemical composition and nature of containers and such other factors. Khan *et al.* (2002) stressed the need for microbiological safety of foods.

Understanding the type and the nature of microbiological contamination in the products will indicate how long it will stay without spoilage and helps to improve the quality measures to be taken to stretch the keeping quality of the products. Microbial assessment was carried out in each of the product formulated under the present investigation based on which shelf stability of the product could be recommended.

Microbial assessment of nectars

Microbial quality assessment of nectars developed from jackfruit revealed that no microbiological growth was seen in the nectars formulated from both varieties of jackfruit till a period of 45 days. Absence of yeast, mould and bacteria in the initial stage reflect that processing conditions were proper and are free of contamination. However by the end of two months, negligible growth was observed in the nectars stored under ambient condition. This may be due to either leakage due to faulty sealing or secondary infection from storage atmosphere. No contamination was observed in the nectars formulated from two varieties of jackfruit stored under refrigerated condition. This further confirms the fact the growth of micro-organisms at lower temperature is suppressed as the activity of bacteria is reduced.

The bacterial count in nectars was found to be range between 3.0 x 10^2 – 6.0 x 10^2 cfu/ml. Specific identification tests in the nectars for bacteria revealed presence of *Acetobacter* and the yeast identified as *Saccharomyces*, *Candida* and mould *Penicillium* specie. The bacterial growth was detected in control and papaya blended varikka nectars, and also in blended nectars made from koozha variety at negligible level. Papaya blended koozha nectar was found more prone to bacterial attack.

Irene (1997) reported similar results in the RTS beverage prepared from Neelam mangoes. Colonies of *Pencillium* were detected in RTS after four weeks of storage. She also found that fermentation test was found to be positive in the fresh RTS beverage prepared from Neelam. Doodnath and Badriel (2000) reported that microbial infestation was minimum (10–100 cfu/ml) in the watermelon nectar stored for five weeks. Sarvanakumar and Manimegalai (2001) reported that the microbial floral analysis of stored RTS in refrigeration condition indicate the presence of 1.2 x 10^6 cfu/ml bacteria, 1 x 10^4 cfu/ml fungi and 1-2 x 10^5 cfu/ml yeast which were negligible in number and safe for consumption. Krishnaveni *et al.* (2000) reported that the jackfruit RTS samples packed in white and green coloured bottles had 5.0 x 10^6 cfu/ml, 0.0–5.0 x 10^4 cfu/ml and 4.0 x 10^5 cfu/ml of bacteria, fungus and yeast population respectively after 180 days of storage at room temperature. Chitra (2000) reported that the microbial population of the banana RTS were 1-12 x 10^6 cfu/ml and 1-6 x 10^6 cfu/ml of bacteria and 1-13 x 10^4 cfu/ml and 1-6 x 10^4 cfu/ml fungi respectively stored under ambient temperature and refrigerated condition for

300 days. Hema (1997) reported no visible changes in the Jamun based nectar stored for five weeks, after which microbial infestation with yeasts was visible. Diju (1995) reported colonies of *Penicillium* species in the RTS prepared from passion fruit after a storage of six weeks. However, Beena (1998) reported no microbial population in papaya based nectars upto a period of six months, stored under ambient condition.

Microbial Assessment of Fruit Bars

The fruit bars formulated from jackfruit pulp of two varieties were free from any microbial contamination initially and even after a period of five months. However towards the sixth month, both bacteria and fungal growth was observed in the fruit bars at negligible level.

Bacterial count for fruit bars ranged between 2.2×10^2 to 7.5×10^2 cfu/ml. Bacterial growth was detected more in papaya blended koozha bar followed by control koozha bar and lowest in control varikka bar. Fungal growth was found in papaya and mango blended varikka bar and control koozha bar.

The bacteria identified was *Streptococcus* and *Bacillus* whereas, the yeast identified was *Candida* and mould was *Mucor* specie. Absence of microbes at zero time reflect that the processing was upto the mark and microbes have come up during storage as secondary infection. In support of the above finding, Krishnaveni *et al.* (1999) reported that the initial bacterial and fungal count in jackfruit bars standardized by the author were found to be nil and appeared during storage.

Microbial analysis of sapota fruit bar (180 days) by Kumar and Manimegalai (2002b) indicated the presence of 4×10^4 cfu/ml bacteria, 2 x 10^4 cfu/ml yeast when stored for 180 days.

Jyothi (1997) reported colonies of *Aspergillus* and *Penicillium* in the mango bars stored under ambient condition after a period of eight months. Bindu (1995) and Riji (1995) have reported the microorganisms responsible for the decay of dried jackfruit and pineapple were *Aspergillus* and *Penicillium*.

Microbial Assessment of Health Drink Mixes

The health drink mixes formulated from jackfruit seed flour showed no microbial contamination till a period of five months, however by the end of 6^{th} month negligible contamination was noted. Bacterial count was slightly more in spiced health drink mix (3.5×10^2 cfu/ml) as compared to malted health drink mix (3.0×10^2 cfu/ml). However no fungal count was observed in the spiced health drink mix, whereas fungal count was detected in the malted health drink mix (2.2×10^2 cfu/ml).

The bacteria identified was streptococcus whereas fungal spores of *Mucor* and *Penicillium* were observed.

Neelofer (2004) reported negligible contamination in the therapeutic health drink mix developed when stored for two months.

Microbial Assessment of Biscuits

It is highly encouraging to note that the biscuits formulated from seed flour did not show any microbial contamination even after two months of storage at ambient condition.

Microbial assessment of laddus

Confectionary product developed from jackfruit seed flour was found to be microbiologically safe only upto 10 days. Fungal growth was observed in the laddus analysed after 15 days. The mould identified was *Rhizopus*.

Results of the microbial assessment indicate that microbial contamination in the formulated products was negligible, which confirm that appropriate processing and packaging has been adopted while formulating the products.

5.5 ASSESSMENT OF THE PRODUCTS FOR FPO STANDARDS

In India, the quality of the preserved products is controlled by the government through Food Product Order (FPO) enacted in 1955. In the present study products standardized using the two varieties of jackfruit were analysed for specifications prescribed by FPO for the similar products. This is an essential step to ensure the quality of the products.

Nectars formulated in the present investigation was assessed for FPO standards prescribed. FPO prescribe minimum of 20 per cent juice content and 15 per cent TSS for the fruit nectars. All the nectars formulated from the two varieties of jackfruit were found to have juice content between 50-60 per cent and the TSS between 18.06°Brix – 24.72°Brix. Sensory and microbiological evaluation of the nectars revealed that the product was in confirmation with the FPO standards. The SO_2 content in the finished product was also within the prescribed limit *i.e.*, <70 ppm. Thus the nectars developed satisfy the FPO requirements suggested.

With respect to jackfruit bars, FPO has specified moisture content less than 20 per cent and SO_2 level less than 750 ppm. The fruit bars formulated in the present study had a moisture content far below the prescribed limit (9.15 – 11.79 per cent) and SO_2 content ranged between 480 – 510 ppm. Visible moulds or fungi were not observed in the bars till five months of storage at ambient temperature. Thus the jackfruit bars also satisfy the FPO requirements specified.

