STUDIES ON PRESERVATION OF JACKFRUIT (*Artocarpus heterophyllus* Lam.) BULBS IN HIGH CONCENTRATION OF SUGAR

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DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
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STUDIES ON PRESERVATION OF JACKFRUIT (*Artocarpus heterophyllus* Lam.) BULBS IN HIGH CONCENTRATION OF SUGAR

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Certificate

This is to certify that the thesis entitled **"Studies on Preservation of Jackfruit (*Artocarpus heterophyllus* Lam.) bulbs in high concentration of Sugar"** submitted by **Mr.Nagarajappa,K.** for the award of degree of **MASTER OF SCIENCE (Horticulture)** in **Post Harvest Technology of Horticultural Crops** of the University of Agricultural Sciences, Bangalore, is a record of bonafide research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
JUNE , 2001

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INTRODUCTION

I. INTRODUCTION

The jackfruit tree (*Artocarpus heterophyllus* Lam.) is an important minor fruit crop of tropics. It bears the largest edible fruit and tree trunk is also famed for its timber. Due to the quantity and the quality of food contained in multiple fruit, there is no other fruit that is as popular as this in some of the tropical countries, especially in Southern Asia where this plant has been in cultivation since the beginning of Christian era (Chandler, 1958; De Candolle, 1986). The fruit is consumed in much quantities by some families in Asia. In the South Indian State of Kerala and in Sri Lanka, it is a standard part of their diet in some seasons of the year. The fruit and the timber are in great demand in some part of the globe and form a big source of income.

Although jack lacks systematic cultivation on plantation scale, it is omnipresent in the homesteads, on road sides and in the forest in South India. In the Southern States such as Kerala, Karnataka, Tamil Nadu and Andhra Pradesh, it is found growing extensively. Its cultivation is widespread also in the states of Assam, West Bengal, Goa, Maharashtra, Orissa and Andaman and Nicobar Islands. In the absence of a systematic survey, the exact data on its extent of cultivation in various parts of India are not on hand.

Karnataka is one of the important states with regard to jackfruit cultivation. Here, it is cultivated in Western Ghats and in the Southern plains. The figures reveal that it is cultivated over an area of about 8,800 ha with an estimated production of over 2,00,000 tonnes of fruits annually (Anon, 1986). The jackfruit tree is valued for its money earning capacity. There are instances in which a single jackfruit tree is reported to earn an income of several thousand rupees

is one season alone. Because of this reason its cultivation is becoming quite popular among the small holder category of the farming community.

Of late, the jackfruits are being valued by the processors to make best use of the heaps and heaps of jackfruits that glut in to the market during the season of its harvest (April-August). The results of the research indicate that a score of products, either processed or dehydrated, can be developed on commercial scale. The noteworthy among these products are: Squash, nectar, fruit bars, toffees, jam, jelly, canned bulbs, dehydrated bulbs and a lot of many others (Bhatia *et al.*, 1955b and 1955a; Siddappa and Bhatia, 1952).

The ripe jackfruit bulbs are rich in sugars with a calorific value of about 90 calories per 100 gram fresh weight. Bhatia *et al.* (1955a) reported that ripe bulbs contain 20.6 per cent of total sugars. The bulbs are rich in calcium, potassium, iron and contain a fair amount of carotene but only a small amount of vitamin C.

Jack fruit a poor man's fruit, which is available in plenty during the season in the market and on road side push cart vendors are sold in most unhygenic conditions by the vendors. It is therefore envisaged to findout hygenic and scientific methods to preserve the bulbs for a short time by preserving it in sugar syrup and packaging so that it could be sold in consumer packages convenient to use and having high nutritive value. This endeavour helps not only to utilise the excess produce of jackfruit during the season, but also ensures the development of a sustained jackfruit processing industry on a cottage scale in rural areas. When this is achieved the contribution of jackfruit will be immense to the food processors.

Keeping in view the above requirements and in order to explore the possibility of preparing and preserving the jackfruit products in a hygenic way. The present study was undertaken with the following objectives:

1. To extend the shelf life of jackfruit bulbs temporarily.
2. To make jackfruit available in ready to use form.
3. To minimise the post harvest losses during harvesting season and to overcome the glut in the market.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The jackfruit (*Artocarpus heterophyllus* Lam.) is one of the most common and popular fruits of India. However, not much systematic research work has been done on the aspects of processing and preservation of its fruits and their storage behaviour. Hence, a brief review of the earlier work done on jackfruit and other related fruit crops is presented in this chapter.

2.1 Suitability of fruits for preserves

The suitability of fruits for preserving in high sugar syrup as preserves, jam and candy are discussed here under.

Almost all the fruits, which are pulpy in nature, can be successfully preserved with sugars. The fruits commonly employed for this purpose are – jamun, mango, guava, litchi, passion fruit, papaya, peach, grapes, pineapple, cherry, pear, fig, melons, avocado and jackfruit (Roy, 1968; Candillat, 1970; Fregoni, 1971; Sanchez Nieva, 1977; Anderson and Allen, 1981; Simoniya *et al.*, 1981 and Ambadan, 1987). Good quality candy could be prepared from fruits like ber and banana (Crowther, 1979 and Gupta *et al.*, 1980).

Some of the tropical and subtropical fruits that are used for the preparation of jam includes cashew, apple, guava, banana, carombola, kiwi fruit, mango, papaya, passion fruit, loquat, kumquat, pumelo, cape goose berry, mandarin and temperate fruits like plum, chesnuts, strawberry, rasberry, black currant and red currant (*Mazumdar, 1979; Simoniya et al., 1981; Gogoushvili and Fishman,* 1982; Stanley and Wilson, 1984 and Benk, 1985).

The pineapple, mango, water melon, papaya, radish and carrot were analysed for total sugar, acidity and ascorbic acid content. The fruits and vegetables were cut into strips of 3 cm in length, 2 cm width and 2 cm breadth. These strips were treated with preservatives and firming agents, blanched and processed to preserves and candies. The products were analysed for total sugar, moisture, acidity and ash contents. The moisture content in preserves and candies prepared from various fruits and vegetables ranged from 28 to 31 per cent and 16 or 19 per cent respectively. In preserves, total sugar content ranged from 67 to 70 per cent and in candies from 79 to 83 per cent. The prepared products were subjected to organoleptic taste test. The preserves and candies were shelf-stable upto 12 months in ambient temperatures. The study indicated a good prospect of processing preserves and candies from pineapple, mango, watermelon, papaya and carrot (Uddin, 1991).

Jackfruit is a non-seasonal tropical fruit, consumed and preserved in various forms. The drying of the fruit to make leather is a convenient method of marketing the fruit as confectionery. The marketing trails of the product among 230 teenagers in Malaysia during 1995. Jackfruit leather was well received by the urban Malaysian teenage group, but they had low awareness of fruit leather products. There might be significant market potential for jackfruit leather, depending on price, packaging, marketing and distribution (Man and Sanny, 1997).

2.2 Principle and methodology for preserves

In the preparation of jackfruit preserves, the bulbs are covered with 2½ times their weight of 40°Brix sugar syrup containing 0.3 per cent added citric acid and concentrated in a glass flask under vacuum of 26 to 28 inches for 1-2 hours and left overnight at room

temperature so that the fruit may absorb sugar. Next day the concentration is continued to about 65 per cent solids and after an interval of 1-2 hours it is continued to about 72 per cent solids. The finished product is firm in texture bright in colour and has full jackfruit flavour. The product is packed in glass jars (Bhatia *et al.*, 1955a).

To prepare a canned jackfruit, the fruits are cut into several pieces, the pulp is removed from the fruit, deseeded, cleaned, halved and washed with cold water. They are then packed in plain tin cans with 40°Brix syrup of 0.5 per cent acidity. The cans after exhausting and sealing are processed for 20 minutes (Pruthi *et al.*, 1955).

Roy (1968) studied the preparation of preserves and candy of syzygium to ascertain the possibility of preserving this fruit. After suitable preparation, the fruits are immersed in 30°Brix sugar solution, boiled for 3 minutes and left for 24 hours. The strength of the syrup was raised by 10°Brix each day till it reached 50°Brix, when 0.1 per cent acid was recorded the strength was raised to 70°Brix. The fruits were left in the syrup for a few days and were then drained. Candy was prepared by drying the product, the products were found with good flavour.

Preparation of candy in paste form was reported by Lehman, 1969. Dried prunes, peaches, apricots and pears were mixed with water, ground into a paste, starch and sugar were added, the composite was extruned and cut into cubes. Miata (1970) worked on the candied fruits and vegetables and reported that the product prepared is based on the principle that water content of fruits and vegetables are replaced by sugar solutions.

Fruit preserves are obtained by contacting the fruit with gaseous SO_2 or soaking it in a 5 g/l aqueous solution of SO_2 for few hours untill it has been impregnated with SO_2 at the rate of 0.3 - 2 g/kg of fruit. It is then stored at -15°C to -25°C until required when it is soaked in syrup at 50°C and pH 2.5 to 4 (Anon., 1974). Dekinder (1974) worked on the production of almond confection. Water, sugar and almond are heated until the sugar is deposited on the almond. They are then roasted with addition of more sugar and passed over a sieve. More water and sugar are added again and heated. The resultant almonds can be kept without the necessity of protective packaging.

The fruits which are to be preserved (as whole or in cut pieces) are placed in an autoclave in which they are washed to eliminate salts, cooked at atmospheric pressure, cooled, rewashed and subjected to equilibration with sugar syrup of 25-75 per cent depending on the fruit.

Adsule and Roy (1975) have conducted an experiment on the suitability of mango varieties for canning, freezing and chemical preservation of pulp of varieties Bombay green, Dashehari, Langra, Chousa and Baneshan and they inferred that the variety Dashehari had highest overall rating followed by Langra, Safeda, Bombay green and Chousa irrespective of the method of preservation.

The concentration of the syrup is then increased by addition of high concentration syrup to 77-78°C with constant recirculation of syrup to ensure equilibration of sugar concentration in syrup and in fruit. The candied fruits are cooled, drained and packaged (Fabry, 1978). The development of candy is based on the principle of diffusion of sugars into the fruits.

Gossens (1981) studied the method of processing fruits such as peaches in order to prepare them in form of fruits in syrup. The fruits in their whole state, unpeeled and without the stone removed are deep frozen and stored. At the time of their further processing they are unfrozen partially and the stone removed immediately are peeled and subjected to the usual operation involved in preparing them for incorporation in syrup.

Crystallized sugar product containing a food ingredient is prepared by concentrating the sugar syrup at temperature of 250-300°F to a solid content of approximately 90-98 per cent by weight, mixing the concentrated syrup with a predetermined amount of food ingredient and subjecting the mixture to impact bearing until a crystallized sugar product is formed (Chen *et al.*, 1982).

Fruits are rapidly infused with sugar solutes by means of an infusion bath, which is maintained at a constant solute concentration. The infused fruits may be packaged with the syrup of sameBrix with good organoleptic properties (O'Mahony *et al.*, 1985).

Pear preserves are prepared by peeling, coring, slicing and blanching in hot water at 90°C for 3 minutes before placing in syrup (70-72°Brix). Slices for ready to eat product are blanched similarly by using syrup containing 42.5 per cent sugar, 15 per cent water followed by equilibration overnight (Upasani Rani and Bhatia, 1986).

Augustine *et al.* (1988) reported the process of producing the preserves which includes bathing of fruits in a aqueous sugar solution having 70-95 per cent sugar by weight. Processing of fruits for preserves involves immersing the natural fruit in a syrup and heating the syrup and fruit to replace water and air bubbles in the

fruit pulp by the syrup, while the fruit remains immersed in the syrup (Kawabara, 1988).

Jacob and Narasimhan (1998) studied the instrumental colour, texture and sensory quality changes in blast frozen and cryo-frozen ripe jackfruit bulbs packed in A2½ cans and stored at –18°C. They concluded that colour retention was best in cryo-frozen product. The cryo-frozen bulbs were rated at par till 6 months and later superior to blast frozen bulbs. Therefore the rapid freezing enabled to produce 5 to 6 times better quality frozen product than conventional methods of freezing.

In a study by Singh *et al.* (1999), minimum concentration of sugar solution of preparation of the amla preserve was found to be 60°Brix. The preserved amla samples prepared in 40 to 50°Brix initial sugar concentration got spoiled after 30 days. Result indicate that the process should be carried out at or below 40°C in order to minimise non-enzymatic growing and loss of ascorbic acid content of the fruits. It was further concluded that amla preserve should preferably be stored at least for 60 days before consumption. An empirical mathematical model was found to describe adequately the process of osmotic concentration of amla.

2.3 Storage and quality of preserves

Samples of glass packed fruit preserves stored at temperature of 20°C and 40°C in dark and under continuous illumination with 650 or 3500 Lux. For 18 months showed slight changes in colour, flavour, smell and consistency. Illumination with 650 and 3500 accelerated the changes (Robinson, 1968).

Firm ripe Allahabad guavas canned in 40°Brix syrup with various per cent concentrations of citric acid were stored at room

temperature and 37°C. The cans without citric acid served as the control. It was found that addition of citric acid accelerated colour formation at room temperature and extent of browning at 37°C and that 0.25 per cent citric acid impaired flavour within 6 months at room temperature. Canning in plain syrup assisted natural colour and flavour retention over prolonged storage at room temperature, but no treatment was effective at preventing discoloration at 37°C (Setty *et al.*, 1968).

