# UTILIZATION OF SELECTED UNDEREXPLOITED FRUITS FOR PRODUCT DEVELOPMENT

By

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**(2000 - 16 - 05)**

**THESIS**

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## DECLARATION

I hereby declare that the thesis entitled **Utilization of selected underexploited fruits for product development** 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 to me of any degree diploma fellowship or other similar title of any other University or Society

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## CERTIFICATE

Certified that the thesis entitled **Utilization of selected underexploited fruits for product development** is a record of research work done independently by Miss Teena Joy under my guidance and supervision and that it has not previously formed the basis for the award of any degree diploma fellowship or associateship to her

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# ABBREVIATIONS

| | |
|---|---|
| % | Percentage |
| µg | Microgram |
| CD | Critical difference |
| cm | Centimeter |
| CRD | Completely Randomized Design |
| FPO | Fruit Product Order |
| g | Gram |
| kg | Kilogram |
| KMS | Potassium metabisulphite |
| mg | Milligram |
| ml | Millilitre |
| ppm | Parts per million |
| RTS | Ready to serve |
| TSS | Total soluble solids |
| w | Kendals coefficient of concordance |

# Introduction

# INTRODUCTION

India has been gifted with a wide variety of agro climatic and soil conditions and enjoys an enviable position in the horticultural map of the world India is the second largest producer of fruits next only to China and their production has tripled over the last 50 years (Reddy 2002)

Fruits are perhaps the first edible natural food consumed by man Fruits are no longer considered as a luxury since they belong to an important class of protective foods which provide adequate vitamins and minerals needed for the maintenance of health

Fruit industry can play an important role in salvaging the wastage utilising cull and sub grade fruits stabilising prices during glut season generating employment opportunities meeting the requirements of defence forces in border areas and last but not the least earning foreign exchange for the country by development of exports (Shaw *et al* 1993) Therefore the country s urgent requirement is to enhance the processing of nutritious food in a sustainable manner and improves the farm family income in order to ensure household food security nutritional security and economic security

A production of 60 million tonnes of fruits is required to meet the need of over one billion population of the country by 2002 Since it is not possible to attain such a high production utilizing the underexploited fruits in a highly profitable manner can solve this problem

Accordingly development of newer products from these underexploited 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 Therefore value added products prepared from under utilized fruits would play a significant role not only

for their domestic market but also for their export (Srivastava and Sanjeev 2002)

For most of underexploited fruits there is no recognized orcharding their nutritional and plant protection management is no body s business owners if any go only to collect the harvest and little is known about their utilization or value addition Such group of fruit species is considered as under utilized fruits (Singh 2002)

Bilimbi roseapple and lovi lovi fruits are such unconventional fruits having potentialities for making different types of products and need to be tried by the processing industry to promote its expansion Due to the ignorance in the technical know how of it s processing these fruits are not fully utilized during period of plenty Therefore to ensure production and minimize post harvest losses there is dire need for exploring the possibilities of utilizing this fruit in the processing industry Hence it was the useful thought to make an attempt towards evaluating the processing qualities of these fruits for production of various products

Bilimbi roseapple and lovi lovi fruits are very useful and profitable crop particularly in developing countries where a subsistence agricultural pattern is established In the present study an attempt is being made to develop products utilizing these underexploited fruits It is important that whether a new fruit product is acceptable or not is to be investigated before it is introduced into open market

With these points in mind the present study is taken up with bilimbi roseapple and lovi lovi fruits with regard to their value addition

Objectives outlined in the present study include

- To ascertain the physico chemical and sensory characters of the selected underexploited fruits
- Development of value added products such as bilimbi jam and pickle roseapple squash (rose and white type fruits) lovi lovi (sweet type) preserve in sugar and lovi lovi (sour type) in brine
- To ascertain the organoleptic chemical and shelf life qualities of the products developed

# Review of Literature

# 2 REVIEW OF LITERATURE

The relevant literatures available on the study entitled Utilization of selected underexploited fruits for product development have been briefly reviewed here Wherever sufficient literature is not available on the fruit or the product tried in this experiment result of experiments conducted on related fruits or the products are also cited The literatures are reviewed under the following subtitles

2 1 Importance of fruits and fruit products
2 2 Need for processing fruits
2 3 Significance and utilization of underexploited fruits
2 4 Important characters of bilimbi roseapple and lovi lovi
2 5 Physico chemical characters of other important underexploited fruits
2 6 Product development from underexploited fruits
2 7 Effect of storage on product quality

## 2 1 IMPORTANCE OF FRUITS AND FRUIT PRODUCTS

Reddy (2002) proudly reported that India is found to be the second largest producer of fruits next only to china and their production has tripled over the last 50 years

Sethi (1993) reported that in India inspite of high production of fruits 20 30 per cent of the produce are not utilized due to post harvest problems and hence a huge quantity of fruits are lost in the country Poornia *et al* (1994) has also stressed that nearly 30 per cent of the fruits are lost due to spoilage during handling transportation lack of storage and processing facilities

Fruits are highly perishable and hence to reduce wastage and to make it available throughout the year the fruits should be processed into

value added products (Khurdiya and Roy 1985) Kaushal (1987) has stressed on the rise in demand for processed fruits and vegetables because of the increased defence requirements and urbanisation trend According to Anvilla *et al* (1993) the consumption of processed foods is likely to increase in the future

Some of the important underexploited minor fruits grown in India are pomegranate karonda ber bael bilimbi cashew apple roseapple jack fruit lovi lovi and custard apple (Eipeson and Bhowmik 1992) According to Pareek and Sharma (1993) underexploited fruits are the several less known fruit species which have the potential for commercial exploitation Roy (2000) identified that under utilized tropical fruits have potential in the world market He further argued that most of the minor fruits like amla bael bilimbi jamun roseapple karonda and lovi lovi are entirely unknown in the world market and need to be popularized