In the case of health drink mixes the prescribed limit of moisture is less than 10 per cent during the entire period of storage. There was no fungal or bacterial attack in the health drink mixes for a period upto five months.

The biscuits standardized in the present study with jackfruit seed flour had a moisture content which was on par with moisture level suggested by the BIS specification (<6 per cent). The ash content, acid and peroxide value of the finished product was also within the prescribed limits. The result obtained indicated that all the products developed in the present study are in conformity with standards prescribed and hence could be commercialized.

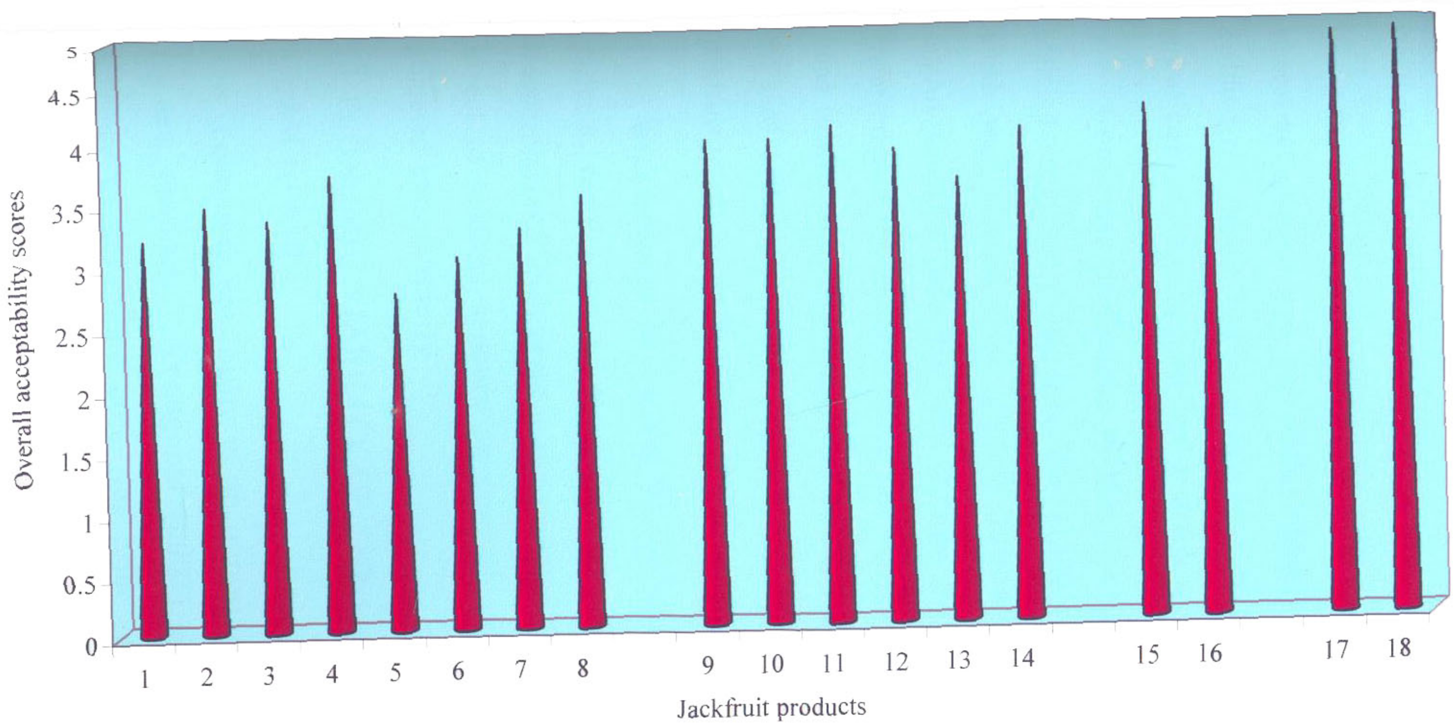
5.6 ASSESSMENT OF CONSUMER ACCEPTANCE AND PREFERENCE OF THE PRODUCTS

Acceptability, nutritional quality and cost are the prime elements of quality of foods. Potty (1993) viewed that any food product developed should give prime importance to the above principles. Thomas (2004) reported that food acceptance by consumers is the basis for the sustainability of any food processing sector.

Potter (1986) also has the opinion that consumer quality acceptance should always be considered while bringing a product into the market. The consumer preference groups are not specifically trained but can provide a good insight into what customers will prefer generally. Mani and Srinivasan (1990) stated that consumers who prefer a particular brand will be conscious of quality rather than price or shelf life. According to Singh *et al.* (1989) unique image of a product should be made in order to enable them to achieve an advantage over competitor's products.

Consumer acceptability of different products developed was carried out among consumers selected at random from different categories of people. Among various products standardized in the present study consumer acceptance of all the products was found reasonable, with the maximum consumer acceptance for confectionary product. Fig. 13 represents the consumer acceptance of products developed from jackfruit.

Consumer acceptance was more towards the nectars and fruit bars formulated from varikka variety as compared to koozha variety. Among the blended products, consumers showed higher acceptance when mango and pineapple was blended.



1 Control varikka jackfruit nectar
2 Pineapple blended varikka jackfruit nectar
3 Papaya blended varikka jackfruit nectar
4 Mango blended varikka jackfruit nectar
5 Control koozha jackfruit nectar
6 Pineapple blended koozha jackfruit nectar
7 Papaya blended koozha jackfruit nectar
8 Mango blended koozha jackfruit nectar
9 Control varikka jackfruit bar
10 Papaya blended varikka jackfruit bar
11 Mango blended varikka jackfruit bar
12 Control koozha jackfruit bar
13 Papaya blended koozha jackfruit bar
14 Mango blended koozha jackfruit bar
15 Malted health drink
16 Spiced health drink
17 Biscuits
18 Laddus

Fig. 13. Consumer acceptance of products developed from jackfruit

Blending of jackfruit pulp with other fruit pulps, significantly improved the acceptance of the products. Papaya blended nectar and fruit bar was accepted for its appearance and colour whereas mango blended nectar and bar for taste and flavour.