Mandarin oranges in syrup were packaged in 10 different plastic film bags and stored at room temperature in dark or in light. After 30 days, the colour of each sample was determined. It was found that colour loss in samples packaged in polyethylene and polypropylene bags were greater than that of samples in polyvinylchloride and polyamide bags. Light and oxygen permeating the films were the cause for the colour loss (Matsui and Chimizu, 1970).

Pear and strawberry preserves made using glucose syrup (25, 30 and 40%) and strawberry and plum preserves made using dextroxe syrups (0, 20, 30, 40 and 50%) were compared with products made of sucrose syrup to study the sweeting capacity and chemical characteristics of glucose syrups of high and low degree hydrolysis. Samples were stored for 18 months at 15°C. No difference in colour, consistency or taste was found. For light syrup additions of approximately 30 per cent dextrose or glucose syrup were judged favourable for the products (Thieme, 1970).

Deterioration of canned products during storage can occur as a results of microbiological, enzymatic and/or biochemical effects. The rate of deterioration doubles for every 10°C rise in storage

temperature. Cold storage at 0-5°C will lower the effects of deterioration (Wunsche, 1970).

Irradiation treatment and moisture level ensuring safe storage of candied jackfruit for 6 months under ambient conditions was studied (Giron *et al.*, 1973). Fruits of various moisture levels were prepared by osmotic dehydration and conventional syruping at 70°Brix with subsequent oven drying at 60°C for 0-5 hours. Products were irradiated at 0, 150, 300 and 500 krad. It was found that irradiation had no effect of moisture content while osmotic dried and oven dried samples with 53.8 and 34.1 per cent moisture had spoilt after one month storage. Irradiation at dose levels used did not effect organoleptic qualities but improved the texture of low moisture products. Browning occurred in all samples during first month of storage.

Haden variety mangoes prepared for canning in syrup by (1) boiling water or (2) spin cooker process packed in lacquered or unlacquered cans stored at room temperature for less than 12 months were examined at intervals for customary characters. Boiling water with canning in unlacquered cans were considered best enabling satisfactory storage for the determination of DM, sugars, titratable acidity in syrup and fruits showed that optimum concentration of sugar in syrup for plums, peaches, black currant and strawberries were 30 per cent, 35 per cent, 40 per cent and 25-30 per cent respectively (Korobkina *et al.*, 1979).

The effect of composition of infusion without heat treatment in quality of preserved cranberries was studied (Zhuk and Gubina, 1980). For infusion water, cranberry juice, 5 and 10 per cent solutions of sugar and a mixture of sugar and salt were used. The samples were stored for 10 months at 0 and 20°C . Better results

were achieved with storage at 0°C with cranberry juice infusion or with solution of sugar and salt or 10 per cent sugar solution.

Physico-chemical evaluation was done on fresh processed jam and slices in heavy syrup. Both products exhibited browning during storage, perhaps because of lower pH. But such browning did not impair their acceptability (Hernandaz *et al.*, 1982).

Potter *et al.* (1982) worked on the quality of stored peach slices with syrup in flexible retort pouches and found that retort pouches processed fruits were acceptable by a sensory panel and were preferred to tin plate canned peaches after storage of four months at 37°C. The tin canned slices were brown soft and had poor flavour following 37°C storage, while the pouch product maintained high quality. However, processing peaches in flexible pouches did not prevent pinking. The flexible pouch was found to provide a significant advantage in terms of storage stability 12 months at room temperature. Darkening occurred under all conditions during the second half of storage, but it did not affect the taste (Martin *et al.*, 1973).

In view of the trend towards a reduction in the sugar content of jam, plum and apple jam were made with 2 part puree to 1 part sugar (experiment) and with established 1.25 parts puree to 1 part sugar (control); the DM content was 66 per cent in both the cases. In a third variant the DM content of the experimental jam was reduced to 60 per cent. It was observed that both the experimental jams had better taste characteristics than control, but after three months storage at 20°C their spreadability was poor (Vorob'evo and Onishchuk, 1974).

Characteristics of crystallization, colour and firmness, may be affected by sucrose inversion and the browning reaction was accompanied by apparent reduction in concentration of reducing sugars (Weekel, 1970).

Candied jackfruit dried to 14-15 per cent moisture content was γ-radiated at 0-500 krad. Doses of 150 krad reduced microbial load and extended storage life of low moisture product (Anon., 1975).

Fruits frozen in sugar syrup are known to have better properties such as colour ascorbic acid and vitamin B contents, flavour and consistency than those frozen without syrup. On the other hand, the high sugar content is not desirable. Experiments on freezing plum, peaches, black currents and strawberries in syrups containing 20-50 per cent sugar were carried out to determine optimum sugar concentration for individual fruits.

Amla preserves were analysed forBrix, acidity, pH and reducing sugars during storage. It was seen that T.S.S. (°Brix) ranged between 66.6 and 69.3 (Sethi and Anand, 1982). The keeping quality of the low sugar jam was tested during 10 months storage at room temperature and refrigerator (5°C). It was found that in general sorbitol and xylitol jams on were better than conventional sucrose jam (Hyvonen and Torma, 1983).

Physico-chemical and organoleptic changes of candy prepared from pear were studied storage at 25-27°C, 37°C in a controlled cabinant for 24 weeks or in a refrigerator for 16 weeks. The candy packaged in cellophane/polyethylene bags retained its quality for about 16 weeks at 37°C and for 40 weeks at 25-27°C and in refrigerator temperature (Upasana Rani and Bhatia , 1985).

Effects of packstyle (as slices in Sucrose syrups), slices with dry sugar and individually quick frozen (IQF) and freezing method were studied and it was found that mango slices frozen in syrup yielded a product of higher acceptability than slices packed in dry sugar and IQF (Isaacs, 1986).

Preserves, jam and candy products of amla were studied for chemical changes during storage for 135 days. Increased acceptability was seen in preserves upto 135 days storage, in jam upto 45 days and in candy it decreased with storage (Tripathi *et al.*, 1988).

Distilled water and various sugar solutions were used to reconstitute air dried and freeze dried apple (*Malus pumila* Cv. Golden Delicious) pieces. The mass transfer between dehydrated fruit pieces and solutions during rehydration, as well as physico chemical properties of the reconstituted apple pieces, were determined, water uptake and solid gained or solid lost was a function of reconstitution time and concentration of sugar solution for freeze dried and air dried apple pieces. The shapes of response surfaces indicated that the mass transfer between dehydrated apple pieces and sugar solution took place mainly during the period of rehydration (5-10 min). Water activity, freezing point, amount of freezable water and firmness were linearly correlated with the soluble solids content of the apple pieces (Mastrocola *et al.*, 1998).

Pineapple (*Ananas comosus* L.) with 14.6 per cent sugar and 0.53 per cent acidity were used in the study of pineapple candy processing, sugar, glucose syrup, salts and citric acid were added at amount of 37.5 per cent, 50 per cent, 0.4 per cent and 0.02 per cent of squeezed pineapple respectively during the process of evaporation. The pineapple juice was concentrated to a half volume of original juice was concentrated to a half volume of original juice by rotatory

evaporator and then added back to the process for the flavour improvement. After 3-4 hours of evaporation, the product contained 82 per cent sugar, 0.87 per cent acidity, 2.5 per cent, 7/12 in munsell colour system and less than 10 gram of yeast and mold. The sensory test was done on the products for preference. The product flavour and texture were accepted by the consumer, the quality of the product did not change for 6 months stored (Sombat-Khotavivattans and Chintana Dupadissakoon, 1985).

Jackfruit variety (*Artocarpus heterophyllus* Lam.) NSI variety was harvested at 14, 15, 16 and 17 weeks' maturity (from the first appearance of the spike), and allowed to ripen at ambient temperature for 0, 1, 2, 3, 4 and 5 days before processing as canned slices in syrup. Sensory evaluation and analysis were carried out on the raw and canned fruit and on the stored canned fruit after 6 and 12 months storage. The results showed that fruit harvested at 15 to 16 week's maturity and stored for 3 days to ripen, gave optimum quality in the canned product. The processed 'Mangaka' could be kept upto 12 months without deterioration of quality (Chin and Nushirwan-Zainuddin, 1990).

The experiments were conducted in the laboratories of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. Bulbs, rinds and cores of jackfruit were used for preparing jams and jellies. Good quality of jam was prepared from the bulbs and good and excellent quality of jellies was prepared from bulbs, rinds and cores. Biscuits were prepared from different proportions of jackfruit seed powder. One sample of biscuits was found to be excellent and others were found to be as good (Hoque, 1991).

After washing, trimming, sorting, corting and pricking low grade apples were candied by standardized methods (fast and slow set methods). The prepared candies were stored in different packaging materials under different storage conditions. The products were analysed fresh and after every 1.5 months of storage upto a period of 6 months for quality and nutritional changes as well as for total soluble solids (TSS), Acidity, TSS : Acidity ratio, pH, reducing, non-reducing and total sugars. It was found that the products could be safely packed in polyethylene pouches for sufficient length of time. However, better results were obtained from those packed and stored in glass jars. The products, were also evaluated organoleptically for colour, consistency, flavour and absence of defects (Sharma *et al.*, 1998).

2.4 Laws and standards for fruit preserves

Food laws concerning dextrose and glucose syrup in Germany was surveyed. Dextrose can be used in place of sucrose in most products excluding jams and marmalade (Schroeter, 1969). Preserves made from all kinds of fruit and vegetable and by boiling in sucrose/glucose syrup and packaged in glass jar or can includes standards for fruit or vegetables as per cent of total container contents from 45-50, total sugars of >68 and SO_2 content <0.01 (Anon., 1970). Standard procedure was developed for canning date pulp. Best result were got by mixing date pulp with equal weight of 20°Brix cane sugar syrup (Makki *et al.*, 1981).

2.5 Spoilage and stability of preserves

Complete puncture of all layers in the laminate was the most important factor in allowing water vapour and oxygen to enter

the package. The product inside foil laminated pouches are thus spoilt (Hu *et al.*, 1969).

Dried flesh of sea buckthorn fruits was shown to contain 1400 mg per cent and dried pressed juice 2300 mg per cent in vitamin C. Loss of vitamin c in both products after five months storage amounted to about 11 per cent in relation to primary content in fresh products. This stability of vitamin C. The fresh juice with 300 mg per cent of vitamin c can be used for vilminizing product like jam, syrup and jelly (Michelic and Vijic, 1969).

Jellies which show a tendency to moisten at 78 per cent RH and the yeast activities which commences will result in partial or total deterioration of jelly products (Kozharov, 1970). Jam samples were found to be contaminated by 12 Spp of *Aspergillus* and 16 Spp of *Pencillium* during storage (Burbianka and Stic, 1972).

An arbitrary parameter rejection time that is the time required for a fungal inoculum to form a two mm diameter colony was used to Express the shelf life of jam. Individual and combined effects of water activity (a_w), pH value and temperature on rejection time of low sugar jam was estimated from the radial growth of fungi. The decrease in a_w (0.94 – 0.90) and temperature (25-15°C) practicable for low sugar jam were more effective in increasing the rejection time than the feasible decrease in pH (3.7 – 2.9) (Horner and Anangostopoulos, 1973).

Syrups prepared from orange juice serum were tested for stability against microbial and chemical degradation. Syrups containing 70 per cent soluble solids did not support growth of yeast whereas pure sugar syrup prepared at 70°Brix maintained cultures of yeast for 35 days at 30°C (Bruemmer and Bowers, 1977).

Strawberry preserves during a 26 week storage period revealed that colour deterioration occurred at a much faster rate and this deterioration was due to a faster rate of browning (Abers and Wrolstad, 1979).

Apple and pear preserves were prepared containing sodium benzoate and potassium Sorbate as preservatives at 0 to 0.08 per cent and their quality over 90 days storage was assessed as regards the microbial load. Of the organisms isolated from fruit preserves *Aspergillus flavus* was most resistant to preservatives (Huang and Wang, 1984).

In amla preserves fermentation is affected by heat resistant *Bacillus cereus* which increase the acidity. The growth of bacteria is checked by using sodium benzoate and potassium Sorbate. A combination of two preservatives had a synergistic action (Vijaysethi and Anand, 1984).

2.6 Packs and packaging of preserves

A 0.71 light weight, approximately rectangular container for liquids consists of materials like polyethylene (PE)/board/PE/Aluminium foil/PE. Total wall thickness is 410-425 um; total weight 27 grams and dimensions are 6.5 x 6.5 x 20.5 centimeters (Anon., 1969). The kinetics of swelling of polyethylene (PE) film, special polyvinyl chloride (PVC) and polypropylene (PP) films were investigated by the dynamic sorption method in distilled water and 9, 17 and 23 per cent brines. It was found that the rate of swelling decreased with rising concentration of brines (Pliner and Govourkhing, 1969).

Investigations with lollipop products packaged in cellophane showed that overseas shipments must be sent in protective

outer packages. Hermetically sealed polyethylene foil used as lining in cardboard boxes gave adequate protection even under tropical climate conditions (Czerniawski and Krogulski, 1970).

Foods (jam) were packaged in bags made from lacquered cellophane, PP, PE, two types of PE/cellophane, imported viscothene or PE/AL/Cellophane laminates. Among them PE/AL/Cellophane bags proved satisfactory (Bushkanets *et al.*, 1971). Acrylonitrile/butadene/Styrene polymerization stable under heat, having good stiffness and flexibility with good impact resistance are found to be good packaging for jams (Anon., 1972). Preserved food products in plastic containers are protected against oxygen or water vapour diffusing through the container wall by enclosing the container in a gas tight casing (Tellings, 1973).