**2 1 1 Nutritional Importance**

Fruits as a source of nutrition have a very important place in the human diet In the developing countries fruits of high nutritive value must get priority over those having attractive appearance (Purohit 1991) Under utilized minor fruits provide nutrition strength and vigour to our body and restore the loss of minerals and aminoacids and thus protect against deficiencies and certain chronic diseases (Singh *et al* 1998) Minor fruits are not only rich source of minerals and vitamins but can also contribute in a big way in maintaining national health and overcome hunger and malnutrition (Misra and Rai 2000)

Apart from traditional fruits there are numerous non traditional fruits such as jackfruit phalsa pummelo wild apricot amla bael and jamun which can supplement carotene vitamin C riboflavin

calcium and iron which would highly help to satisfy our dietary needs of nutrition (Rathore 2001)

Sethi (1987) reported that about 15g of amla consumed daily could help dietary needs of vital vitamins Demand for the west indian cherry has increased in the Brazilian and external market mainly due to its high vitamin C content (Lopes *et al* 2000) According to Kikani (2001) vitamin C content is highest in aonla (800 1000 mg) Maini and Kaur (2001) identified that bael fruit has rich source of riboflavin and ascorbic acid

Jujube fruit is highly nutritious and rich in vitamin A B complex and C whereas phalsa fruit is rich in vitamin A and C (Chadha 1990) Ascorbic acid carotene and carbohydrate are found to be present more in passionfruit (Khurdiya 1994) Kaushal *et al* (1999) reported that kiwi fruit has good source of vitamin C and B

The nutritional value of dates showed its obvious contribution in the human health when consumed with other foods Dates meet some of the daily nutritional requirements because of its considerable content of protein carbohydrates vitamins and minerals which are essential in the human diet for maintenance of proper equilibrium (Al showiman and Baosman 1999)

Dhan (2000) studied about the vitamin C content in amla and its products like chavanaprash and murabba in which ascorbic acid ranges from 48 60 mg 100 $g^{1}$ Besides a good source of ascorbic acid acerola cherry is also known as an excellent source of bioflavonoids Acerola is also a good source of retinol iron calcium and phosphorus and can be processed easily into jelly puree confectionery liquors and sauces (Mezquita and Vigoa 2000)

Jamun is a very good source of iron (Pal *et al* 1999) Rathore (2001) advocated that minor fruits like phalsa bael and woodapple are excellent sources of calcium and phosphorus whereas custard apple ber and karonda are rich sources of iron

Sadashivan and Neelakantan (1976) had found that ripe jackfruit bulbs are rich in sugar and contain fair amounts of carotene protein and minerals Valentini and Botta (1999) reported that sucrose was the main sugar in mature fruits followed by glucose and fructose and citric and malic acids were the main organic acids in apricot fruit Legua *et al* (2000) noted that predominant sugar was fructose and predominant organic acid was malic acid in pomegranate juice Avocado is the most nutritious fruit on earth in terms of calorific value minerals and vitamins (Aipe *et al* 2001)

Wang *et al* (1997) studied that the pH and soluble solid content of carambola fruits increased during ripening while the titratable acidity decreased Singh and Acharyya (1999) observed that vitamin C and total soluble solids (TSS) contents increased with increasing ripeness whereas acidity decreased as the phalsa fruit ripened Kaushik *et al* (2000) reported that biochemical parameters such as total soluble solids ascorbic acid and carotenoids were higher at the ripe stage while acidity protein crude fibre pectin tannins were higher at green stage Jun and Hui (2001) showed the results that acidity decreased gradually with fruit maturity while ascorbic acid reducing sugar and soluble solid contents increased

More than 95 per cent of the volatile compounds were identified in one of the underexploited fruit *Malpigh a glabra* by Casadebaig *et al* (2000) Pino *et al* (2000) identified various volatile components in annona which includes alpha thujene and alpha pinene as major component but it is not utilized properly so far Zhang *et al* (2001) isolated new phenolic constituents from fruit juice of aonla

Vaidehi *et al* (1977) suggested that if we make several uses of our under utilized fruits we may overcome the problem of deficiencies due to lack of fruits and vegetables in out diet and these fruits could be processed and utilized for domestic and export markets

**2 1 2 Medicinal Importance**

The under utilized fruits have a close association with local beliefs and are used in health care of the people (Singh *et al* 1998) George *et al* (2000) have explained that most of these minor fruits are blessed with immense medicinal values and are extensively used in Indian system of medicine

Minor fruit like jamun has stomachic carminative and diuretic properties apart from its cooling and digestive properties (Pal *et al* 1999) Jamun an under utilized tropical fruit is valued for its medicinal and therapeutic properties with the use of its volatile components (Vijayanand *et al* 2001)

It has been successfully identified that jackfruit could be very useful in the treatment of the dreaded disease of human beings AIDS (Chadha 1990) In ayurveda it has been used for curing inflammation constipation skin disease and wound healing (George *et al* 2000) Rathore (2001) was of the opinion that most of the people are familiar with the medicinal properties of locally grown fruits

Bael fruits are mildly laxative and the slices of the unripe fruits in the form of murabba are used in chronic cases of diarrhoea and dysentery (Singh 1963) In the after treatment of bacillary dysentery this minor fruit is useful adjuvant as it helps to remove constipation which hinders the healing of ulcerated surfaces of intestine (George *et al* 2000)

Chadha (1994) found that aonla is the main ingredient of chyavanpras which is famous for its therapeutic value n ayurvedic system of medicine Kikani (2001) described that aonla have antiscorbutic diuretic laxative and antibiotic propert es that can be highly utilized for combating several diseases such as chronic dysentery bronchitis diabetes fever diarrhoea jaundice dyspepsia and cough