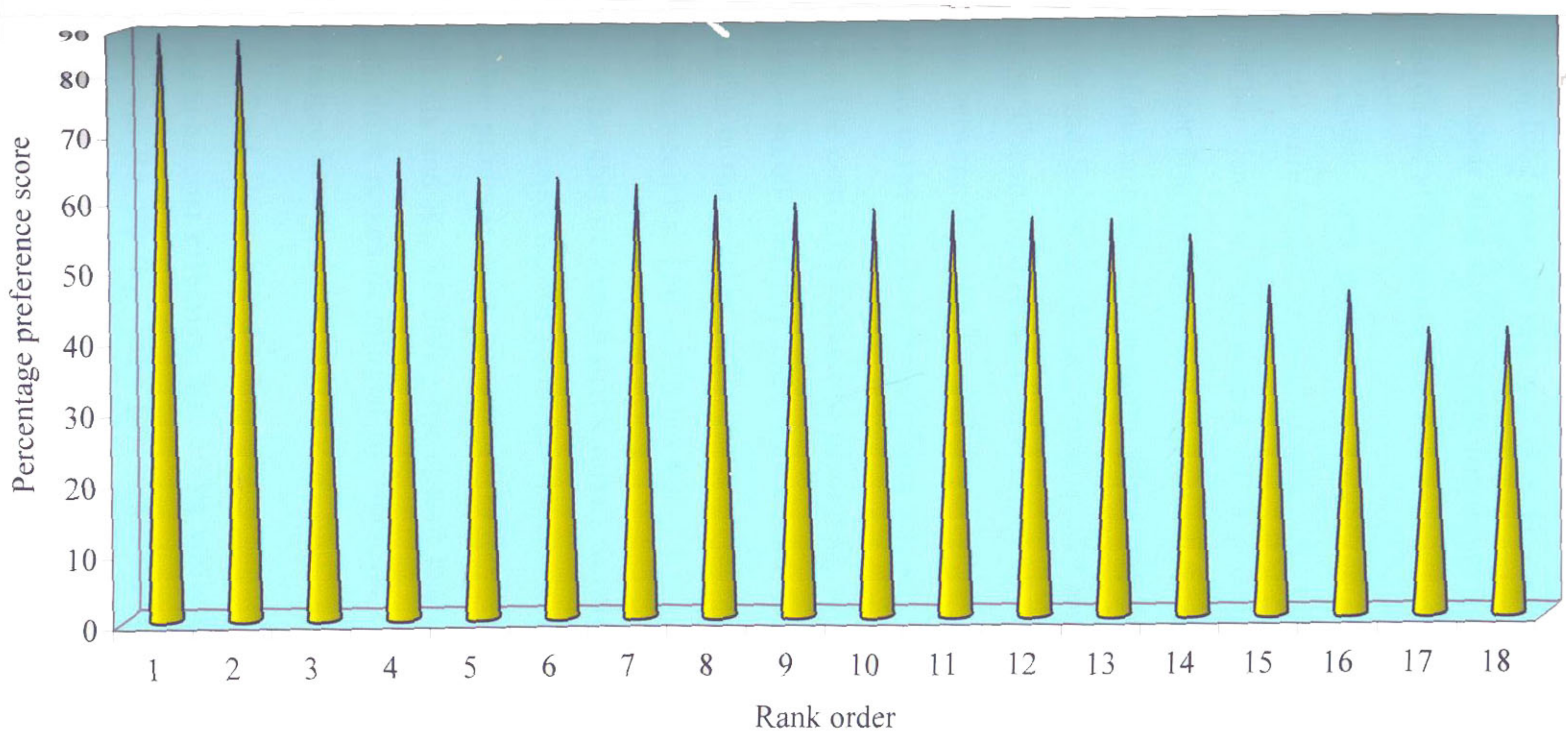
Among the four products standardized from jackfruit seed flour highest acceptance was for laddus closely followed by biscuit. Among the health drink mixes higher acceptance was shown for malted health drink mix as compared to spiced health drink mix.

Consumer preference of the jackfruit products was also tested and depicted, highest preference for confectionary product (89.2 per cent) which was ranked first, closely followed by biscuits (87.2 per cent), control varikka fruit bar and mango blended varikka bar were equally preferred and stood third (65.2 per cent), whereas jackfruit varikka nectar stood fourth (62.0 per cent) and control koozha bar sixth with percentage score of (59.2 per cent). Fig 14 represents the consumer preference of jackfruit products as per Rank Order.

With respect to variety of the fruit as well as with the type of products, results are encouraging and the products developed could be commercialized with great margin of profit. Consumer choices differ with respect to various sensory parameters and hence the products could be promoted commercially.

5.7 ECONOMIC VIABILITY OF THE PRODUCTS DEVELOPED WITH JACKFRUIT

Economic feasibility is an important factor in the development of any new products. Venugopal (2003) opined that despite the relative affluence in developed countries price remains the key factor for high proportion of the public and hence manufactures and retailers continue to compete on the prices of the products. Kumbhar and Singh (1991) remarked that cost of production depends on the purchase of the raw



1 Laddu
2 Biscuit
3 Control varikka bar
4 Mango blended varikka bar
5 Control varikka jackfruit nectar
6 Mango blended koozha bar
7 Control koozha bar
8 Pineapple blended varikka jackfruit nectar
9 Mango blended koozha jackfruit nectar
10 Papaya blended koozha bar
11 Mango blended varikka jackfruit nectar
12 Papaya blended varikka bar
13 Malted health drink mix
14 Papaya blended varikka jackfruit nectar
15 Papaya blended koozha jackfruit nectar
16 Pineapple blended koozha jackfruit nectar
17 Control koozha jackfruit nectar
18 Spiced health drink mixes

Fig. 14. Consumer preference of jackfruit products as per 'Rank Order'

materials, cost involved in processing, packaging and marketing and profit margin set up by the industry. Amla (1993) stated that while developing any new food product the cost is to be kept at minimum. Nagarajan (1993) made it clear that the strategy for development of food products is to be based on the affordable price and cost effectiveness.

Under the present investigation the nectars formulated from jackfruit were found to be comparatively cheap and vary from Rs. 12.00 to 21.00 per litre for the nectars. It is pertinent to record that the blending with other fruits enhanced the cost of the products slightly. However the cost of nectars were minimum when compared to similar products in the market and hence could be promoted for marketing as it would fetch good returns. Coconut beverages developed by Neelofer (2004) were found to range between Rs. 19.8 – 27.5 per litre. The commercial fruit nectars available in the market ranged from Rs. 40 – 70 per litre.

The cost of production of one kg of fruit bars ranged between Rs. 23.00 – 40.00 and the cost was found to be lower than the fruit bars available in the market. The commercial fruit bars available in the market range between Rs. 150 – 200 per kg.

The cost of health drink mixes developed was less compared to the protein enriched health formulas available in the market. The cost of the finished products was accounted to be Rs. 72.00/kg for malted health drink mix and Rs. 88.00/kg for spiced health drink mix. Cost of coconut health drink mixes developed by Neelofer (2004) was found to be higher and ranged between Rs. 115-121 per half kg.

Seed flour biscuit formulated under the present study was also found to be cost effective, Rs. 50/kg while that of confectionary item *viz.*, laddu was Rs. 90 /kg. The prices are comparable with the confectionary item available in the present day market.

The results confirm that jackfruit products developed under the present investigation are remunerative in price.

Product yield ratio of jackfruit products

Product yield was ascertained for each product standardized from jackfruit. Jackfruit nectars gave higher yield ratio when compared to other products developed. Moreover, products formulated with koozha variety gave higher yield when compared to varikka variety.

Jackfruit bars standardized gave slightly lower yield due to drying. Seed flour products *viz.*, health drink mixes, biscuit and confectionary item developed were almost similar in product yield and are reasonable.