PVDC coated paper for packaging pourable fruit jelly concentrates was found to be suitable with good sensory properties. The product was well maintained for upto 6 months storage provided its water content did not exceed seven per cent (Muravin *et al.*, 1980).

Suitability of plastic pouches of (a) low density polyethylene (LDPE) (b) polycell (c) PE coated paper (d) laminate of paper/AL foil/LDPE and (c) Alcellopsible tube for packaging mango jam for storage at room temperature and 37°C was studied. Data on the physico-chemical, microbiological and organoleptic studies revealed that (d) and (e) were best suited (Gowramma *et al.*, 1981). The lamicon plastic food bottles made of three to five layers of ethylene vinyl alcohol Co polymer (EVAL) with >one common plastic resins ensure extended shelf life of food requiring high gas barrier properties of its packaging (Anon., 1983).

Candied crisp mei, candied date and candied kumquat with different sugar contents and packed in different packaging materials like PET/Saran/CPP and PE/EVA in normal and vacuum packs were observed for quality. Changes during four months storage. No mould growth was seen in candied fruits in vacuum packs. Mould growth rate of candied fruits in normal packs decreased with increasing sugar content and was lower with PET/Saran/CPP than with PE/EVA (Chen *et al.*, 1988).

Paper/plastic laminate flexible tube with a dispensable head was found to be good pack for packaging jam (Reil, 1990).

Changes in quality characteristics of boiled dried anchovy during storage under different packaging condition for 6 months were studied. For the packaging trials, kraft paper (KP), kraft paper laminated with 0.03 mm polyethylene film (KP/PE) and 0.1 mm polyethylene film with nitrogen gas substitution (N_2 gas) were employed. In case of KP, the reaction of thiobarbituric acid, browning rate of lipid oxidation and hunter colour values of L^a and b were remarkably higher than those packaged in KP/PE or N_2 gas. Judging organoleptic evaluation boiled dried anchovy could be preserved in room temperature 3 months in KP and 4 months in KP/PE or N_2 gas. From the stand point of quality stability by packaging methods, it was concluded as good in sequence as N_2 gas, KP/PE and KP. The results suggest that the quality of boiled-dried anchovy be well preserved by packaging with inert gas (N_2 gas) or impermeable material to vapours and oxygens (Jo *et al.*, 1987).

Different packaging procedures were tested for their ability to maintain post harvest quality and to extend the shelf life of peaches. Fruits were stored in open aluminimum trays, unperforated paper bags, perforated paper bags or perforated polyethylene bags at

2°C and 85-95 per cent RH. No significant weight loss, volume change or increase in titrable acidity was found after 30 days of storage in perforated polyethylene bags. Titratable acidity of stored peaches with other packaging increased and pH decreased over time TSS content showed the greatest increase in fruits stored in trays and perforated paper bags and the smallest increase in those stored in perforated polyethylene bags. Total sugars and total phenolics increased significantly after 30 days of storage. In 1992 and 1993, polyphenol oxidase (PPO) (Catechol oxidase) activity was high at harvest, decreased during the first 30 days of storage, then started to increase in unpacked fruits and those packed in perforated or unperforated paper. In fruits storage in polyethylene bags, PPO activity during storage decreased in 1992 but increased in 1993 (El-Shiekh and Habiba, 1996).

Ripe fruits from 5 years old trees of 11 *Zizyphus mauritiana* cultivars were packed in polyethylene bags (100 gauge thickness with 0.5% ventilation) and stored at ambient temperature, physiological weight loss, total soluble solids content, titrable acidity and ascorbic acid, total sugars and reducing sugars contents were recorded at 4 day intervals. Organoleptic properties were also assessed. Fruits of all cultivars kept well for 8 days. Those of cultivarse Umbran, gola, sanaur-6 and Mehrun were good for 12 days, while fruits of Sanaur-2 were still tasty and crisp after 15 days (Naik and Rokhade, 1996).

2.7 Treatments for quality improvement in preserves

The addition of honey to canned jackfruit bulbs is reported to enhance flavour but at the same time it is reported to spoil the consistency. Deep freezing of fruit in sugar syrup and then thawing it prior to syrup treatment has beneficial effects as pricking of

the fruit increases the absorption of sugars (Siddappa and Bhatia, 1954 and 1959). The use of starch syrup in manufacture of jam improved consistency and reduced sweetness (Ohler, 1969). Automatic coating of candy improved the product quality over manual method of coating (Shaughnessy, 1969). Sake cake added during production of bean jam enhanced flavour and improved storage stability (Anon., 1970a). Use of β-carotene, B-apo-8 carotenal and canthaxanthin improves the colour of products such as jellies, soft drinks and sugar confectionery (Counsell and Webb, 1971). Glucose syrups are used as sweeteners flavour enhances, bodying agents, humectants and texturing agents in sugar confectionery, jam and jellies (Palmer, 1971). Applications of sorbitol in the confectionery industry for stabilization of product moisture content, improvement of its softness structural characters, aroma fixation and in prevention of crystallization was out lined by Neri, 1973.

The addition of n-butyl and ethyl esters of 4-hydroxy butyric acid at 120 and 100 ppm respectively was reported to be responsible for enhancing flavour in canned jackfruit bulbs during storage (Natarajan and Karunanithy, 1974). Phytolaccanin and betanin could be successfully used as food colorants in jellies (Driver, 1975). Blanching of fruit prior to processing improves the sugar diffusion and prevents floating of fruits (Basamkov, 1976).

Addition of ascorbic acid to the syrup improved the colour and flavour of frozen sliced strawberry (Paichoalino, 1977).

The development of preserves using HFCS as a sweetener was reported to improve the flavour retention (Andres, 1978). Vacuum treatment during production of preserved compotes raises the fruit DM and sugar syrup penetration into the fruits (Gromor and Dibison, 1979). Preserves made from frozen fruit were found to be

better stored than the preserves of fresh fruits (Aizenberg, 1980). Potable alcohol added to fruit was found to improve the quality of preserves (Dettmar and Pietsch, 1980).

The treatment of mechanically processed fruit with hydrolytic enzyme preparations accelerated the penetration of sugar syrup into fruit in candy (Allambergenorv and Ubaiduplaev, 1981).

Application of fumaric acid in jam as a partial substitute for citric acid had good properties (Krajewska *et al.*, 1983). Use of rum and arrak in improving the taste of flavoured jam encouraged the consumption (Kretzschman, 1983).

Investigations into the shelf-life and the changes in nutritional value during storage of Bordotto-type brown mottled beans conventionally canned in brine and vacuum packed were performed. Results show that the shelf-life of vacuum packed beans is shorter than that of their counterpart canned in brine. After the first four months of storage, the nutritional value of both type of preserved beans does not undergo any appreciably change (Tomasicchio *et al.*, 1994).

Experiments were conducted to investigate the effect of blanching and/or glucose impregnation at atmospheric or lowered pressure on the kinetics of moisture transfer during the initial falling rate period of air drying of apple pieces. The moisture diffusivity of water was strongly decreased by glucose uptake during the impregnation step and shrinkage. Studies of the cell structure using transmission electron microscopy revealed that neither pretreatment greatly altered the resistance of the cellular tissue appeared to have a role in the drying behaviour (Nieto *et al.*, 1998).

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The materials used and the methods adopted in the experiment conducted at the Division of Horticulture, Gandhi Krishi Vignana Kendra (G.K.V.K.), Bangalore during the year 1999 - 2000 to study the "Preservation of Jack fruit bulbs in high concentration of Sugar" are presented in this chapter.

The experimental station is located at latitude of 12°58'N and longitude of 77°35' E and attitude of 930 meters above the mean sea level.

3.1 Type of jackfruits used for experiment

Optimum matured jackfruits with (1) golden yellow coloured bulbs (V_1) and (2) orange coloured bulbs (V_2) were used for the study. The fruits were obtained from the local market during the month of July, which is the main harvesting season for jackfruits around Hessaraghatta, Bangalore. Only those fruits, which were uniform in size having broad, shallow spikes, were used for the experiment.

3.2 Preparation of fruits for experimentation

The selected fruits of both the types (V_1 and V_2) were cut separately along their equatorial axis with the help of a sharp knife smeared with edible oil. The bulbs were then carefully separated from the rind and placenta. Care was taken to handle, the bulbs with minimum bruisses. The collected bulbs were kept in a glass container for further experimentation.

3.3 Analysis of Fresh fruits

The jackfruit of both the types (V_1 and V_2) were analysed to know the composition of the constituent parts and the physico-chemical parameters of their bulbs.

3.3.1 Weight of fruit

The individual fruits were weighed by using a balance and the average weight of the fruits used in the experiment was recorded in kilograms.

3.3.2 Number of bulbs and seeds

The number of bulbs used in the experiment was recorded by counting the bulbs in the fruits and the average number of bulbs per fruit was recorded. The seed obtained was also counted and are expressed similarly.

3.3.3 Weight of the bulbs

The weight of the bulbs used in the experiment was recorded by weighing the bulbs in a sensitive balance and expressed as weight of bulbs per fruit.

3.3.4 Weight of peel and placenta

The peel and placenta of the jackfruits was weighed by using a balance and the average weight was recorded in kilograms.

3.3.5 Edible to non-edible ratio

The edible to non-edible ratio was calculated by dividing the weight of edible portion by weight of non-edible portion.

3.3.6 Pulp to seed ratio

The pulp to seed ratio was calculated by dividing the weight of pulp by weight of seeds. The results of the analysis are furnished in Appendix I.

3.4 Treatment details

Variety

V_1 : Yellow coloured bulbs

V_2 : Orange coloured bulbs

Sugar concentration

S_1 : 50°Brix syrup strength

S_2 : 60°Brix syrup strength

Interactions

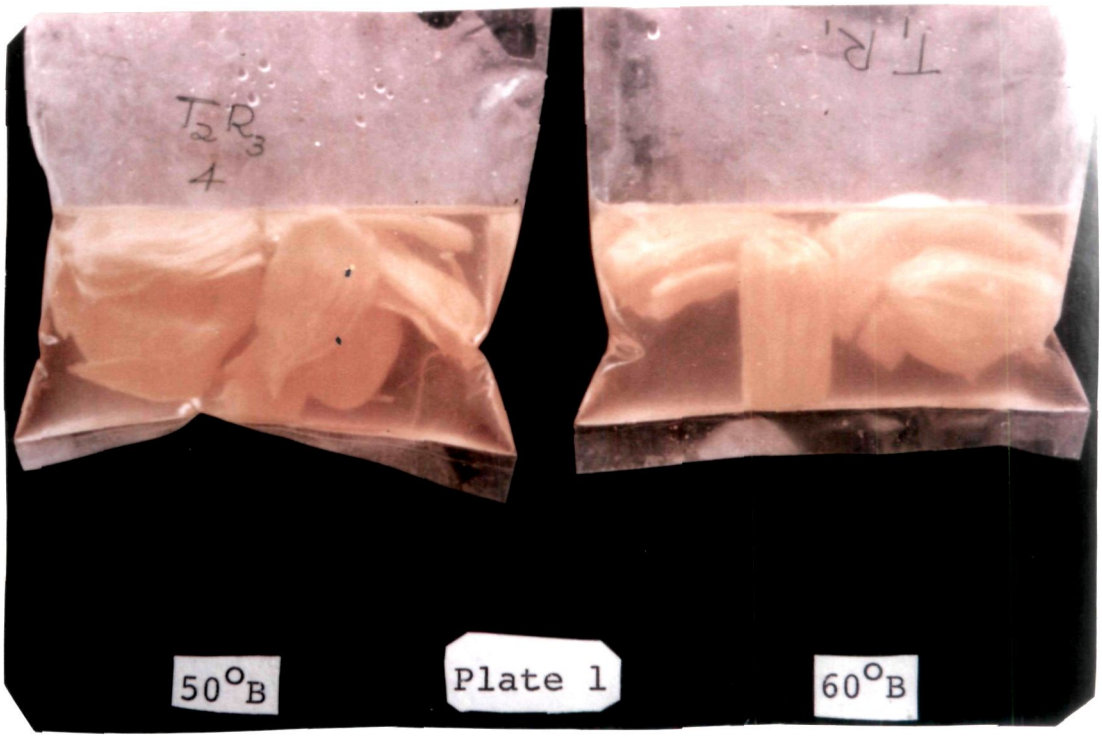
1. V_1S_1 : Yellow bulbs in 50°Brix
2. V_1S_2 : Yellow bulbs in 60°Brix
3. V_2S_1 : Orange bulbs in 50°Brix
4. V_2S_2 : Orange bulbs in 60°Brix