Porchezhian *et al* (2000) reported about the phytochem cal and pharmacological investigat ons on some medicinally important *zizyphus* species

**2 1 3 Importance of Fruit based Beverages**

According to Manay and Shadaksharaswamy (1987) there has been a tremendous increase in the non alcoholic beverages such as fruit based drinks synthetic drinks sweetened aerated water or carbonated drinks because of rapid growth and development of beverage industry in India Olsen (1991) pointed out that world trade in tropical fruit juice concentrates and pulps has expanded rapidly and would continue its upward trend over the next several years Kalra *et al* (1991) highlighted that fruit based beverages are rightly being encouraged as they provide much needed vitamins and minerals

Khurdiya (1988) pointed out that about 65 per cent of the total processed products manufactured by Fruit Product Order (FPO) licences in India are sweetened aerated water Khurdiya (1990) reported that the dietetic value of real fruit based beverage is far greater than that of synthetic products which are being produced in large quantities and the fruit juice are added to the beverage which can impart natural colour and flavour there is no need for synthetic additives There is a noticeable sh ft from consumption of alcoholic beverages to natural fruit based beverages (Varde 1991) Manan *et al* (1992) stated that fruit based ready to serve

beverages and fruit juices are not only rich in minerals vitamins and other nutritive factors but also are delicious and have an universal appeal

Vaidehi *et al* (1977) opined that it would be very useful if the unconventional fruits are studied for their beverage value and used for the manufacture of acceptable fruit drinks for consumption Ambadan (1984) stated that it is necessary to introduce new fruit beverage utiliz ng fruits like passion fruit guava grape litchi phalsa etc because of their exotic aroma and excellent colour Seidemann (1995) reported that passiflora fruits are consumed fresh but the crop is mainly grown for its aromatic fruit juice which is used in the beverage industry

Khurdiya (1988) reported that fruit beverages are able to offer more variety of flavour nutrient and other physiological benefits with a greater margin of safety in a drink with lower inherent cost As reported by Kaur and Khurdiya (1993) fruit beverages are becoming increasingly popular in the market with the growing consciousness of people in the nutritive value of fruits

## 2 2 NEED FOR PROCESSING FRUITS

Processing fruit based products is a method of reducing post harvest losses of perishable foods like fruits Bhatia and Rani (1986) has classified the causes of post harvest loss of perishable crops in develop ng countries as primary losses due to insects microbes and mechan cal damages and secondary losses due to poor storage and inadequate transport facilities

Processing of fruits can be defined as adding value to conventional and innovative fruit items through various permutations and combinations providing protection preservation packag ng convenience carriage and disposability (Rao 1989) Due to the perishable

nature of fruits and vegetables the post harvest loss of these commodities is four to five times higher than in food grains (Roy 2001) He further suggested that processing of underexploited fruits can add value and find good business opportunities in India He also reported that under utilized fruits which are not easily marketed in the fresh form should be processed into acceptable products so that the growers get a renumerative price and consumers all over the world get the opportunity to enjoy the fruit in the form of its processed products The growing of rare traditional exotic fruit species and demand for dried fruits were discussed by Piccirillo (2001)

Maini and Anand (1985) pointed out that development of fruit preservation industries can help to generate employment support growers upgrade local nutrition and increase the gross national product The post harvest handling of fresh fruits physiological and biochemical aspects harvesting and field handling packaging transportation marketing and storage aspects of many minor fruits were discussed by Bose (1990) Many of the minor tropical fruits are completely unknown to consumers living in temperate climates With the interest in exotic and unusual products growing in the more developed countries real potential exists to cultivate an export market based on the production of tropical fruits (Nichols and Christie 1993)

The fruit and vegetable processing industry has been declared as a thrust area and is likely to take off in the near future as a potential earner of foreign exchange through export of processed fruits and vegetables (Kapoor 1993) The food industry can provide processed fruit products at reasonable and steady prices throughout the year meeting the requirements of defence forces in border area and earning foreign exchange for the country by development of exports (Shaw *et al* 1993) Fruit processing helps to imitigate the problems of underemployment during off season in agriculture sector (Poornia *et al* 1994) Over recent years there

has been an increase of interest in all industries of Mediterranean countries in the so called under utilized fruit crops (Llacer *et al* 1995)

Many underexploited fruits were considered as marginal crops in the past in many countries like Turkey Italy Egypt and Cyprus as reported by Aksoy (1995) Gregoriou (1995) Mansour (1995) and Monastra (1995) Because of the crisis within agriculture there is increasing interest in the commercial production of under utilized fruit crops (Romero *et al* 1995) It is necessary to improve marketing techniques and breeding stock for all of these under utilized crops (Mars *et al* 1995) There is increasing interest in developing production of some minor fruits but at the same time production of some minor fruits is declining due to limited domestic and international market (Blumenfeld (1995) Lionakis (1995) and Loudyi (1995)

Whilst the greatest growth potential exists for the major tropical fruits minor tropical fruits such as litchi carambola passion fruit and mangosteen are attracting considerable interest at the retail and consumer levels Factors influencing the demand for tropical fruit include the growth of market share in retail distribution by multiples consumer purchasing power product promotion consumer education and above all the increased availability of and access to well presented quality fruit (Proctor 1990) Stefano and Rotundo (1991) concluded that world apricot production could reach a rise of 25 per cent by the year 2000 which are seen to be most heavily involved in trade Maikhuri *et al* (1994) have recently made an attempt to utilize the wild fruits as a source of income particularly for poor rural inhabitants and unemployed youths of the region through making a variety of edible products such as jam jelly squash sauce etc Moura *et al* (2000) assessed for firmness size shape colour and weight and reported that cashew apple had all the best characteristics for fresh fruit market The combination of preharvest cultivation practices post harvest handling chain and cold chain are

emphasized so as to effectively reduce post harvest losses of litchi (Liang and Ping 2001)