5.8 BYPRODUCT RECOVERY FROM JACKFRUIT WASTE AND ITS QUALITY ANALYSIS

Gupta (2001) opined that, economic success of any fruit processing industry depends upon the utilization of waste products that are produced during the various stages of processing.

According to Marwaha *et al.* (2000), in India, food processing, agro industrial and agricultural sectors generate more than 1000 million tonnes of solid wastes every year of which fruit and vegetable processing wastes contribute a major proportion. Existing food processing industries alone contribute to the 6 MT waste per year. Disposal of the huge quantum of waste is creating a serious problem for the public, industries and for the municipal authorities due to their putresicable nature.

Tandon *et al.* (1995) stated that processing of fruits and vegetable accounts for about 1.0 per cent of the total produce. The waste generated can be effectively utilized to recover by products *viz.*, pectin, starch and fibre.

5.8.1 Quality Analysis of Pectin Extracted from jackfruit Waste

In the present investigation jackfruit waste arising after processing was subjected to recover byproducts *viz.*, pectin and starch. Pectin was extracted from jackfruit rind and pericarp whereas starch was extracted from jackfruit seeds.

The pectin extracted from the fruit pulp was qualitatively analysed in terms of equivalent weight, methoxyl conent, viscosity, jelly grade, jellying capacity and yield and cost benefit ratio which give an indication of the quality of pectin.

Equivalent weight is used for calculating the anhydrouronic acid content and the degree of esterification. The results revealed that equivalent weight of varikka pectin as 499.66 as against 331.73 in koozha pectin. Alexander and Sulebela (1980) reported that equivalent weight of pectin extracted from grape fruit peel as 940 whereas that of sweet orange peel was 859. Srirangarajan and Srikhande (1977) reported equivalent weight of pectin extracted from mango peel was 964 for Alphonsa variety, while Beerh *et al.* (1976) reported an equivalent weight of 1094 for pectin extracted from mango peel of Totapuri variety. Pruthi *et al.* as early as in 1960 reported equivalent weight of guava fruit pectin as 949. Srivas and Pruthi (1976) reported equivalent weight of fig fruit as 957. In this context the equivalent weight of pectin obtained from both the varieties of jackfruit was comparatively low.

The most important property of pectin is its ability to produce strong gels. The jellying strength of pectin depends on molecular weight and methoxyl content (Pilnik and Voragen 1970). Ranganna (1986) reported that methoxyl content of commercial pectins generally varies from 8 to 11 per cent and gels could be formed with higher amounts of sugar (65 per cent). Pectins with lower methoxyl content (less than 7 per cent) produce gels with lower concentration of sugar. The methoxyl content of pectin extracted from varikka and koozha fruit was found to be 12.26 and 15.26 per cent by which it can be inferred that the pectin extracted from jackfruit possessed good jellying strength and could be utilized for preparation of jelly.

Francis and Bell (1975) reported a methoxyl content of jackfruit pericarp (Artocarpus intregrifolia) as 2.79 per cent. Methoxyl content of lime peel was reported to be 8.62 per cent and that of grape fruit peel was 7.40 per cent (Alexander and Sulebela 1980).

According to Ranganna (1986) sugars, proteins and starches influence the viscosity of fruit juices to a slight extent, the main influence on the viscosity is due to pectin. The viscosity of extract is an indication of the quality and the quantity of pectin present and can be used as an index for the quantity of sugar to be added. The relative viscosity of pectin extracted from jackfruit was found to be higher for varikka variety (1.08) as compared to koozha variety (1.00). Tandon *et al.* (1995) had reported viscosity of four mango varieties *viz.*, Totapuri, Chausa, Dashehari and Langra as 1.019, 1.047, 1.008 and 1.032 respectively and hence relative viscosity of pectin extracted from jackfruit is comparable with mango pectin extracted from the peels of the fruit.

Ranganna (1986) reported that "grade" of pectin means the weight of sugar with which one part by weight of pectin will, under suitable conditions, form a satisfactory jelly. This jelly, subjected to the usual finger testing, should have the proper texture, resilience and consistency. The jelly grade of varikka variety was found to be 180 whereas for koozha it was 160. Tandon *et al.* (1995) reported the jelly grade of four mango varieties as 160 for Totapuri, 170 for Chausa and 180 for Dashehari and Langra variety. Jelly grade of various fruits were estimated by various researchers. Alexander and Sulebela (1980) reported 225 in lime peel whereas that of grape fruit peel as 250, Agarwal and Pruthi (1972) found jelly grade of orange peel as 200. Sharma *et al.* (1985) reported jelly grade of apple Pomace as 160, whereas Bhatia *et al.* (1959) reported jelly grade of papaya fruit to be 227.

Jelly grade was reported to be low in some of the fruit pectins. Francis and Bell (1975) reported jelly grade of bread fruit as 80 whereas, Srivas and Pruthi (1976) reported Jelly grade of cashew apple pomace to be 75.

Hence, it can be concluded that jelly grade of the pectin extracted from jackfruit was high and quite comparable with the values reported by earlier researchers.

Jellying capacity was also assessed in the pectin extracted from jackfruit. The jellying capacity or rate of setting for the pectin from jackfruit was found to be 'rapid setting' by nature and took 20 minutes.

The cost of extraction of pectin was worked out and was found to be Rs. 1290 for 100 g of pectin for both the varieties of jackfruit.

The percentage yield of the pectin extracted from jackfruit was estimated to be higher for varikka (3.68 per cent) as compared to koozha (2.88 per cent). Tandon *et al.* (1995) reported pectin yield of four varieties of mangoes and found an yield of 6.1 per cent for Chausa variety, followed by Langra variety (5.0 per cent), Totapuri variety (4.6 per cent) and 3.1 per cent for Dashehari variety.

Tandon and Garg (1999) reported the yield of pectin form the Mallika variety of mango as 2.8 per cent, Nisar Pasand mango (2.3 per cent) and Sahab Pasand mango as 2.8 per cent. The yield of pectin depends upon ripeness of fruit, variety, moisture content and extractant used (Tandon *et al.*, 1995). The quantity of pectin obtained from jackfruit was also almost on par with mango peels.

The pectin extracted from fresh rind and perigones of jackfruit of both the varieties, when compared revealed higher yield of pectin from varikka variety and also found to be qualitatively superior in terms of equivalent weight, methoxyl content, viscosity and jelly grade. However jellying capacity and cost of extraction of pectin was found to be same for both the varieties.

5.8.2 Quality Analysis of Starch Recovered from jackfruit

Carbohydrates contribute a major class of organic compounds that play a significant role in sustaining and supporting plant life. Starch is the reserve carbohydrate of the plant kingdom and is important to plants as much as glycogen to animals. Starch is generally deposited in the seeds, tubers or root of plants in the form of minute granules or cells (Kerr, 1995).

Berry and Kalra (1987) pointed out that jackfruit seeds encased in the soft cream coloured pulp are rich source of starch. In the present study jackfruit seed were utilized for extracting starch and this starch was further analysed for amylose content, alkali number, granule size, relative viscosity, gelatinization, temperature and yield.