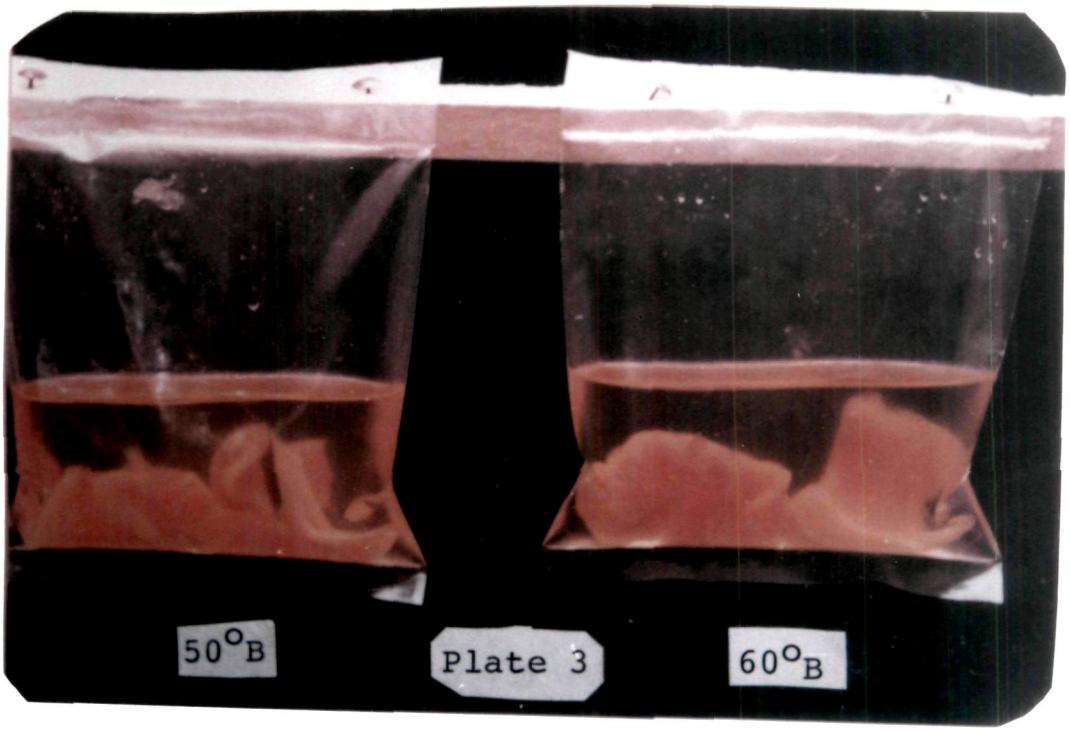
3.5 Methodology of preserving the bulbs

The sugar syrup of 50° Brix (S_1) and 60° Brix (S_2) was prepared by adding the required amount of cane sugar to the boiling water of known quantity. The strength of the sugar syrup was confirmed by testing it with a hand refractometer (28° to 62° Brix range). The syrup was filtered to remove the impurities using a

Plate-1: Jackfruit preserves from yellow coloured bulbs at 50° Brix and 60° Brix on the day of preparation

Plate-3: Jackfruit preserves from orange coloured bulbs at 50° Brix and 60° Brix on the day of preparation


T_2R_3
4
T_1R_1
50°B
Plate 1
60°B


50°B
Plate 3
60°B

muslin cloth. The required quantity of citric acid and sodium benzoate were added to this syrup so as to maintain 0.5 per cent acidity and 250 ppm preservative. The bulbs obtained were steam blanched by boiling the water in a vessel over which a muslin cloth was tied and bulbs spread uniformly over it. The bulbs were exposed to steam for 2 minutes.

The bulbs of V_1 and V_2 were then preserved separately in the prepared syrup of S_1 and S_2.

About 100 gms of the deseeded blanched bulbs were filled into the 6 x 8 inches, 300 gauge polybags and on to them the sugar syrup was poured.

The polybags were then sealed using a hand sealing machine. The sealed bags were stored under ambient conditions in the laboratory for periodical observations.

3.6 Observations recorded during storage studies

At regular interval of 15 days two bags from each replication were utilized for analysis and the following observations were recorded for a period of three months.

3.6.1Changes in the TSS of the preserved bulbs

After draining the syrup with a 16 mm mesh sieve the bulbs were squeezed and the TSS of the bulbs was recorded using a hand refractometer (28-62°Brix range). The values were corrected at 20° C using the temperature correction chart.

3.6.2 Changes in the sugar content of preserved bulbs

The total sugars and reducing sugars were estimated by following the method described by Lane and Eynon (1923).

Twenty five grams of the bulbs were blended in a mixie using 100 ml distilled water. It was neutralized by the addition of IN-NaoH using phenophthalein indicator. The volume was made upto 250 ml and filtered through a Whatman filter paper number – 1.

From this 25 ml of the sample was taken and 2 ml lead acetate was added to it. After 10 minutes potassium oxalate was added to achieve clarification and filtered through Whatman filter paper number-3. The clear extract was made up to 100 ml by addition of distilled water. From this, a known amount of sample was taken for reducing sugar estimation and the results are expressed as per cent on weight basis.

For total sugar estimation 50 ml of the clear extract was taken. To this 10 ml of HCl (1 + 1) was added and kept overnight for inversion. After neutralization the volume was made upto 100 ml and titrated against Fehling's solution using methylene blue indicator on a hot plate. The total sugar content is expressed as per cent invert sugars.

The non-reducing sugar per cent was obtained by subtracting the reducing sugar per cent from the total sugar per cent.

3.6.3 Changes in total titratable acidity of preserved bulbs

Five gram of the bulb was blended in a mixie by adding about 25 ml of distilled water. It was filtered through Whatman filter

paper number – 3 and made upto 100 ml. 10 ml of this filtrate was titrated against the standard (0.1 N) NaOH using phenolphthalein indicator. The titratable acidity was expressed as per cent citric acid.

3.6.4 Changes in the sensory traits of preserved bulbs

3.6.4.1 Colour of bulbs

The colour changes of the preserved bulbs was recorded by visual assessment and grouped as good, normal and less than normal.

3.6.4.2 Texture of bulbs

The changes in the texture was assessed by actual chewing and eating of the bulbs and grouped into firm, hard and soft.

3.6.4.3 Spoilage of bulbs if any

Visually the bags were assessed for spoilage and were grouped as no spoilage, slightly spoiled and fully spoiled.

3.7 The organoleptic evaluation of preserved jackfruit bulbs at the end of storage

The organoleptic evaluation of jackfruit preserves for quality attributes such as colour, flavour, texture and overall acceptance was assessed by a panel of 6 judges who scored on a 9 point hedonic scale (Amerine *et al.*, 1965). The following chart was used for evaluation of the preserve.

Organoleptic evaluation score card for jackfruit preserve after 90 days

Product : Jack fruit preserve

Date :

Name:

Using the Hedonic scale on display would you please rate each of the sample by placing a number in the appropriate column, rank the sample from higher to lower score in descending order of acceptability.

Sl. No.	Code	Quality attributes			
		Colour	Flavour	Texture	Overall acceptability
1					
2					
3					
4					

Hedonic scale

Like extremely	– 9	Dislike slightly	– 4
Like Very much	– 8	Dislike moderately	– 3
Like moderately	– 7	Dislike very much	– 2
Like slightly	- 6	Dislike extremely	- 1
Neither like nor disliked	- 5		

3.8 Statistical analysis

The experiment was laid out by adopting, a factorial CRD. The data obtained from the observations were subjected to two way analysis of variance. The limit of probability fixed for the test of significance was P = 0.05.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Studies on the "Preservation of jackfruit bulbs in high concentration of Sugar" was conducted at the Division of Horticulture, University of Agricultural Sciences, G.K.V.K. Campus, Bangalore during the year 1999-2000 and the results are presented in this chapter.

4.1 Storage of jackfruit preserves

The data on the various changes that were noticed during the storage of jackfruit bulbs of two types (V_1 and V_2) in 50 and 60°Brix sugar syrup are presented here under.

4.1.1 Changes in the total soluble solids (TSS) of jackfruit preserves during storage

The data on the changes in the TSS of jackfruit preserves (bulbs) during storage are presented in Table 1.

Data indicated that there was a significant variation in the TSS during 60 and 90 days after storage in the two varieties of jackfruit. V_1 was found to be significant over V_2.

In both the types (V_1 and V_2) the TSS continued to increase as the storage progressed. The influence of two kinds of jackfruit was manifested right from the first 15 days itself. At the onset of storage the TSS of V_1 and V_2 bulbs were 28.60 and 25.50 Brix. The data further revealed that there was a drastic increase to 43°Brix in V_1 and 42.7°Brix in V_2 after 15 days and the increase was about 14.4 and 17.7°Brix respectively. Thereafter the TSS continued

Table-1: Changes in the total soluble solids (°Brix) of jackfruit preserve during storage period of 90 days

Factors	15		30		45		60		75		90	
Variety												
(V_1)	43.080		47.857		50.974		53.374		55.757		58.790	
(V_2)	42.750		47.757		50.164		51.562		55.274		57.274	
Sugars												
(S_1)	37.950		44.157		44.114		45.895		51.040		53.340	
(S_2)	47.880		51.457		57.024		59.040		59.990		62.724	
Interactions												
V_1S_1	37.960		44.657		44.891		48.224		51.557		54.624	
V_1S_2	48.200		51.057		57.057		58.524		59.957		62.957	
V_2S_1	37.940		43.657		43.337		43.567		50.524		52.057	
V_2S_2	47.560		51.857		56.991		59.557		60.024		62.491	
	Sem±	CD (P=0.05)	Sem±	CD (P=0.05)	Sem±	CD (P=0.05)	Sem±	CD (P=0.05)	Sem±	CD (P=0.05)	Sem±	CD (P=0.05)
Variety (V)	0.228	NS	0.201	NS	0.197	NS	0.196	0.816	0.193	NS	0.183	0.760
Sugars (S)	0.228	0.946	0.201	0.836	0.197	0.817	0.196	0.816	0.193	0.800	0.183	0.760
Interaction (VxS)	0.322	NS	0.285	1.182	0.279	NS	0.278	1.154	0.273	NS	0.259	NS

NS = Non significant
V_1 = Yellow coloured bulbs
V_2 = Orange coloured bulbs
S_1 = 50°B Sugar syrup
S_2 = 60°B Sugar syrup
V_1S_1 = Yellow bulbs in 50°Brix syrup
V_1S_2 = Yellow bulbs in 60°Brix syrup
V_2S_1 = Orange bulbs in 50°Brix syrup
V_2S_2 = Orange bulbs in 60°Brix syrup
Note: Use of symbols V1, V2, S1, S2, V1S1, V1S2, V2S1 and V2S2 may be noted in the ensuing tables

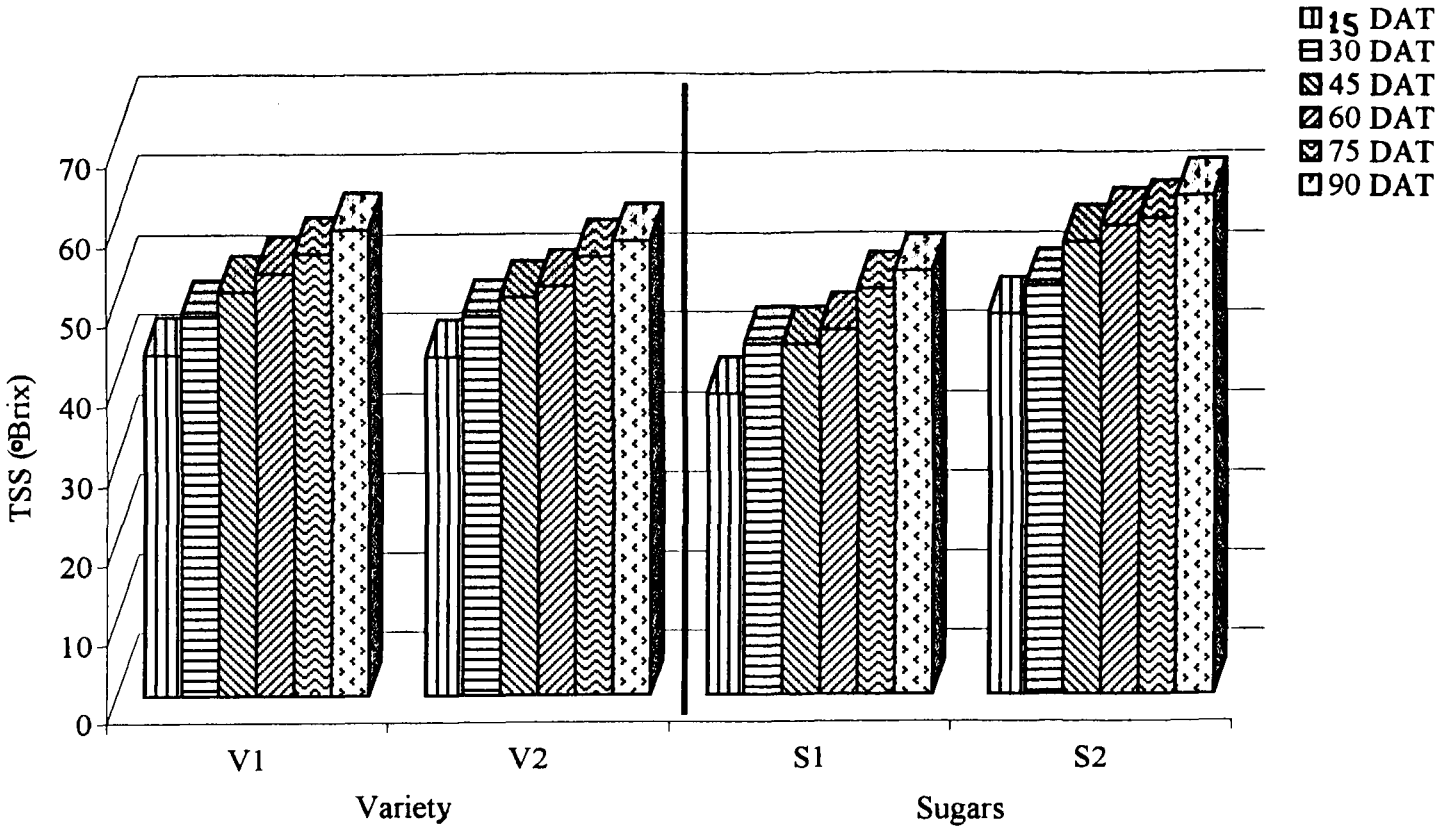


Fig. 1: Changes in the total soluble solids (°Brix) of jackfruit preserve during storage period of 90 days

to increase at minimum rate. The results were non significant during 15, 30, 45 and 75 days after storage.