Vaidehi *et al* (1977) pointed out that cultivation of new fruits and development of products from many of the notable fruits could bring benefit nutritionally and economically If the fresh and processed fruits are evenly marketed from the places of abundance to the place of scarcity not only will the consumers get the produce at a reasonable price but also the producer will not be forced to sell at throw away prices (Roy 2001) So there is an urgent need to exploit under utilized fruits

## 2 3 SIGNIFICANCE AND UTILIZATION OF UNDEREXPLOITED FRUITS

India has a wide range of indigenous tropical fruits that are under utilized A large number of these fruits are known for their medicinal and nutritive value and have excellent flavour and very attractive colour (Roy 2001)

The consumers today are trying to avoid chemicals and synthetic foods and choose therapy and nutrition through natural resources (Pal *et al* 1999) Bhattacharya *et al* (1999) studied about the antioxidant activity of active tannoid principles of amla The indigenous fruits of India have an important role to play in satisfying the demand for nutritious delicately flavoured and attractive natural foods of high therapeutic value (Roy 2001)

Some of indigenous fruits are not easy to eat out of hand Ripe bael fruit is not consumed freely because of eating difficulty but it may become popular if properly processed (Roy and Singh 1979a) Studies on processing and utilization of kumkaut conducted by Bawa and Saini (1988) revealed that the high acidity of the juice sweet nature of peel

and consumer acceptance of various products indicated the potentiality of kumkaut for processing Ranote *et al* (1993) reported that the physico chemical and sensory quality before and after thermal processing of kinnow juice highlighted the potential for its conversion into quality ready to serve beverage The recent trend in the export of horticultural produce is examined Among the aspects discussed are the major destinations of the export products the significant role and distinct features in horticultural product export and some of the horticultural produce with their prices in the world market Development of strategies for the three major activities (production post harvest handling and export promotion) of the horticultural sector is needed to meet the domestic and international demand (Jugale *et al* 2000)

Hasan and Chattopadhyay (1997) reported that fruit colour is an important quality trait for consumer preference in litchi He further concluded that litchi fruit peel have more than 70 TSS/ acidity ratio and more than 35 0 mg 100 $g^{1}$ anthocyanin which is highly useful for good quality and consumer appeal Pino *et al* (2000) identified 56 components in star fruit of which the major ones were butyl acetate ethyl decanoate and hexadecanoic acid According to Bulbulla and Ramcharan (2000) many underexploited species such as averrhoa annona syzygium that have so far adapted well to the high pH conditions and they further reported that these fruits have fruited in the growth of first year itself

Wild pomegranate fruits are a potential source of anardana (dried aril) This species may have commercial potential due to the abundance of wild fruits and the fact that it is well adapted to adverse soil conditions and could be grown on waste lands (Kher 1999) Amin *et al* (2000) identified the suitability of loquat fruits for fresh consumption and processing because they were larger in size less in an astringent taste have higher percentage of pulp rich in β carotene and have lower tannin and total sugar content Araujo and Minami (2001) selected averrhoa fruit for

processing which had good fruit size high acidity content and a low number of seeds Al Maiman and Ahmad (2002) added that the amounts of moisture sugar protein and ash were higher in pomegranate juice

According to Muthukrishnan and Palaniswamy (1972) west indian cherry is suitable for preparation of clarified juice squash jam jelly and pickle Khurdiya and Roy (1985) pointed out that jamun an indigenous fruit having an attractive colour and excellent taste can be profitably used for beverage industry He elicits that the juice of ripe fruits is used for the preparation of syrup and wine Amla is grown throughout the country and finds use in the manufacture of preserve pickle jam jelly squash chutney and various ayurvedic preparations (Jain *et al* 1986) Kadam *et al* (1992) reported that ber is processed for the production of ready to serve beverage (RTS) candy and wine

Different fruit powders with avocado banana and guava were standardised by Pruthi and Lal (1959) Passion fruit juice powder has been standardised by Pruthi (1960) Sadashivan and Neelakantan (1976) had reported that jackfruit can be utilised for making squash Amban (1987) observed that jack preserve was found to be an acceptable and appealing product Bose (1990) had pointed out that jackfruit bulbs can be utilized for making pickles fruit leather or thin pappad besides canning Jayaraman and Gupta (1991) standardized the preparation of dried papaya and jackfruit and they were found to be best in appearance flavour and texture A wide variety of products can be prepared utilizing underexploited fruits which include different types of beverages jams jellies preserves candies canned and dehydrated products (Eipeson and Bhowmik 1992)

## 2 4 IMPORTANT CHARACTERS OF BILIMBI ROSEAPPLE AND LOVI LOVI

### 2 4 1 Bilimbi

The bilimbi *Averrhoa bilimbi* L is closely allied to the carambola but quite different in appearance manner of fruiting flavour and uses The only strictly English names are Cucumber tree and Tree sorrel bestowed by the British in colonial times Bilimbi is the common name in India and is found throughout South Eastern Asia which is its region of origin (Le *et al* 1998) Chadha (2001) reported that bilimbi tree adapts better to heat grows well in humid tropical areas and cannot tolerate freezing temperatures

Bilimbi tree is cauliflorous with deep red bisexual flowers The inflorescence is cymose in nature From the emergence of the inflorescence 15 20 days are required for fruit set with a further 35 40 days required for fruit maturity The development of bilimbi fruit follows a linear pattern of growth for the important characters (length girth volume and weight) Babylatha *et al* 1993)