Amylose content of varikka seeds was 32.36 per cent as against 22.53 per cent in koozha seeds. Jancy (1999) remarked that amylose and amylopectin sub units in starch are heterogenous and they widely vary in the seeds. The amylose content of jack seed starch was reported as 15-28 per cent (Berry and Kalra 1987). Peshin (2001) reported amylose content of potato tubers as 3.71 per cent. In another study Hoover *et al.*, (1997) found amylose content of mung bean starch as 45.33 per cent.

According to Jancy (1999) alkali absorption and swelling of starch granules bear importance from the point of view of industrial application as many of the techniques adopted for modifying and derivatizing starch are catalysed by alkali. She further remarked that there is a positive correlation between swelling of starch granules and alkali concentration. It is generally seen that at a constant temperature starch granules in alkali suspension swell as a function of the equilibrium concentration of alkali. When starch granules are placed in a strong alkaline solution protons of the –OH group are dissociated leaving behind negative charges on the starch molecules. It is the repulsion between negative charges that result in swelling of starch granules. In the present study alkali number was estimated as 2.15 in varikka seeds and 3.82 for koozha seed starch. Peshin (2001) reported swelling volume of starch of different cultivars of potato estimated at 95°C for various concentration between 25 – 40 ml/g at 1.00 per cent starch concentration.

Zobel (1988) pointed out that size, distribution, shape and morphology of starch granules are markedly influenced by their botanical origins. Thus cereal starches are generally small and polyhedric while tuber starches are often large and ellipsoidal or spherical in shape. The size of varikka seed starch was 8.17 μm as against 7.21 μm of koozha seeds. The granule size for potato starch was found to range between 40-59.6 μm (Peshin, 2001). Aggarwal *et al.* (2004) reported diameter of starch granules of mung to range between 10 – 31.8 μm. Berry and Kalra (1987) reported size of jackfruit seed starch to range between 7.11 μm. The observation is true in the two varieties of jackfruit seeds studied.

Starch forms a viscous paste when heated in the form of an aqueous dispersion. Generally root or tuber starches swell more rapidly within a narrower range of temperature than that generally observed in the case of common cereal starches (Jancy 1999). The viscosity of varikka seed starch was found to be 1.01 and that of koozha 1.06. Tandon and Garg (1999) reported viscosity of mango seed kernel starch to be 1.016. Viscosity of jackfruit seeds are comparable to mango seed kernel starch.

The gelatinization temperature of the starch extracted was also analysed and was found that gelatinization temperature was 80.2°C for varikka seed starch as against 67.9°C for koozha seed starch. The higher gelatinization temperature of varikka starch may be attributed to the fact that longer chains require much high temperatures to break as compared to short chains as indicated by the amylose content of varikka seeds starch which was higher.

The yield of starch on dry weight basis was 6.9 per cent in varikka seeds as against 6.1 per cent in koozha and indicate higher starch content in varikka seeds. Tandon and Garg (1999) have reported starch yield from mango kernel to be 24.7. Peshin (2001) reported yield of starch from different potato cultivars to range between 18.4 – 23.0 per cent on dry weight basis. In this context yield of starch from jackfruit seeds is low.

The above results gave valuable insight to some of the important properties of jackfruit seed starch. Due to its high viscosity and swelling power jackfruit seed starch can be exploited for use in textile, food, paper and pharmaceutical industries. For the production of seed starch, surplus and damaged fruit available during gluts could be used.

Summary

6. SUMMARY

The present study entitled "Utilization of jackfruit for product development and byproduct recovery" was aimed at developing value added products from jackfruit and to assess its chemical, nutritional, organoleptic and shelf life qualities along with consumer acceptance and preference. The waste arising after the processing of jackfruit was also utilized for byproduct recovery and the quality evaluation of the byproducts was studied in detail.

Under the present investigation two main varieties of jackfruit *viz.*, muttan varikka and koozha were utilized for product development. Physico-chemical characteristics of the two varieties of jackfruit studied, revealed that physical attributes *viz.*, interspine distance and the peduncle length of the fruits were almost alike, while number of spines per unit area, weight and length of the fruit, number of fruits per plant and yield per plant vary significantly between the two varieties. Number of spines per unit area and number of fruits per plant were more for varikka, whereas the weight, length and yield of fruit were more for koozha variety. Physical features of jackfruit bulbs and seeds indicated that length and weight of bulbs (12.38 cm and 5.36 g) and seeds (6.96 cm and 4.43 g) of koozha variety was more as compared to, varikka variety bulbs (10.26 cm and 4.72 g) and seeds (5.77 and 3.20g) and number of seeds per fruit were more in koozha variety.

Chemical and nutritional characteristics of jackfruit bulbs were analysed and significant difference was observed in TSS, total sugar, reducing sugar, β-carotene, pectin and polyphenol between the two varieties. pH was higher in koozha fruit while acidity was more in varikka bulbs; TSS and total sugar were found to be higher in koozha variety as compared to varikka variety. Nutritional characteristics *viz.*, β-carotene

was found to be higher in koozha variety while vitamin C was found to be more in varikka bulbs.

Assessment of jackfruit seeds revealed higher moisture, acidity, total sugar and reducing sugar in koozha seeds as compared to varikka seeds. Among the various nutrients assessed in jackfruit seeds, protein, starch and mineral content was comparatively more in koozha seeds, whereas carbohydrate was accounted higher in varikka seeds. The fibre content was more or less similar in the seeds of both varieties.

In the present study, the products developed from jackfruit pulp were clarified juice, jackfruit nectars and fruit bars, whereas from seed flour, health drink mixes, bakery and confectionary products were standardized.

Extraction of clarified juice from varikka jackfruit indicated that maximum juice yield was obtained when the pulp was treated with one per cent enzyme at 40°C and incubated for two hours. Clarified juice thus obtained was found to have pH 5.6, with 2.05 per cent acidity and TSS of 15.03°Brix. Quality evaluation of the clarified juice indicated excellent clarity and 31 per cent higher juice yield when compared to untreated pulp. Negligible browning was observed in the clarified juice extracted.

Standardization of jackfruit nectars with two varieties of fruit were successfully carried out under the present investigation. Plain nectars as well as blended nectars were standardized with jackfruit in combination with other fruit pulps. Four nectars of different taste and flavour were formulated from each variety of jackfruit.

Chemical features of the nectars indicated that varikka nectars were found to have higher acidity, TSS, total sugar, reducing sugar, β-carotene and polyphenols compared to koozha nectars standardized. Significant difference was also observed in the varikka and koozha nectars with respect to chemical and nutritional characteristics studied.

Organoleptic evaluation of the nectars formulated indicated that overall acceptably of plain and blended nectars ranged between 77 – 79 per cent indicating good acceptance of the products. Blending with other fruit pulps resulted in improvement in flavour and taste in the nectars. All the sensory attributes such as appearance, flavour, taste and consistency of nectars formulated from varikka variety stood superior as compared to koozha nectars.