The strength of the syrup of 50°Brix (S_1) and 60°Brix (S_2) by and large varied significantly during the entire storage period of 90 days as influenced by variety. There was a sharp decline in TSS of both 50°Brix (S_1) to (37.9°Brix) and 60°Brix (S_2) to (47.8) during first 15 days) and continued to decline till 60 days after storage. Later there was a slight increase of TSS in the syrup strength of 50°Brix to 51.04 and 53.34 °Brix during 75 and 90 days after storage. In case of 60°Brix the TSS increased upto 62.7°Brix at 90 days after storage. S_2 was found to be significant over S_1.

Interaction effect was statistically significant with regard to changes in their TSS during 30 and 60 days of storage. Their increase in TSS was higher during first 15 days and later there was a small increase in all the treatment combinations (V_1S_1, V_1S_2, V_2S_1 and V_2S_2).

Although there were differences between V_1S_2 (51.05) and V_2S_2 (51.85) and between V_1S_1 (44.65) and V_2S_1 (43.65°Brix), the variation was not much. However, there was maximum difference between V_1S_1 and V_1S_2 and between V_2S_1 and V_2S_2 at 30 days after storage. Thus V_2S_2 was found to be significant over other combinations. These changes were also true at 60 days after storage.

4.1.2 Changes in the total sugars content of jackfruit preserves during storage

Data on the changes in the total sugar content of jackfruit preserves during storage are presented in Table 2.

It is evident from the data that the total sugar content of the jackfruit preserves prepared from V_1 and V_2 in two different syrup strength increased throughout the storage period of three months

The initial total sugars of V_1 and V_2 were 26.09 and 25.15 per cent respectively. The increase in V_1 (42.46%) and V_2 (42.04) was rapid during first 15 days of storage. Later the increase was less in the subsequent storage periods and at the end of 90 days storage they contained about 58.44 and 56.51 per cent.

Increase in the total sugar content was significant during 60 and 90 days after storage and V_1 was found to be significant over V_2. The increase was not significant during the rest of the storage periods.

With respect to the sugar syrup as influenced by variety, the total sugar per cent increased gradually and reached upto 53.0 and 61.9 per cent in S_1 and S_2 respectively, at the end of 90 days storage. Changes in the total sugar content were statistically significant during entire storage period and S_2 was significant over S_1.

Interaction effect was found to have significant variations in total sugar content during 30 and 60 days after storage. The combination involving a orange coloured bulb in 60°Brix syrup (V_2S_2) maintained a higher total sugar content of 46.50, 51.39, 56.30, 59.05, 59.26 and 61.50 per cent during their respective storage periods of 15, 30, 45, 60, 75 and 90 days compared to other treatment combinations. It was followed by V_1S_2, V_1S_1 and V_2S_1. Thus the combination V_2S_2 was significant over V_1S_1, V_1S_2 and V_2S_1 at 30 and 60 days. The significant difference was not much between V_2S_2 and V_1S_2 and between V_1S_1 and V_2S_1

Table-2: Changes in total Sugars per cent of jackfruit preserve during storage period of 90 days

Factors	15		30		45		60		75		90	
Variety												
(V_1)	42.463		47.141		48.150		52.750		55.014		58.447	
(V_2)	42.041		47.098		49.011		51.104		54.540		56.517	
Sugars												
(S_1)	37.617		43.284		40.952		45.545		50.324		53.023	
(S_2)	46.886		50.955		56.209		58.309		59.231		61.941	
Interactions												
V_1S_1	37.654		43.772		40.189		47.934		50.832		54.514	
V_1S_2	47.272		50.511		56.112		57.566		59.197		62.380	
V_2S_1	37.581		42.797		41.716		43.156		49.816		51.532	
V_2S_2	46.501		51.399		56.307		59.052		59.265		61.502	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Variety (V)	0.191	NS	0.210	NS	1.428	NS	0.213	0.884	0.207	NS	0.188	0.781
Sugars (S)	0.191	0.795	0.210	0.871	1.428	5.922	0.213	0.884	0.207	0.860	0.188	0.781
Interaction (VxS)	0.271	NS	0.297	1.231	2.020	NS	0.301	1.251	0.293	NS	0.266	NS

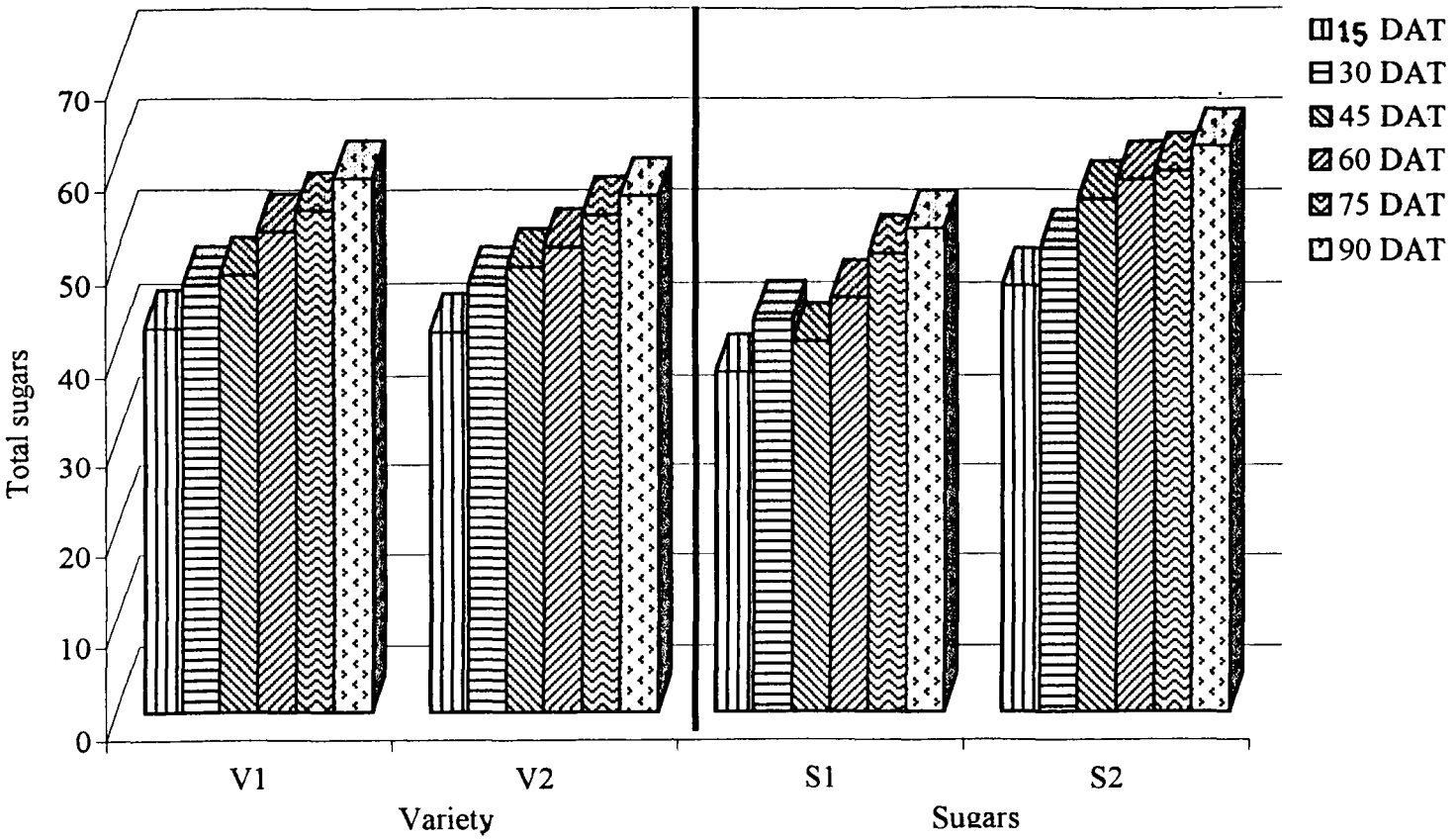


Fig.2: Changes in total sugars per cent of jackfruit preserve during storage period of 90 days

However, there was a clear difference between V_1S_1 and V_2S_2 and between V_2S_1 and V_2S_2 at both 30 and 60 days after storage.

4.1.3 Changes in the reducing sugars content of jackfruit preserves during storage

The changes in the reducing sugar per cent of jackfruit preserves during storage are presented in Table 3.

From the data it was observed that the reducing sugar content of the jackfruit preserves increased as the storage progressed.

The influence of variety had significant differences on the reducing sugar content of the jackfruit preserves increased as the storage progressed.

The influence of variety had significant differences on the reducing sugar content after 45 days of storage and V_1 was found to be significant over V_2. The maximum level of reducing sugars was 56.75 and 54.37 per cent in V_1 and V_2 after 90 days storage. The reducing sugar per cent was almost same (51%) in both V_1 and V_2 at 75 days after storage. The changes in the reducing sugar content between the varieties were not significant during 15, 30 and 75 days after storage.

The results were statistically significant between the two syrup strength used and S_2 was found to be significant over S_1 at all stages of observation.

The interactions were significant only at 45 and 60 days after storage. However, the significant differences were not much between the treatment combination V_1S_2 (49.62%) and V_2S_2 (50.15%).

Table-3: Changes in reducing sugars per cent of jackfruit preserve during storage period of 90 days

Factors	15		30		45		60		75		90	
Variety												
(V_1)	35.349		36.018		42.210		48.139		51.983		56.756	
(V_2)	34.186		38.793		41.001		45.658		51.358		54.378	
Sugars												
(S_1)	29.761		31.150		33.322		40.477		47.007		50.991	
(S_2)	39.773		43.660		49.889		53.319		56.333		60.143	
Interactions												
V_1S_1	29.972		31.339		34.799		43.441		47.531		52.611	
V_1S_2	40.726		40.697		49.622		52.837		56.435		60.901	
V_2S_1	29.551		30.962		31.846		37.514		46.484		49.371	
V_2S_2	38.821		46.624		50.156		53.802		56.232		59.386	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Variety (V)	0.134	NS	0.194	NS	0.224	0.930	0.210	0.871	0.217	NS	0.220	0.913
Sugars (S)	0.134	0.557	0.194	0.806	0.224	0.930	0.210	0.871	0.217	0.902	0.220	0.913
Interaction (VxS)	190	NS	0.275	NS	0.317	1.315	0.297	1.232	0.308	NS	0.311	NS

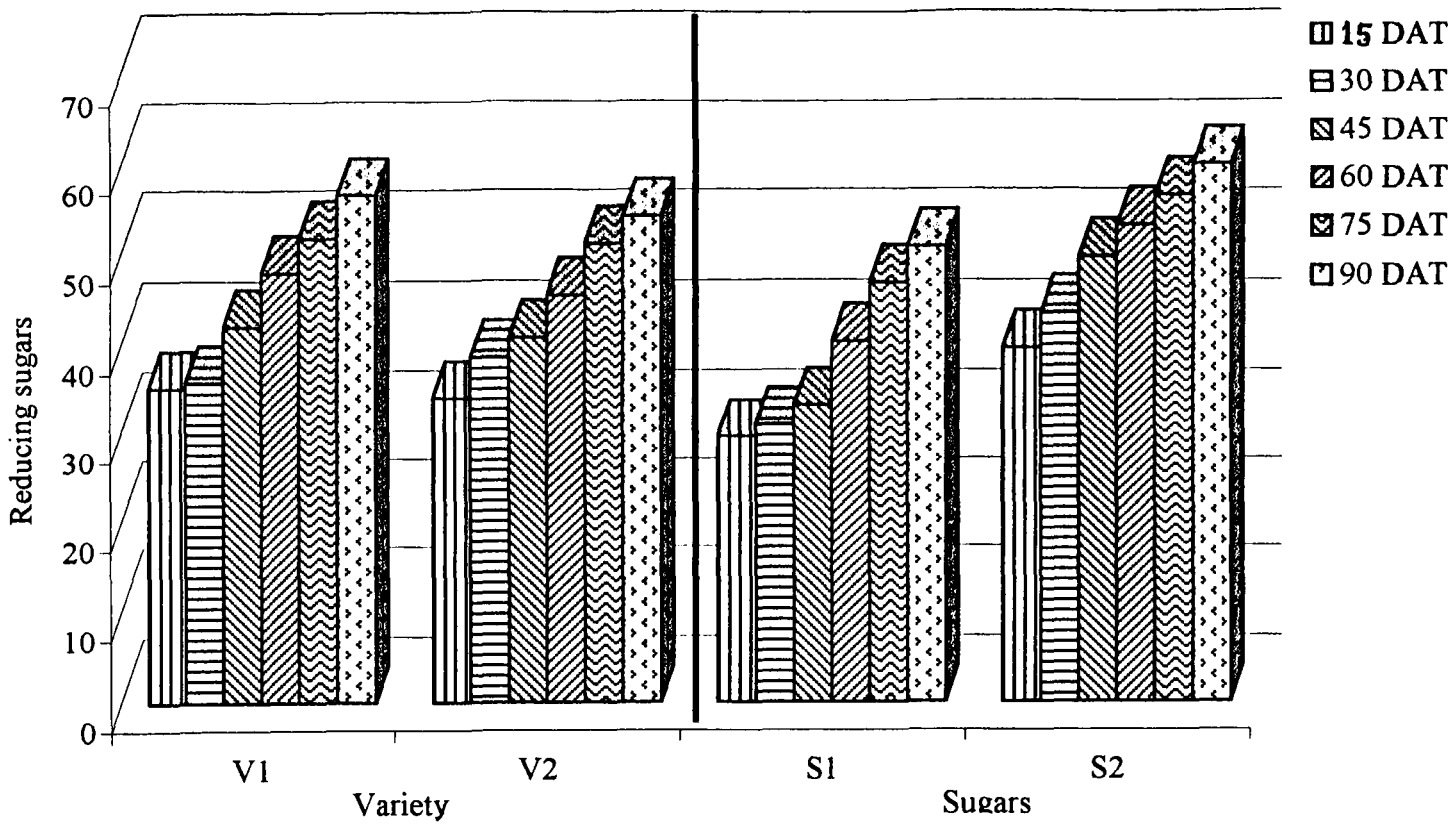


Fig.3: Changes in the reducing sugars per cent of jackfruit preserve during storage period of 90 days