The bilimbi fruit is borne in clusters on older branches The fruit is ellipsoid or nearly cylindrical faintly five sided 4 10 cm long capped by a thin star shaped calyx at the stem end and tipped with five hair like floral remnants at the apex (Singh 1969) The fruit is crisp when unripe turns from bright green to yellowish green ivory or nearly white when ripe and falls to the ground Its pulp is green soft juicy and very sour with few seeds (Morton 1987)

The volatile constituents of bilimbi fruits were isolated by steam distillation and it includes hexadecanoic acid 2 furaldehyde and 9 octadecenoic acid Butyl nicotinate and hexyl nicotinate were the dominant esters (Wong and Wong 1995) Lima *et al* (2001) observed that

there were high quantities of total soluble solids and ascorbic acid and lowest amount of oxalic acid in riped fruits of bilimbi Physical and chemical characteristics such as fresh weight size percentage juice pH moisture content total soluble solids total titratable acidity vitamin C and minerals were evaluated by Teixeira *et al* (2001)

The bilimbi fruit is edible and can be made into pickles jams and preserves (Tajuddin and Prakash 1996)

Bilimbi fruit is said to have astringent stomachic refrigerant and antiscorbutic properties in traditional medical literature A syrup made by heating the juice of the ripe fruit with sugar and water on a slow fire is useful in relieving thirst febrile excitement and also in some cases of internal haemorrhoids The fruit in the form of curry is useful as a dietary supplement to treat piles and scurvy as reported by Morton (1987)

Gunasegaran (1992) reported that bilimbr fruit has a wide range of medicmal uses in India Pushparaj *et al* (2000) investigated that the ethanolic extract of bilimbi leaves has hypoglycaemic hypotriglyceridaemic anti lipid peroxidative and anti atherogenic properties

**2 4 2 Roseapple**

Roseapple is a member of the myrtle family myrtaceae and is technically known as *Syzygium jambos* It is sometimes called jambasier by French speaking people plum rose or malabar plum in the English speaking West Indies jaman in India and yambo in the Philippines (Morton 1987) The roseapple is native to the East Indies and Malaya and is cultivated and naturalized in many parts of India South East As a and the pacific islands (Martin *et al* 1998) The roseapple tree may be merely

a shrub but is generally a tree reaching 25 or even 40 ft in height and has a dense crown of slender wide spreading branches (Chadha 2001)

Roseapple fruit is nearly round oval or slightly pear shaped 4 5 cm long with smooth thin pale yellow or whitish skin sometimes pink blushed covering a crisp mealy dry to juicy layer of yellowish flesh sweet and resembling the scent of a rose in flavour (Singh 1969) In the hollow centre there are one to four brown medium hard more or less rounded seeds which loosen from the inner wall and rattle when the fruit is shaken (Popenoe 1974) Roseapples bruise quite easily and are highly perishable They must be freshly picked to be crisp (Morton 1987) He also reported that roseapple is more often used in jellies and jams or preserved in combination with other fruits of more pronounced flavour

According to Chattopadhyay and Ghosh (1992) roseapple is a fair source of iron They further observed high nitrogen concentration in roseapple fruit at 20 days after fruit set Forty three volatile constituents were identified by Wong (1996) in roseapple including 28 which have not been previously reported in this fruit He further stated that the volatile composition of roseapple was quite different from the volatiles of other syzygium fruits Fairly high ratios of sugar acidity and vitamin C content were further reported in roseapple fruit by Mandal (1997)

In India roseapple is regarded as a tonic for the brain and liver and an infusion of the fruit act as a diuretic (Popenoe 1974)

**2 4 3 Lovi lovi**

Lovi lovi (*Flacourtia* species) a minor fruit member of Kerala homesteads with very attractive berries belongs to the family Flacourtiaceae It is a small genus of shrubs or small trees distributed

throughout the warmer parts of Asia (CSIR 1956) About eight species are recorded in India many of them are yielding edible fruits (Hayes 1970)

Two species are found in Kerala *Flacourtia cataphracta* (sweet type) and *Flacourtia inermis* (sour type) *Flacourtia inermis* a Malayan species generally known as lovi lovi louvi or Tomi Tomi are small trees with shrub like stature and light green coloured leaves (Tajuddin and Prakash 1996) Fruits of *Flacourtia inermis* are sour and astringent They are rich in pectin and acid and are suitable for jams jellies syrups and preserves (Prasad 1998)

Saka and Msonthi (1994) analysed and found the highest sodium content in *Flacourtia indica* (589 $\mu g\ g^{1}$) George *et al* (1999) conducted studies on flowering and fruit development of *Flacourtia cataphracta* on 15 year old bearing trees in Kerala and revealed that flowering was earlier by two to three weeks in male than in female trees A total of 98 100 days was required from flower initiation to fruit harvest The fruits recorded the highest values for length circumference and weight 80 days after fruit set The shelf life of the fruits was low as the scarlet colour was lost within one hour of harvest and shrivelling was observed from the second day onwards

Fruits of *Flacourtia cataphracta* are ellipsoid in shape and are dark red or purple when ripe The fruit has a rather pleasant tart flavour The flesh is firm brownish green and fairly juicy The fruits are used for making marmalades jams or preserves (Prasad 1998)

Prasad (1998) analysed and reported that ripe fruits of lovi lovi has high quantities of TSS total sugars reducing sugar and non reducing sugar which will be highly useful for product development He further reported that the leaves and young shoots of lovi lovi are astringent and stomachic

## 2 5 PHYSICO CHEMICAL CHARACTERS OF OTHER IMPORTANT UNDEREXPLOITED FRUITS

Ogawa (1999) given the detailed study about the chemical constituents of many minor underexploited fruits which include hydrocarbons phenolic compounds alkaloids polysaccharides alcohols glycosides organic sulphur compounds volatile compounds flavonoids and terpenoids Aular *et al* (2000) conducted a study on physical and chemical characteristics of yellow passion fruit Rodriguez *et al* (2000) investigated the physical physicochemical and chemical changes during maturation of persimmon