Data on the changes in the chemical and nutritional constituents of jackfruit nectars revealed that varietal difference was reflected in the chemical constituents such as acidity, pH, TSS, total sugar, vitamin C and polyphenols with storage. Treatments applied in the formulation of jackfruit nectars were found to have distinct impact on the chemical and nutritional constituents of nectars except for TSS. All the chemical and nutritional features except TSS were found to be influenced by the storage condition. The nectars stored under refrigerated condition were less prone to changes as compared to those stored at ambient condition and the various chemical constituents ascertained in the nectars change as the storage period advanced except TSS.

Changes in the organoleptic attributes of nectars with storage indicated that appearance, flavour and taste attributes of nectars were influenced by the variety of the fruit whereas colour, consistency and overall acceptability were unaffected by variety. An other important observation was that sensory features *viz.*, colour and appearance was outstandingly enhanced when papaya pulp was blended, whereas taste and flavour was improved when pineapple and mango pulp was blended. Consistency of the nectars was more as less the same for all the nectars formulated. All the sensory attributes including overall acceptability of nectars were stable when stored under refrigerated condition as compared to those stored under ambient condition. Storage period influenced all the sensory attributes in the nectars and the scores declined gradually over a period of 60 days. Taking into account of all the parameters ascertained shelf life of the nectars recommended is 45 days.

Six different fruit bars with distinct taste and flavour were standardized from the two varieties of jackfruit under the present investigation. Results obtained confirmed that jackfruit bars could be successfully formulated individually and in combination with other fruit pulps *viz.* papaya and mango.

Data on the chemical and nutritional features of the fruit bars indicated that all the chemical attributes *viz.*, moisture, acidity, pH, TSS, total sugar, reducing sugar, β-carotene, vitamin C and polyphenols vary with the variety of jackfruit. Significant difference was also observed with respect to all the chemical constituents between the various treatments applied in the present study. However the sensory attributes of the fruit bars formulated neither vary between the two varieties nor with the treatments applied. The overall acceptability of the fruit bars was found to range between 4.17 to 3.89 out of 5 indicating 82 per cent acceptability among the judge panel.

Data on changes in the chemical constituents analysed in the fruit bars upto a period of six months depicted difference with respect to the variety and storage period. Moisture, acidity, TSS, total sugar and reducing sugar of the fruit bars were found to increase significantly with storage whereas pH, β-carotene, vitamin C and polyphenols decreased significantly.

The organoleptic features of the jackfruit bars indicated that both varieties of jackfruit could be utilized for the formulation of fruit bars. Blending papaya pulp with jackfruit pulp imparted better appearance, colour and textural qualities to the fruit bars, while blending with mango pulp resulted in better flavour, taste and overall acceptability in the products. The appearance and overall acceptability of the fruit bars was found to be influenced by the variety of jackfruit whereas the other attributes *viz.*, colour, flavour, taste and texture of fruit bars remained unaffected by variety. It was also confirmed that among the various treatments applied appearance and colour attribute was adjudged to be the best when papaya was blended. As the storage period advanced sensory attribute scores and overall acceptability declined. On account of the various factors analysed the shelf stability suggested for the fruit bars is five months.

Present investigation also explored the possibility of utilization of jackfruit seeds in product development. Procedure for obtaining good quality of seed flour was standardized under the present study and the flour was utilized to develop health drink mixes and confectionary products as it is a valuable source of nutrients. Two types of health drink mixes were standardized *viz.*, malted health drink mix and spiced health drink mix. Malted health drink mix was standardized in which wheat malt was incorporated in the former while various spices were added in the latter mix.

The chemical and nutritional parameters ascertained in the health drink mixes revealed that moisture, pH, acidity, TSS, total sugar and reducing sugar were higher for spiced health drink mix and both are nutritionally rich. A higher energy content in the malted health drink mix was seen as compared to spiced health drink mix.

Organoleptic assessment of health drink mixes revealed higher preference for malted health drink mix as compared to spiced health drink mix. Malting enhanced the taste and flavour significantly. Significant difference was observed with respect to appearance and colour attribute in the two health drink mixes. The malted health drink mix was adjudged superior to spiced health drink mix in overall acceptability however, both the mixes scored above 80 per cent indicating well acceptability of the two mixes developed.

Assessment of changes in the chemical and nutritional characteristics of health drink mixes revealed significant increase in the moisture, acidity, TSS, total sugar, reducing sugar, peroxide and acid value of health drink mixes towards the end of six months of storage. However, the nutritional characteristics remained intact throughout entire storage period. Sensory scores of the health drink mixes declined gradually with storage of six months. Appearance, taste and flavour scores declined after 150 days whereas colour and clarity scores declined only after 180 days of storage. Taking into account of all the factors, shelf life suggested for health drink mixes is five months.

Biscuits standardized from jackfruit seed flour depicted moisture 6.01 % with acidity 0.63 %, pH 4.06 and TSS 38.05°Brix respectively. Free fatty acid and peroxide which are the two important criteria for shelf stability of biscuit was found to be 0.04 per cent and 0.01 per cent respectively. Biscuits standardized was found to be nutrient rich with 395 Kcal and 8.01 g protein and appreciable amounts of minerals.

Changes in the chemical and nutritional characteristics of biscuits with storage revealed significant increase in the moisture content and decline in pH after 10 days of storage. Other features *viz.*, TSS, total sugar and reducing sugar increased significantly after 15 days of storage while mineral content decreased. Organoleptic scores of the biscuit decreased gradually with storage of 60 days. Crispness of the biscuit declined with storage as expected, so also taste and flavour. Taking into account of all the parameters the shelf life suggested for biscuit is two months.

Confectionary products standardized from jackfruit seed flour *viz.*, laddu was the most acceptable product but of short life. Moisture content of jackfruit seed flour laddu formulated was 23.80 per cent with pH 4.06 and 1.42 per cent acidity. Seed flour laddu was also high in energy, protein and fat (903 Kcal, 14.67 g and 47 per cent respectively).

Sensory evaluation of jackfruit seed laddu indicated that all the organoleptic features *viz.*, appearance, colour, flavour, taste and texture were highly appreciated by the panel judges and adjudged to be excellent with an overall acceptability of 83.4 per cent.

Changes in the chemical constituents was observed with storage. Sensory features also declined with storage. Based on the parameters ascertained the shelf life suggested is 10 days.

All the products standardized were assessed for microbial contamination which was found to be negligible in all the categories of products. However towards the end of storage period some microbial infestation was observed in the products. The bacteria identified was *Acetobacter* in the nectar whereas in fruit bar it was *Streptococcus* and *Bacillus*. In the case of fungus growth of *Sacchromyces* and *Candida* species were observed for nectars, whereas in bars mould growth was observed (*Mucor*). Fungal spores of *Mucor* and *Penicillium* were recorded after 150 days of storage in the health drink mixes, whereas in the case of confectionary item, mould growth of *Rhizopus* was observed by the end of 15th day. No microbial contamination was observed in the biscuit even after two months of storage at ambient temperature.