The differences were much more between V_1S_1 (34.79%) and V_1S_2; V_1S_1 and V_2S_1 (31.84%) and between V_2S_1 and V_2S_2 at 45 days after storage. Combination V_2S_2 was thus highly significant over other combinations. The same trend was observed at 60 days after storage. The interaction effects were non significant on 15, 30, 75 and 90 days after storage. The maximum level of reducing sugar content was 59 and 60 per cent in combination V_2S_2 and V_1S_2 at 90 days after storage. The minimum was 29 per cent in combinations V_1S_1 and V_2S_1 at 15 days after storage. Thus the reducing sugar content varied between 29 and 60 per cent between the storage periods.

4.1.4 Changes in non-reducing Sugars content of jackfruit preserve during storage

The data on the non-reducing sugar per cent of jackfruit preserves during storage are presented in Table 4.

From the data it can be inferred that the non reducing sugar content of the jackfruit preserves increased upto 30 days of storage and from 45 days after storage it gradually declined as the storage extended.

The influence of variety had no significant difference during the entire, storage period. The maximum level of non-reducing sugar of 9.19 per cent was recorded.

The results were also statistically non significant in respect of the syrup strength as influenced by variety.

Although there were variations in the non reducing sugar content of the interactions, the results were non significant.

4.1.5 Changes in the total titratable acidity of jackfruit preserves during storage

The data on the changes of total titrable acidity of jackfruit preserves during storage are presented in Table 5.

An increase in acidity was noticed in the jackfruit preserves with the prolonged storage. Although, the initial titratable acidity of both V_1 and V_2 were same (0.13%) the changes were higher (0.131, 0.150, 0.328, 0.381) in V_2 than in V_1 (0.143, 0.141, 0.328, 0.387) during 15, 30, 75 and 90 days after storage. However, the influence of variety on the changes in the total acidity was non significant during the entire storage.

The varietal influence was observed on the acidity of S_1 and S_2 as the storage progressed and changes were more pronounced in S_2 than S_1. Although the variation was seen, they were non significant on all the dates of observation.

The acidity of all the treatment combinations increased as storage preceded. The increase was higher in V_2S_2 (0.139, 0.143, 0.218, 0.241, 0.288 and 0.381) at 15, 30, 45, 60, 75 and 90 days of storage compared to other combinations. However, the changes in the acidity was minimum and statistically non significant during storage.

4.1.6 Changes in the sensory traits of jackfruit preserves during storage

Data on the various sensory characters that are judged with the jackfruit preserves during storage are presented in Table 6..

Table-4: Changes in non-reducing sugars per cent of jackfruit preserve during storage period of 90 days

Factors	15		30		45		60		75		90	
Variety												
(V_1)	5.461		8.756		4.329		2.999		1.368		0.242	
(V_2)	6.228		8.799		5.070		3.330		1.800		0.409	
Sugars												
(S_1)	6.119		9.195		4.652		3.419		1.906		0.342	
(S_2)	5.570		8.360		4.746		2.910		1.262		0.309	
Interactions												
V_1S_1	5.987		9.156		3.779		2.882		1.576		0.257	
V_1S_2	4.936		8.357		4.879		3.117		1.160		0.227	
V_2S_1	6.252		9.234		5.526		3.957		2.236		0.428	
V_2S_2	6.205		8.364		4.614		2.704		1.364		0.391	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Variety (V)	0.110	NS	0.171	NS	0.142	NS	0.136	NS	0.071	NS	0.011	NS
Sugars (S)	0.110	NS	0.171	NS	0.142	NS	0.136	NS	0.071	NS	0.011	NS
Interaction (VxS)	0.156	NS	0.243	NS	0.200	NS	0.192	NS	0.101	NS	0.016	NS

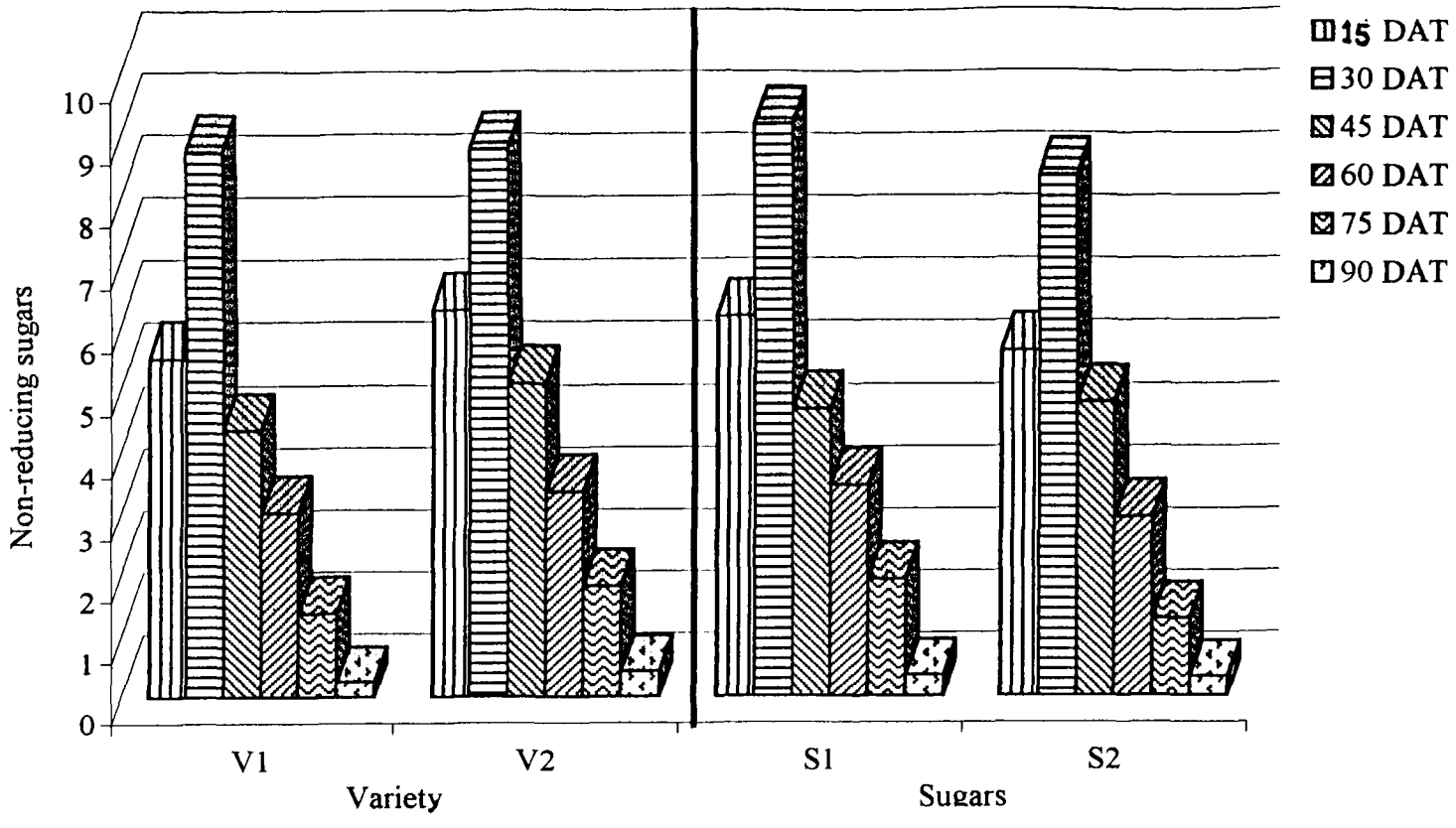


Fig.4: Changes in the non-reducing sugars per cent of jackfruit preserve during storage period of 90 days

4.1.6.1 Colour of the bulbs

The colour of the yellow type bulbs (V_1) was judged good in both in S_1 and S_2 upto storage period of 45 days. Later at 60 and 75 days of storage the colour of yellow bulbs were found to be only normal and at 90 days of storage they were below normal in 50°Brix. But in case of 60°Brix (S_2) they still had good colour after 75 days and at 90 days of storage they were only normal. In case of orange coloured bulbs (V_2) the natural colour was retained throughout the 90 days in 60°Brix, but with 50°Brix it was kept only upto 75 days and after 90 days of storage, it was found to be just normal.

4.1.6.2 Texture of the bulbs

The texture of the V_1 remained from upto 30 days in S_1 and upto 45 days in S_2. Softening of bulbs initiated as early as 60 days storage in S_1 and in S_2 they remained hard from 60 days storage and never became soft. In case of V_2, the bulbs were firm upto 60 days in S_1 and softening was observed after 75 days of storage. Whereas the bulbs in S_2 were firm upto 60 days and later from 75 days after storage they crystallized.

4.1.6.3 Spoilage of the bulbs

The bulbs of both V_1 and V_2 retained good quality without any spoilage till the end of 90 days in 60 (S_2) whereas, bulbs of V_1 in S_1 were slightly spoilt after 75 days of storage. However, the bulbs of V_2 in 50 were not affected even after 90 days of storage. Thus bulbs of V_1 and V_2 in 60°Brix were better than bulbs in 50°Brix and acceptable.

Table-5: Changes in total titratable acidity per cent of jackfruit preserve during storage period of 90 days

Factors	15		30		45		60		75		90	
Variety												
(V_1)	0.143		0.141		0.264		0.288		0.328		0.387	
(V_2)	0.131		0.150		0.253		0.264		0.323		0.381	
Sugars												
(S_1)	0.142		0.149		0.288		0.300		0.363		0.399	
(S_2)	0.132		0.142		0.229		0.253		0.288		0.369	
Interactions												
V_1S_1	0.162		0.141		0.288		0.312		0.368		0.417	
V_1S_2	0.125		0.141		0.241		0.265		0.288		0.358	
V_2S_1	0.123		0.157		0.288		0.288		0.358		0.381	
V_2S_2	0.139		0.143		0.218		0.241		0.288		0.381	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Variety (V)	0.006	NS	0.005	NS	0.011	NS	0.006	NS	0.010	NS	0.009	NS
Sugars (S)	0.006	NS	0.005	NS	0.011	NS	0.006	NS	0.010	NS	0.009	NS
Interaction (VxS)	0.096	NS	0.082	NS	0.016	NS	0.008	NS	0.014	NS	0.013	NS