Neog and Mohan (1991) observed that the fruits of carambola contained moisture (91 14%) TSS (8 0 $^{0}$brix) titratable acidity (0 57%) reducing sugar (6 25%)and total sugars (10 85%) Chattopadhyay and Ghosh (1996) observed that fruit size increased continuously throughout the growth phase in carambola fruit They further studied that mature fruits contained 3 10 per cent total sugar 0 64 per cent acidity and ascorbic acid concentration as 166 75 mg 100 g $^{1}$ Narain *et al* (2001) observed that the carambola fruit was oblong in shape with an average length of 7 92 cm and width of 5 24 cm

Visentainer *et al* (1997) analysed the composition of pulp of acerola which includes ascorbic acid moisture protein carbohydrate fibre lipids calcium lead iron sodium and zinc Semensato (2000) and Vendramini (2000) studied about the chemical composition and volatile components of acerola which shows good source of vitamin C soluble solids and sugars

Venkitakrishnan *et al* (1997) observed that in jambolan fruit starch and non reducing sugar level declined whereas the total soluble sugar content increased with increase in reducing sugar Anthocyanin

content of litchi fruit was negatively correlated with pH titratable acidity and TSS content of fruit pulp (Bhattacharjee *et al* 2001) Shanker *et al* (1999) and Chaubey (2001) studied about the physical changes such as weight volume colour and specific gravity of the litchi fruit

Jaiswal (1997) studied about the physical characteristics chemical constituents and organoleptic quality of bael fruit Kaushik and Yamdagni (1999) analysed for protein fibre pectin phenol and carotenoid contents in bael fruit during growth and development Singh *et al* (2000) revealed that significant variation in fruit characters namely shape size weight volume and rind thickness were recorded among bael cultivars

Ghosh and Chattopadhyay (1993) analysed that the loquat fruit contains fruit weight of 10 28g pulp thickness of 1 02 cm specific gravity of 0 85 TSS content of 6 9 $^{0}$brix and ascorbic acid concentration of 3 93 mg 100 g $^{1}$ edible pulp The proximate composition of the peel pulp and core of bread fruits revealed that the highest moisture ash protein fat and fibre contents occurred in the core while the pulp had the highest contents of carbohydrate starch and organic matter (Adewusi *et al* 1995) Supe *et al* (1997) studied about the physico chemical analysis of different aonla cultivars Arce *et al* (2000) observed that total soluble content was 10 12 per cent acidity was 0 15 0 20 per cent and total sugars was 3 4 5 per cent in sapote mamey fruit

Fadhl *et al* (1999) reported about the chemical analysis of shabowa dates which includes reducing sugar between 13 30 64 10 per cent and protein between 3 70 11 37 per cent and contains sodium potassium calcium iron and copper in a significant manner Matsuura *et al* (2001) analysed the physico chemical characteristics of barbados cherry and reported that this minor fruit has high vitamin C content Al Maiman and Ahmad (2002) studied about the physico chemical characteristics of

pomegranate and reported that edible portion of pomegranate comprised 63 58 per cent of juice and 36 21 per cent of seeds

Onal and Cinsoy (1998) evaluated some characteristics of apricot such as fruit weight flesh firmness taste aroma and soluble solid content Kundu *et al* (2001) observed that jamun fruit showed high characteristics for yield fruit size weight and high amount of total soluble solids reducing sugar and total sugar

## 2 6 PRODUCT DEVELOPMENT FROM UNDEREXPLOITED FRUITS

Highly acceptable nutritious products could be developed utilizing underexploited fruits Subhadra *et al* (1965) found out that wood apple could be preserved by converting it into RTS beverage Khurdiya and Roy (1985) developed an acceptable quality RTS beverage from jamun RTS beverage from phalsa fruit was formulated and standardised by Wasker *et al* (1991) Ranote *et al* (1992) studied the suitability of kinnow fruit for conversion into RTS beverage

Nanjundaswamy *et al* (1964) opined that plain guava juice required dilution with sugar syrup to make it a highly acceptable beverage Studies by Muthukrishnan and Palaniswamy (1972) revealed the suitability of west indian cherry for the preparation of clarified juice and squash Roy and Singh (1979b) noticed that by adjusting the amount of pulp brix and acidity good quality nectar and squash could be prepared from bael fruit Tripathi *et al* (1988) developed a recipe for amla juice which was found organoleptically acceptable The juice from ripe fruits of rangpur limes was found to yield good quality squashes and cordial as reported by Krishnamurthy *et al* (1990) Investigations undertaken of Wasker *et al* (1991) ended in the preparation of acceptable quality nectar and squash from phalsa fruit Grewal and Saini (1992) reported that heat treated fruit juice concentrates made from pear juice had higher acceptability

According to Singh (1963) ripe fruits of bael are used for the preparation of sharbet a cooling and refreshing drink Kumar (1990) reported that litchi juices and squashes were considered as a delicacy Passion fruit is used for the preparation of nectar squash and carbonated drinks (Khurdiya 1994) According to Parvathi *et al* (1998) in their studies products such as squash cordial RTS and milk shake were prepared from west indian cherry Mitra and Dwivedi (2000) observed that litchi was suitable for preparing squash

Indigenous fruits like phalsa jamun and kokum can be exploited for beverages and concentrates and can serve as good items for export (Chadha 1994) Prasad and Banker (1999) investigated and given the recipe for the preparation of squash from pomegranate juice Ali and Rab (2000) reported that phalsa produces a highly nutritious juice which is converted to a powder through spray drying