The products developed from jackfruit were compared with the available FPO and BIS standards. It is worth mentioning that all the products developed were comparable with the prescribed standards, and none of the products exceeds the limits suggested for different quality parameters. Consumer acceptance and preference of the products carried out revealed that seed flour products were the most acceptable and preferred items, among the consumers. Varikka fruit products were more acceptable when compared to products from koozha fruits. However fruit bars of both varieties were equally liked and preferred by the consumers. Plain nectars and fruit bars formulated from varikka fruit were more preferred by the consumers over the blended products, which indicated that, jackfruit products even without blending could be converted to consumer acceptable products and marketed profitably.

Cost of products indicted that confectionary product was found to be the most expensive (Rs. 90/kg) followed by spiced health drink mix (Rs. 88/kg) and biscuit (Rs. 50/ kg). All the products standardized were found to be reasonable in price and comparable to the proprietary products available in the market. Among the various products standardized under the present study nectars and fruit bars were found to be the cheapest. However blending with other fruit pulp slightly enhanced the cost of nectars and fruit bars. It may also be pointed out that koozha products were much cheaper as compared to varikka products due to lesser cost of fruit.

Assessment of product yield indicated that fruit nectars gave higher yield when compared to other products developed. Yield was more when koozha variety was used for formulating nectars. The yield of confectionary product was 1 : 0.99 whereas in biscuit it was 1 : 0.97.

The pectin extracted from varikka fruit waste depicted better quality with respect to equivalent weight, viscosity, jelly grade and yield. However the cost of extraction was found to be same for both the varieties but was rather expensive.

The starch recovered from jackfruit seeds indicated higher amylose content, alkali number viscosity, gelatinization temperature and yield in varikka seed starch. The cost of extraction was estimated to be Rs. 55/100 g which is quite reasonable.

Based on research findings following recommendations and conclusions could be drawn.

- Both the varieties of jackfruit could be utilized for product development.

- Technologies developed need to be transferred to the interested entrepreneurs and popularized.
- Processing of jackfruit should be taken up at commercial level in order to avoid wastage during the glut season.
- Modern packaging techniques and upscaling of the products is needed in order to enhance the shelf life and appeal of the products.
- Product diversification with respect to raw jackfruit is to be attempted.
- Jackfruit waste generated could be utilized for byproduct recovery and also for compost production in an ecofriendly manner.
- The starch extracted from jackfruit can be exploited for use in textile, food, paper and pharmaceutical industries.

India has visualized the tremendous potential for commercial and export oriented agri-business. Exploitation of this potential can bring about an era of prosperity with the right mix of employment generation and profit.

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*Original not seen

Appendices

APPENDIX - Ia

DUO TRIO TEST

In the Duo Trio test, reference sample 'R' was given to the members. The members were asked to taste the sample carefully. Then a pair of coded sample was given to the members and asked to match with the reference sample 'R'.

Name :

Product : Date:

Set No.	Code No. of Pairs	Same as 'R'
1		
2		
3		
4		

Signature

APPENDIX - Ib

RANKING TEST

The samples were presented to the members and asked to rank them in numerical order according to their preference or intensity of aroma/taste characteristic of the product.

Name :

Product : Date:

Intensity / Product	Sample code
First	
Second	
Third	
Fourth	

Signature

APPENDIX - Ic

Score card for the assessment of organoleptic qualities of fruit nectar

Name :

Product : Date:

Criteria		V_1T_1	V_1T_2	V_1T_3	V_1T_4	V_2T_1	V_2T_2	V_2T_3	V_2T_4
1. Appearance									
Excellent	5								
Very good	4								
Good	3								
Fair	2								
Poor	1								
2. Colour									
Excellent	5								
Very good	4								
Good	3								
Fair	2								
Poor	1								
3. Flavour									
Excellent	5								
Very much acceptable	4								
Acceptable	3								
Less acceptable	2								
Not at all acceptable	1								
4. Taste									
Excellent	5								
Very good	4								
Good	3								
Fair	2								
Poor	1								
5. Consistency									
Highly acceptable	5								
Acceptable	4								
Moderately acceptable	3								
Less acceptable	2								
Not at all acceptable	1								

Signature

APPENDIX - Id

Score card for the assessment of organoleptic qualities of fruit bars

Name :

Product : Date:

Criteria		V_1T_1	V_1T_2	V_1T_3	V_2T_1	V_2T_2	V_2T_3
1. Appearance							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
2. Colour							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
3. Flavour							
Excellent	5						
Very much acceptable	4						
Acceptable	3						
Less acceptable	2						
Not at all acceptable	1						
4. Taste							
Excellent	5						
Very good	4						
Good	3						
Fair	2						
Poor	1						
5. Texture							
Highly acceptable	5						
Acceptable	4						
Moderately acceptable	3						
Less acceptable	2						
Not at all acceptable	1						

Signature

APPENDIX - Ie

Score card for the assessment of organoleptic qualities of health drink mixes

Name :

Product : Date:

Criteria		T_1	T_2
1. Appearance			
Excellent	5		
Very good	4		
Good	3		
Fair	2		
Poor	1		
2. Colour			
Excellent	5		
Very good	4		
Good	3		
Fair	2		
Poor	1		
3. Taste			
Excellent	5		
Very good	4		
Good	3		
Fair	2		
Poor	1		
4. Flavour			
Excellent	5		
Good	4		
Fair	3		
Poor	2		
Not at all acceptable	1		
5. Consistency /clarity			
Excellent	5		
Good	4		
Fair	3		
Poor	2		
Very poor	1		

Signature

APPENDIX - If

Score card for the assessment of organoleptic qualities of biscuit

Name :

Product : Date:

Criteria		Scores assigned
1. Appearance		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
2. Colour		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
3. Flavour		
Excellent	5	
Very much acceptable	4	
Acceptable	3	
Less acceptable	2	
Not at all acceptable	1	
4. Taste		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
5. Doneness/Crispness		
Well cooked	5	
Cooked	4	
Slightly cooked	3	
Moderately cooked	2	
Uncooked	1	

Signature

APPENDIX - Ig

Score card for the assessment of organoleptic qualities of confectionery item

Name :

Product : Date:

Criteria		Scores assigned
1. Appearance		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
2. Colour		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
3. Flavour		
Excellent	5	
Very much acceptable	4	
Acceptable	3	
Less acceptable	2	
Not at all acceptable	1	
4. Taste		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	
5 Texture		
Excellent	5	
Very good	4	
Good	3	
Fair	2	
Poor	1	

Signature

APPENDIX – IIa

Method of Preparation of jackfruit seed flour biscuits

Ingredients :

Jack seed flour – 35 g

Coconut milk powder 30 g

Maida – 100 g, dalda 70 g

Sugar 50 g

Ammonia bicarbonate – a pinch

Vanilla essence and cashew as desired

(1) Sieve the seed flour and maida along with ammounium bicarbonate

(2) To this add dalda, sugar, coconut milk powder and mix thoroughly, so that no lumps are formed

(3) Powdered cashew and vanilla essence were added lastly

(4) The dough was rolled and the biscuits were cut using a biscuit cutter

(5) The biscuits were baked at 175°C for 35-40 minutes.

(6) The biscuits were packed in laminated pouches and stored in food grade containers.