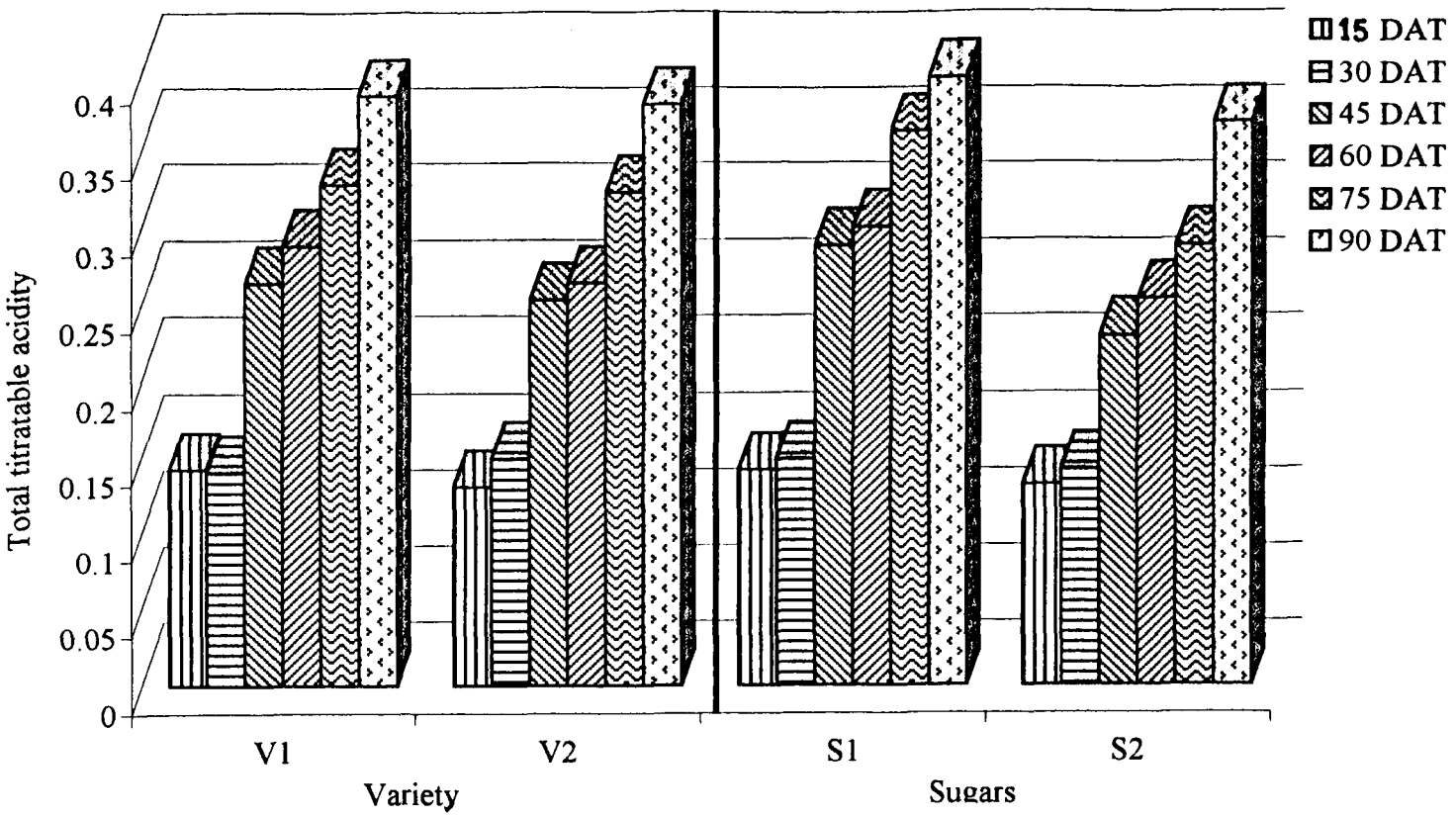


Fig.5: Changes in total titratable acidity per cent of jackfruit preserve during storage period of 90 days

4.2 Organoleptic evaluation of jackfruit preserves at the end of storage

The data on the organoleptic evaluation of jakfruit preserves at the end of storage are presented in Table 7.

At the end of 90 days, the sensory evaluation of the preserved bulbs revealed the following conclusion

4.2.1 Colour of the jackfruit preserve

The preserves from yellow type and orange type scored a score of about 6 and the results were non significant between them. With respect to syrup strength, S_2 (5.21) was better than S_1 (6.3) with significant differences. The interaction effect were not significant with respect to colour.

4.2.2 Texture of the jackfruit preserves

With respect to texture both V_1 and V_2 had equal acceptability with scores of about (8) and results were statistically non significant. The variation in texture of bulbs due to the effect of syrup concentration was also non significant. The data further revealed that the combination effects were also not significant with a score of about 8.

4.2.3 Flavour of the jackfruit preserves

The flavour of V_1 and V_2 had a score of 5 – 7 after 90 days storage and statistically the were non significant. The effect of syrup strength on the preserves was statistically significant and S_2 (7.19) was found to be significant over S_1 (7.19) was found to be significant over S_1 (5.876). The interactions were statistically non significant.

Table-6: Changes in sensory traits of jackfruit preserve during storage period of 90 days

	Yellow type		Deep orange type	
	50°Brix	60°Brix	50°Brix	60°Brix
1. Colour of bulbs				
a) After 15 days	Very good	Very good	Good	Good
30 days	Very good	Very good	Good	Good
45 days	Good	Very good	Good	Good
60 days	Good	Good	Good	Good
75 days	Good	Good	Normal	Good
90 days	Normal	Good	Normal	Good
2. Texture of bulbs				
b) Before 15 days	Firm	Very firm	Firm	Firm
30 days	Firm	Very firm	Firm	Firm
45 days	Firm	Firm	Firm	Firm
60 days	Soft	Hard	Soft	Firm
75 days	Soft	Hard	Soft	Firm
90 days	Soft	Hard	Soft	Firm
3. Spoilage of bulbs				
c) Before 15 days	No	No	No	No
30 days	No	No	No	No
45 days	No	No	No	No
60 days	Slight	No	No	No
75 days	Slight	No	No	No
90 days	Moderate	Slight	Slight	No

1. Colour: Very good, Good, Normal; 2. Texture: Very firm, Firm, Soft, Hard; 3. Spoilage: Spoil, Slightly spoil, Moderate, No spoilage

4.2.4 Overall acceptability of jackfruit preserves

There were no significant differences in V_1 and V_2 with respect to their overall acceptability and had a score of about 8. Regarding the syrup strength used for preserves, S_2 (8.79) was statistically significant over S_1 (7.67). The results further confirmed that the interaction effects were statistically non significant.

Table-7: Organoleptic evaluation of jackfruit preserve after 90 days

Factors	Colour		Texture		Flavour		Overall acceptability	
Variety								
(V_1)	5.629		7.670		6.686		8.153	
(V_2)	5.963		8.194		6.379		8.317	
Sugars								
(S_1)	5.213		7.987		5.876		7.671	
(S_2)	6.379		7.878		7.190		8.799	
Interactions								
V_1S_1	5.545		7.628		7.459		8.719	
V_1S_2	5.713		7.713		5.914		7.588	
V_2S_1	4.713		8.043		5.838		7.755	
V_2S_2	7.213		8.346		6.921		8.880	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Variety (V)	0.473	NS	0.185	NS	0.130	NS	0.225	NS
Sugars (S)	0.473	1.960	0.185	NS	0.130	0.539	0.225	0.933
Interaction (VxS)	0.669	NS	0.261	NS	0.184	NS	0.318	NS

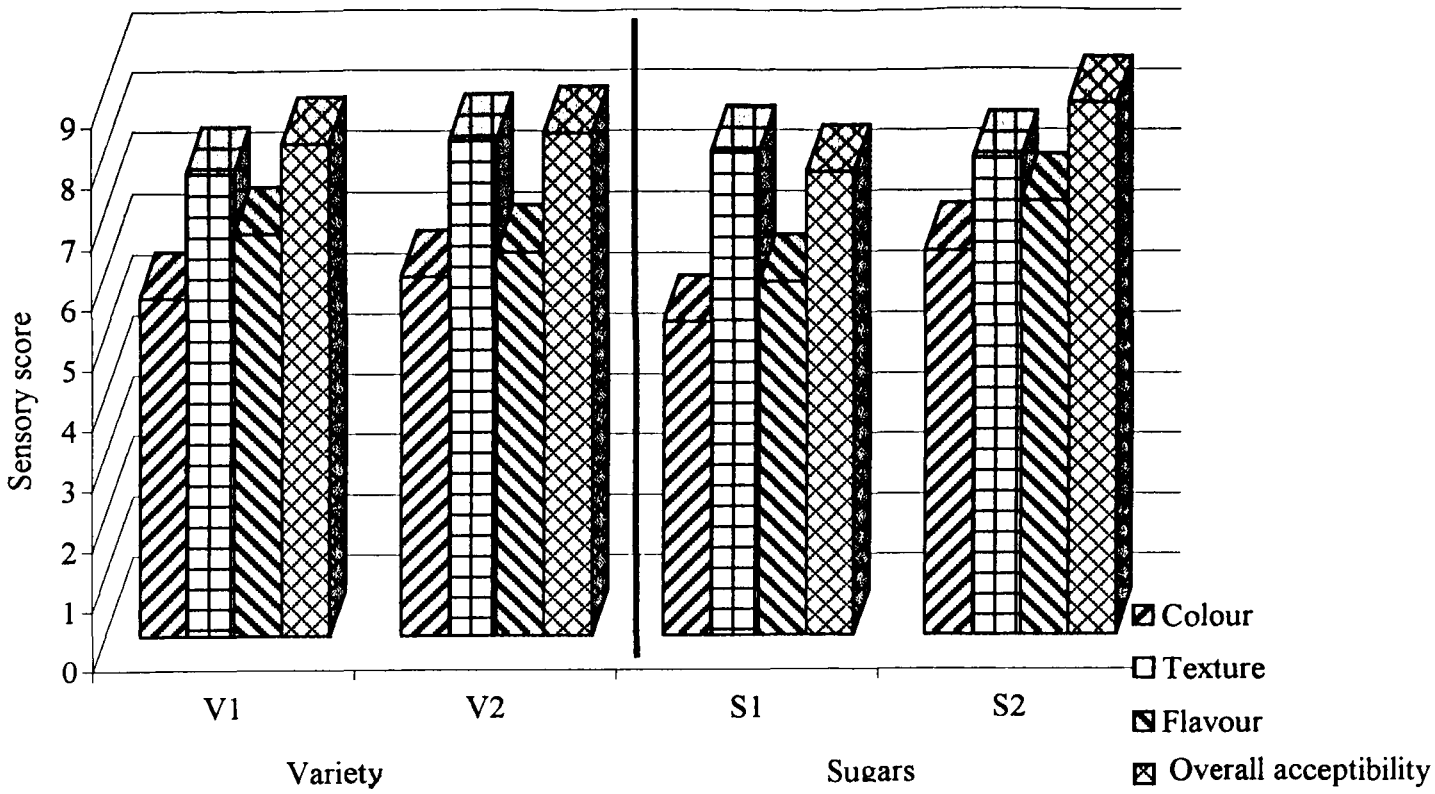
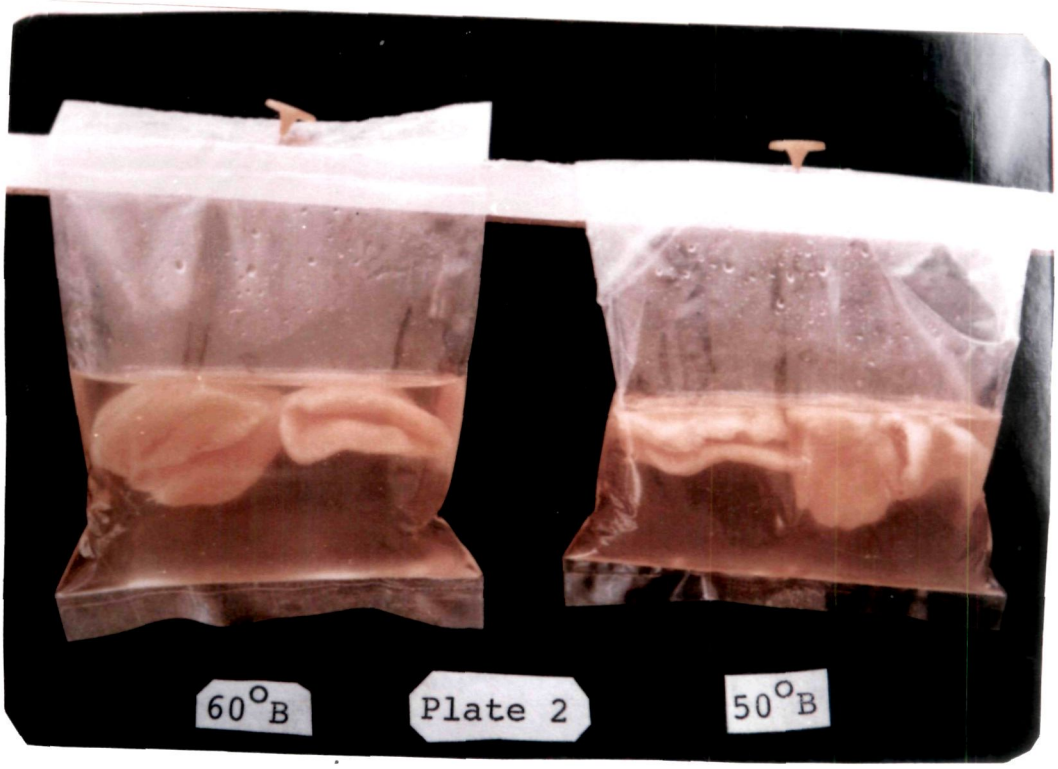
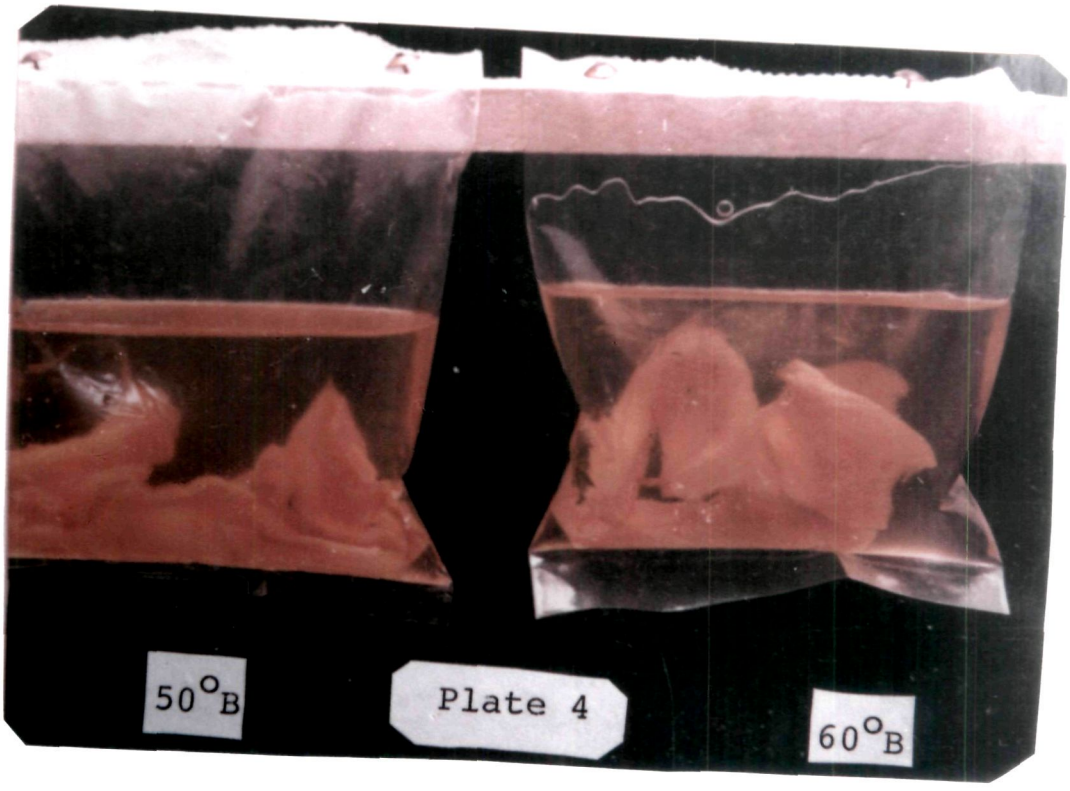