Jamun was used in the preparation of wine in a study reported by Khurdiya and Roy (1984) Studies conducted by Adsule *et al* (1992) to prepare an acceptable quality fermented beverage from ber fruits revealed that wine from ber juice was comparable to that from grape juice except slight astringent taste Zavratnik and Hribar (1996) noted the biochemical changes following fermentation in fruit brandy from persimmon

Muthukrishnan and Palaniswami (1972) reported that west indian cherry was suitable for the preparation of jam jelly and pickle Studies by Roy and Singh (1979b) revealed the possibility of preparing good quality fruit slab toffee and fruit powder from bael fruit by adjusting the amount of pulp brix and acidity Studies on pear candy processing by Rani and Bhatia (1985) resulted in products which elicited high consumer acceptability Kumar (1985) studied that probability of utilizing peel from watermelon for pickle making and found that the pickle made with the

outer green skin had little astringency in taste while the one without outer skin was of better taste

Yousif and Alghamdi (1999) revealed the possibility of processing date into good quality jelly Yousif and Humeid (2000) studied about the optimum processing conditions for jam and jelly made from dates and showed that fruit preparation and degree of ripening affected significantly the quality attributes of the produced jam and he further indicated that there was no need to add pectin to have an acceptable jam texture The suitability of some date cultivars for candy making was studied by Yousif (2001) Alkathiri and Madhi (2001) experimented syrup production from dates and raisins and indicated the possibility of using cheap and low grade raisin for producing syrup

Monzini and Gorini (1991) reported that apricots can be dried or canned or it can be processed for making preserves Man and Sanny (1997) studied the suitability of making leather from jackfruit Nath and Sharma (1998) evaluated aonla fruits for processing into different products such as nectar squash jam candy and pickle According to Artes and Barberan (2000) pomegranate was suitable for making jam marmalade jellies etc

Fresh fruits of aonla are commonly used for making murabba pickles jelly etc (Ram 1975) According to Khurdiya and Singh (1975) ber fruits can be used for the preparation of murabba candy pickle chutney etc Similar products were prepared by Jawanda and Bal (1978) and Srivastava (1978) from ber fruits Dube and Pandey (1978) in their studies reported that bael can be used for preparing leather pulp powder jam and toffee

According to Chadha(1990) and Ram (1990) in their studies on aonla indicated that it can be made into preserves chutney candy dried

chips jelly pickle and powder Karonda are used for making pickles chutney pudding and jelly (Misra and Jaiswal 1990) According to Lavania (1990) jackfruit are used for preparation of pickles dehydrated leather and thin papad Aonla fruits can be processed into preserve candy shred syrup jam and pickle at larger scale to make it available round the year (Nath 1999) Saima (2002) also prepared preserve jelly candy tutifruiti and squash from amla

According to Schirra (1997) products like almond paste almond milk almond butter and almond oil were prepared from almond Apricots were used to produce purees dried fruit pulp and in confectionery (Crivelli 1997) According to Ustun *et al* (1997) persimmons are suitable for preparing jams and marmalade Similar studies were reported by Ustun *et al* (1998) Amin *et al* (2000) reported that loquat fruits are suitable for preparing jams and candies The acerola can be processed easily into jelly puree confectionery and sauces (Mezquita and vigoa 2000)

## 2 7 EFFECT OF STORAGE ON PRODUCT QUALITY

The quality parameters generally selected to ascertain its suitability for public use and to study the effect of processing methods are chemical tests like pH acidity TSS and total sugar physical tests sensory evaluation and microbial tests

### 2 7 1 Chemical and Shelf Life Qualities

Chemical analysis of Jackfruit squash by Sadashivan and Neelakantan (1976) showed that the pH did not change during storage Khurdiya and Anand (1981) noted that the pH remained stable in the RTS beverage from phalsa fruits during storage Chemical changes related to storage were studied by Tripathi *et al* (1988) in amla jam and dehydrated

products The study indicated no change in pH Yang and Wang (1994) reported that during storage of carambola juice the pH did not change significantly The pH remained constant during storage of sand pear juice concentrate as reported by Saini and Grewal (1995)

The Kinnow RTS stored showed negligible changes in pH when evaluated for quality (Ranote *et al* 1992) Canned peach and apricot pulp stored well over 24 weeks produced negligible changes in pH (Shah and Bains 1992) Negligible to slight changes in pH was reported by Ranote *et al* (1993) in kinnow juice during storage Krishnaveni *et al* (2001) reported that there was a decreasing trend in pH during storage of jackfruit RTS beverage

Analysis of Guava pulp stored over a period of 45 days showed an increase in acidity during storage (Kalra and Revath 1981) Analysis of citrus juice stored over a period of eight months at room temperature showed an increase of 37 25 per cent total acidity (Mehta and Bajaj 1983) Similar finding was reported in stored litchi juice by Sethi (1985) Studies conducted in amla juice by Tripathi *et al* (1988) exhibited an increase of 0 86 per cent in acidity during storage Studies conducted by Thirumaran and Seralathan (1990) had noticed similar increase in acidity in tomato juice concentrate Analysis of pomegranate juice showed an increase in acidity during storage (Kahtani 1990) Krishnaveni *et al* (2001) reported that there was an increasing trend in acidity during storage of jackfruit RTS beverage

Analysis of kinnow juice over a period of storage of six months indicated negligible change in acidity (Ranote *et al* 1993) Saini and Baini (1994) reported that during storage of watermelon juice there was no change in the acidity of the product

Sandhu *et al* (1983) noticed a reduction in acidity of kinnow mandarin irrespective of the temperature during three months storage Sandhu *et al* (1985) also observed a reduction in acidity of orange juice concentrate at all storage temperatures