APPENDIX – IIb

Method of preparation of jackfruit seed flour laddu

Ingredients :

Jack seed flour	–	50 g
Maida	–	30 g
Dalda	–	35 g
Sugar	–	75 g
Whole milk powder	–	25 g
Curd	–	50 ml
Cashews	–	as desired

(1) Jack seed flour and maida were roasted separately

(2) To the roasted mixture other ingredients like milk powder, sugar and curd were added. A pinch of yellow colour was added.

(3) The mixture was stirred continuously

(4) Dalda was added in small amounts as and when needed

(5) When the mixture started leaving the pan it was taken out and spread on a greased plate.

(6) The product was then made into small balls and garnished with cashews.

(7) The laddus were packed in laminated covers and stored is food grade containers.

UTILIZATION OF JACK FRUIT (*Artocarpus heterophyllus* Lam.) FOR PRODUCT DEVELOPMENT AND BY-PRODUCT RECOVERY

SHRUTI PANDEY

Abstract of the
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ABSTRACT

The jackfruit (*Artocarpus hetrophyllus* Lam.) a member of the Moraceae family is an important fruit in India and is grown sporadically in other parts of the tropics mostly as a dooryard tree. Jackfruit indigenous to India is the single largest edible fruit and is a heavy yielder than other fruit trees. Among the fruits grown in Kerala, jackfruit tops the list in terms of production (28.9 lakh tonnes). Inspite of this huge production no serious efforts has been taken up so far to utilize this plentiful resource into effective commercial exploitation for the manufacture of value added food products. Hence the present investigation entitled "Utilization of jackfruit for product development and by-product recovery" was taken up to develop diversified food products applying innovative and indigenous technologies and to explore the possibility of by-product recovery from the waste generated after jackfruit processing.

The study comprises in depth analysis of the physico-chemical characteristics of the two varieties of jackfruit, product development utilizing fruit pulp and seed flour, chemical, nutritional, organoleptic and shelf life assessment of the products developed. Consumer acceptance and consumer preference of the products, economic viability and comparison with the food quality requirements were other aspects studied in order to ascertain commercial viability of the products developed.

Products developed under the present investigation are clarified juice, jackfruit nectar and jackfruit bars from the two varieties of jackfruit. Seed flour products such as health drink mixes, bakery and confectionary products are the other products standardized. By-products, *viz.*, pectin and starch were extracted from jackfruit waste and its quality evaluation was ascertained.

Physico-chemical characteristics of jackfruit bulbs and seeds revealed that, varietal difference was reflected in weight and length of fruits and yield per plant and fruit per plant, which was in favour of koozha variety. Fruit bulbs and seeds

were also heavier and more for koozha variety as compared to varikka. However, bulbs were more attractive in varikka fruits and was more suitable for product development. Chemical and nutritional characteristics analysed in the jackfruit bulbs of the two varieties revealed significant difference in total soluble solids, total sugars, reducing sugars, β-carotene, pectin and polyphenols. Assessment of jackfruit seeds indicate higher moisture, acidity, total sugar and reducing sugar in koozha seeds.

Clarified juice extracted from varikka jackfruit pulp by enzymatic treatment gave 30 per cent higher juice yield, and was found to have pH 5.6, 2.05 per cent acidity with a total soluble solids of 15.03° Brix. The juice was sparkling clear with negligible browning.

Fruit nectars were standardized from two varieties of jackfruit individually and by blending with other fruit pulps. Four nectars of different taste and flavour were formulated from each variety of jackfruit. Chemical characteristics of nectars indicated that varikka nectars were found to have higher acidity, total soluble solids, total sugar, reducing sugar and β-carotene compared to koozha nectars standardized. Pineapple blended and mango blended nectar adjudged to be the best for taste and flavour, while papaya blended nectars were preferred for appearance and colour. The chemical and organoleptic characteristics of the nectars were found to change with storage but remained stable till 45 days. Nectars stored under refrigerated condition depicted lesser changes with respect to chemical and organoleptic features as compared to nectars stored under non-refrigerated condition. Nectars formulated from varikka pulp were found to be more acceptable as compared to koozha nectars. The overall acceptability of jackfruit nectars was found to range between 77 to 79 per cent.

In the present investigation, jackfruit bars were standardized individually and also by blending with other fruit pulps. As observed in fruit nectars, blending with papaya pulp enhanced the appearance of the fruit bars while blending with mango pulp resulted in better flavour, taste and overall acceptability. Six different fruit bars standardized were highly acceptable with an excellent percentage acceptability (82.00 per cent). Significant difference was also observed with respect to all the chemical constituents between the variety and the treatments applied. Chemical and sensory features declined gradually with storage. The shelf stability of jackfruit bars recommended is five months in sealed laminated pouches.

The two health drink mixes standardized from seed flour were nutritionally rich and high in mineral content. Malted health drink was preferred to spiced health drink mix in sensory features, though both the mixes scored above 80 per cent for overall acceptability. Mixes were stable for five months and was encouraging to note that negligible decline was observed in nutrient content with storage.

Bakery and confectionary products developed from jackfruit seed flour was the most preferred products. Both the products were found to be nutrient rich and could be relished by different categories of people. It is worth mentioning that seed flour biscuits were less susceptible to deteriorative changes with storage. Shelf life suggested for biscuit is two months, while confectionary product, laddu is of short life (10 days) as expected.

Microbial contamination of all the products standardized was monitored at periodic intervals and was found to be negligible. Consumer acceptance and preference of the products revealed highest acceptance and preference for bakery and confectionary products followed by mango blended fruit bars, plain varikka nectar and pineapple blended nectar. Products developed from jackfruit pulp and seeds were compared with the available FPO and ISI standards and were found to be in accordance with the standards prescribed.

Cost of production and product yield was worked out, for all the products standardized and were found to be reasonable and comparable to the proprietary products available in the market. Taking into account of the cost factor, the jackfruit seed flour biscuit formulated in the present study are ideal, nutrient dense and comparable with proprietary products available in the market. Jackfruit nectars and fruit bars were found to be the cheapest.

By-products recovered from jackfruit waste under the present investigation are pectin and starch. Varikka fruit was found to be more ideal for extraction of pectin and starch as compared to koozha fruit. Quality characteristics of the by-product recovered were also in favour of varikka fruit. However, cost of recovery of pectin was found to be high while that of starch is reasonable.

Based on research findings following recommendations and conclusions could be drawn.

- Both the varieties of jackfruit could be utilized for product development.
- Technologies developed need to be transferred to the interested entrepreneurs and popularized.
- Processing of jackfruit should be taken up at commercial level in order to avoid wastage during the glut season.
- Modern packaging techniques and upscaling of the products is needed in order to enhance the shelf life and appeal of the products.
- Product diversification with respect to raw jackfruit is to be attempted.
- Jackfruit waste generated could be utilized for byproduct recovery and also for compost production in an ecofriendly manner.
- The starch extracted from jackfruit can be exploited for use in textile, food, paper and pharmaceutical industries.

India has visualized the tremendous potential for commercial and export oriented agri-business. Exploitation of this potential can bring about an era of prosperity with the right mix of employment generation and profit.