Fig.6: Organoleptic evaluation of jackfruit preserve after 90 days

Plate-2: Jackfruit preserves from yellow coloured bulbs at 50° Brix and 60° Brix after 90 days of storage

Plate-4: Jackfruit preserves from orange coloured bulbs at 50° Brix and 60° Brix after 90 days of storage


60°B
Plate 2
50°B


50°B
Plate 4
60°B

DISCUSSION

V. DISCUSSION

In the present study, attempts were made to extend the shelf life of jackfruit bulbs temporarily to make them available in ready to use form land reducing the postharvest losses of jackfruit that glut in the market during the harvesting season and to prevent the unhygenity of bulbs in their fresh state. The jackfruit preserves were stored to study the various chemical changes is quality attributes and to assess their acceptance. The results obtained are critically discussed in this chapter.

5.1 Chemical changes in the jackfruit preserve during storage

5.1.1 Changes in the total soluble solids

The jackfruit bulbs, which were embedded in the sugar syrup continuously, gained an increase in total soluble solids during storage period of three months. The rate of increase was greatest during first 15 days. The increase in TSS of the bulbs could be attributed to the absorption of sugar syrup into their tissues. The higher TSS in yellow coloured bulbs than orange coloured bulbs (V_2) could be due to the maximum absorption of syrup by them. Variation in the absorption capacity as induced by the type of bulbs can be ascertained. This can be supported by the fact that yellow bulbs had higher water content (69.54%) than orange bulbs (66.43%) and it could be apparently inferred that maximum syrup was absorbed by yellow bulbs to replace the higher moisture, increasing the TSS.

The absorption of syrup by fruit pulp is quite a common phenomenon as reported by many researchers (Bhatia *et al.*, 1955a;

Bhatia *et al.*, 1955c; Bhatia *et al.*, 1956b). The absorption of syrup is reported to take place by the action of osmosis and replaces the moisture content in the tissue of bulbs by sugar syrup (Bhatia *et al.*, 1956b; Miata, 1970; Kawabara, 1988). Also the handling of bulbs during preparation might have picked them which might have increased the absorption (Siddappa and Bhatia, 1959).

The reduction in the syrup concentration in the earlier storage period may be attributed to the dilution of the syrup by the diffusion of the moisture from the tissues of the bulbs into the syrup solution. The increase in the concentration of syrup towards end of storage with respect to initial concentration may be due to the evaporation of water from the minute pores of the polybags.

The coupling of the kind of the bulb and the strength of the syrup was additive in its effect in the variation in the TSS of the jackfruit preserves.

The TSS of the bulbs irrespective of their kind when put into 60°B (S_2) had higher TSS. This indicates that higher the concentration of sugar more was the penetration into the tissues.

The significant results in the jackfruit preserves at 30 and 60 days storage indicates that the penetration of syrup must be more or less same between 15 days interval compared at 30 days interval. Yellow bulbs in 60°B (V_1S_2) had a higher magnitude of rise in TSS than other combinations. The variation in TSS could also be due to the varietal differences.

The similar magnitude of increase in total soluble solids was also noticed by Bhatia *et al.* (1955c), Bhatia *et al.* (1956a), Palaniswamy *et al.* (1973), Kapur (1975) and Tripathi *et al.* (1988).

5.1.2 Changes in the total sugars

There was a gradual increase in the total sugar content of the jackfruit preserve during storage. The increase in the sugar fraction was relatively higher in case of preserves in 60°B and was significant during 30 and 60 days after storage. The rise in the total sugar content recorded in the present study might be due to absorption of sugars by the bulbs into their tissues. The variations in the total sugar content in the bulbs could be attributed to the procurement of jackfruits from the local market, which might have been harvested from different trees. The variation in the value of the total sugar content of the preserves could be due to varietal differences.

The results with respect to syrup concentration were found to be significant throughout storage and increase in the total sugar could be because of evaporation of water from the syrup solution through the minute pores of the polybags resulting in crystallization of sugars (Brown, 1968).

The increase in the total sugars of the preserves may apparently be due to the hydrolysis of polysaccharides and inversion of non-reducing sugar to reducing sugars leading to increase in total sugars. This is confirmed by the fact that increase in acidity increases inversion (Siddappa and Bhatia, 1959).

Blanching done to this fruits prior to preserving improves the sugar diffusion and thus might have increased the total sugars

(Basamakov, 1976). The results obtained are in conformity with those reported by Palaniswamy (1973), Adsule and Ray (1975) and Tripathi *et al.* (1988).

5.1.3 Changes in the reducing sugars

There was a gradual increase in the reducing sugar content of jackfruit preserve with the extended storage. The higher reducing sugar was found in combination V_2S_2 and it was followed V_1S_2, V_1S_1 and V_2S_1 and the results were significant during 45 and 60 days of storage.

The increase in reducing sugar content of the jackfruit preserves may be attributed to the pick up of the sugar by the bulbs by the processes of osmosis. Hydrolysis of polysaccharides and enzymatic inversion of non-reducing sugar to reducing sugar might have also contributed to the increase in the reducing sugar per cent. The changes might also be due to varietal differences (Siddappa and Bhatia, 1959).

Increase in reducing sugar during storage was also reported by Bhatia (1955a), Bhatia *et al.* (1955c), Bhatia *et al.* (1956a), Bhatia *et al.* (1958), Palaniswamy *et al.* (1973), Kapur (1975) and Tripathi *et al.* (1988).

According to Kalra (1982) the higher values of reducing sugars would be due to inconsistent fehlings solution. The presence of mineral ions increases the reducing sugar content (Weekel, 1970).

5.1.4 Changes in the non-reducing sugars

There was a gradual decline in the non-reducing sugar content of the jackfruit preserves as the storage extended. However, the results were non significant.

The decline in the non-reducing sugar content of the preserves may be due to the inversion of the non-reducing sugars to reducing sugars. This is supported by the increase in acidity which might have helped for its inversion into reducing sugar (Siddappa and Bhatia, 1959). The changes may also be due to varietal differences.

The decline in the non-reducing sugars was also reported by Tripathi *et al.* (1988).

5.1.5 Changes in the total titrable acidity

The jackfruit bulbs which were preserved in syrup gained acidity as storage period advanced. The orange coloured bulbs were found to have higher acidity than yellow coloured bulbs. This variation in acidity could be due to genetical differences. The gain in acidity could be a function of longer storage or increase in concentration of reducing sugars or due to the effect of preservative. However, results were found to be non significant.

The increase or decrease in the acidity during the storage in presence of sugar is a general phenomenon as reported by Bhatia *et al.* (1956b).

Similar increase in acidity was reported by Palaniswamy *et al.* (1973).

The slight spoilage of the preserves might have increased the acidity (Sethi and Anand, 1982).

5.2 Sensory changes in jackfruit preserves

The storage of jackfruit preserves was marked by the loss of its colour, the degree of loss being the function of length of storage. This could be attributed to the fact that the coloured pigments responsible for imparting the characteristic colour to the preserves such as carotenoids were degraded by the action of light, temperature, acids, sugars and preservatives added. The pattern of results obtained in the present study is supported by earlier observations made by Matsui and Chimizu (1970).

The perceivable variations in the colour of the preserved bulbs as influenced by their kind, it was found that orange coloured bulbs retained better colour than yellow coloured bulbs. This could be attributed to varietal differences in synthesising the coloured pigments. However, addition of ascorbic acid to the syrup can improve the colour and flavour of strawberry (Paichoalino, 1977).

The higher syrup strength maintained better colour irrespective of type of bulb. This may be because of lower penetration of light in higher osmotic solution.

Similarly, the texture of the bulbs in 50°B became soft at much earlier stage. The difference in the texture could be only a varietal factor in that the yellow coloured bulbs were more fibrous or due to sucrose inversion (Weekel, 1970). The higher sugar (S_2) crystallized the texture (Siddappa and Bhatia, 1959).

The spoilage of the preserved could be attributed to the transmission of water vapour and oxygen through the polybags (Hu *et al.*, 1969).

The abnormal spoilage may also be due to the evolution of gases from the product (Hernandez and Feria, 1969). Deterioration of canned products during storage could be due to microbial, enzymatic and/or biochemical effects (Wunsche, 1970).

The kind of bulbs however, did not influence the flavour of the preserves. The bulbs retained their flavour for long time because of absence of terpenoids in their bulbs. The small loss in flavour of the preserves may be because of permeability of polybags to aromatic compounds. However, addition of sugar can improve flavour intensity in canned papaya (Mabes *et al.*, 1982).

The influence of syrup strength was found to have significance in colour, texture and flavour retention in that the higher concentration of syrup was better and liked by the judges.

The study revealed that the orange coloured bulbs obtained a highest score of 8.31 for overall acceptability by the judges. The preserves with higher sugar syrup concentration were preferred by the judges. However, the overall acceptance of preserves depended on the individual liking and also the basic genetic make up of the variety.

Future line of work

It would be worthwhile if the following research work related to preservation of jackfruit bulbs in high concentration of sugar can be carried out by future researchers.

1. Studies directed on intensive microbial spoilage during storage.

2. Studies on evaluation of different packaging with aluminium foil varied thickness.

SUMMARY

VI. SUMMARY

The experiment of the "Preservation of jackfruit bulbs in high concentration of sugar" was conducted at the Division of Horticulture, University of Agricultural Sciences, G.K.V.K. Campus, Bangalore during the year 1999 - 2000 to findout the most hygenic and scientific methods to preserve the bulbs temporarily in sugar syrup and consumer packages so that it could be sold in a hygenic way.

The findings of the study are summarised as follows:

1. The jackfruit preserves showed an increase in the total soluble solids, total sugars and reducing sugars with the extended storage of 90 days because of the absorption of sugar syrup into their tissues.

2. As influenced by the variety, the yellow coloured bulbs had higher TSS (48.20), total sugars (58.44) and reducing sugar (56.75) content than orange coloured bulbs and was significant with the storage period of 90 days.

3. The non reducing sugar content and the total titratable acidity was neither influenced by the variety, the syrup concentration nor by their combinations.

4. The jackfruit preserve involving yellow bulbs in 60°Brix syrup (V_1S_2) had higher TSS (62.95°B), total sugars (62.38%) and reducing

sugar (60.90%) compared to other combinations after 90 days of storage.

5. The syrup concentration of 60°B with respect to total soluble solids, total sugar and reducing sugar content was significant over 50°B syrup.

6. Irrespective of the type of bulbs used, when kept in higher syrup concentration were found to have better sensory features and thus orange and yellow coloured bulbs preserved in 60°Brix were accepted.

Thus the preserves of orange and yellow bulbs in 60°Brix sugar syrup could be stored for 90 days in polybags with good chemical and organoleptic properties in a most hygenic way and are most acceptable for consumption.

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**Original not seen*

APPENDIX

APPENDIX - I

Chartacterstic of fresh yellow and orange type jackfruit used in the present study

Sl. No.	Components	Yellow type	Orange type
1.	Weight of fruit (kg)	6.504	5.810 (kg)
2.	Average number of bulbs per fruit	186.00	40.90
3.	Average weight of bulbs (kg)	2.150	1.820
4.	Average weight of seeds (kg)	3.520	2.210
5.	Average weight of peal and placenta	4.22	2.48
6.	(kg)	26.80	25.50
7.	Total soluble solids (°Brix)	26.09	25.15
8.	Total sugars (%)	18.41	17.56
9.	Reducing Sugars (%)	7.55	0.40
10	Non Reducing Sugars (%)	0.13	0.13
11.	Total titratable acid (% citric acid)	69.54	66.43
12.	Moisture content (%)	0.284	0.256
13.	Edible to Non-edible ratio Pulp to seed ratio	0.590	0.550