Guava pulp stored at different temperature showed an increase in TSS content within 45 days of storage (Kalra and Revath 1981) According to Mehta and Bajaj (1983) there was an increase in TSS during storage of kiwi squash There was a gradual increase in the TSS during the entire period of storage in bael Squash (Jain *et al* 1984) According to Wasker and Khurdiya (1987) there was an increase in TSS during storage in phalsa squash Storage studies in litchi squash indicated a pattern of progressive increase in TSS content during storage (Jain *et al* 1988)

According to Rani and Bhatia (1985) in their studies there was a gradual increase in TSS in candy during storage Sethi(1985) reported that TSS got increased in litchi juice during storage Amla jam and preserve exhibited a rise in TSS content during storage (Tripathi *et al* 1988) When pyrus juice was prepared into concentrate TSS of the juice increased with evaporation of water from the product (Grewal and Saini 1992) According to Khurdiya and Lotha (1994) TSS of kinnow mandarin juice increased on storage Prasad and Mali (2000) reported that the total soluble solids increased with increased period of storage in pomegranate squash

According to Jain *et al* (1984) there was a gradual increase in the reducing and total sugars during the entire period of storage in bael squash Rani and Bhatia (1985) in their studies reported that there was an increase in reducing sugar content in candy during storage Sethi (1985) reported that reducing sugar content increased in litchi juice during

storage An increasing trend in reducing sugar was observed in litchi squash during storage (Jain *et al* 1986)

According to Wasker and Khurdiya (1987) in their studies reported that in phalsa squash the reducing and total sugar content increased on storage Storage studies in litchi squash indicated an increase in reducing and total sugar content during storage (Jain *et al* 1988) Reducing and total sugars continued to increase during storage in amla jam and preserve (Tripathi *et al* 1988) According to Khurdiya and Lotha (1994) reducing and total sugar in kinnow mandarin juice increased on storage Yang and Wang (1994) reported that during storage of carambola juice there was an increase in reducing sugar content Similar report was given by Pimentel *et al* (2001) during storage of acerola juice Krishnaveni *et al* (2001) reported that there was an increasing trend in reducing sugar during storage of jackfruit RTS beverage

Geetha and Shivaleela (1982) reported that maximum loss of ascorbic acid occurred in products subjected to continuous boiling steaming etc Sandhu *et al* (1983) reported that the rate of loss of ascorbic acid in kinnow orange juice and concentrate was directly proportional to storage temperature Storage studies of kinnow mandarin juice by Ranote *et al* (1992) indicated that the loss of ascorbic acid was rapid at the initial period of storage but slowed down after six weeks of storage at room temperature Saini and Grewal (1995) reported that loss of ascorbic acid was more pronounced during concentration of unbalanced pear juice (60 7%) than that of blanched pear juice (49 3%)

Sethi *et al* (1980) found that kinnow orange juice preserved by canning bottling and stored for nine months at room temperature had an ascorbic acid content of 17 64 3 53 mg/100ml respectively Studies conducted by Ranote *et al* (1992) indicated that the retention of ascorbic acid was better in $SO_2$ preserved juice than heat processed bottled juice

Mehta and Bajaj (1983) noticed that comparatively lower losses were observed in juice samples preserved with potassium metabisulphite (KMS) than those preserved by pasteurisation and sodium benzoate Thirumaran and Seralathan (1990) reported that the decrease in ascorbic acid was 28 73 per cent in tomato concentrate stored in glass bottles for a period of four months Agarwal *et al* (1995) noticed that the ascorbic acid decreased significantly during the six months storage of tomato concentrate Pimentel *et al* (2001) reported that dur ng storage of acerola juice there was a decrease in ascorbic acid content There was a decreasing trend in ascorbic acid content during storage of jackfruit RTS beverage (Krishnaveni 2001)

**2 7 2 Organoleptic Qualities and Acceptability**

According to Herrington (1991) sensory evaluation technology is a method using skilled management and trained panellists to provide confirmation on the acceptability of the product in terms of product profile consumer acceptability and consistency

According to Sethi (1987) canned litchi pulp was found to be acceptable organoleptically for six months which was stored at room temperature Organoleptic evaluation of stored amla jam indicated an increase in acceptability with storage (Tripathi *et al* 1988) Bhatnagar (1991) reported that keeping quality of watermelon jam was reasonably good under ambient storage conditions for a period of six months According to Shah and Bains (1992) canned peach and apricot pulp was found to be acceptable organoleptically for 24 weeks The organoleptic evaluation of tuti fruiti made from ber indicated that the products were highly acceptable and overall organoleptic score of ber tutifruiti was better than papaya tutifruiti due to its superiority in flavour and taste (Chavan *et al* 1993)

Sethi (1985) has reported that pulp from litchi fruit was found acceptable for six months at room temperature and upto twelve months at low temperature Angela *et al* (1987) reported that dehydrated blue berry products had a good texture flavour and overall acceptability and had a shelf life of 16 64 months Squashes prepared from apricot pulp were found to be acceptable upto eight months as reported by Manan *et al* (1992) Pal (1995) reported that passion fruit RTS was acceptable during its five weeks of storage Majeed (1995) reported the organoleptic stability of karonda products during its eight months of storage period Prasad and Mali (2000) revealed that during storage pomegranate squash was organoleptically acceptable for a period of 3 4 months at room temperature Krishnaveni *et al* (2001) reported that jackfruit RTS beverage was highly acceptable even after storing for six months at room temperature

Organoleptic evaluation of amla candy and dehydrated amla showed that the acceptability decreased with storage (Tripathi *et al* 1988) Changes in sensory characteristics of mango bars during 90 days of storage at different temperature were studied by Mir and Nath (1993) The study indicated that storage decreased overall acceptability and colour

According to Vaidehi *et al* (1977) it is important that a new product is acceptable or not is investigated before introduction to open market

**2 7 3 Microbial Aspect**

Microbiological analysis and chemical composition had been performed for each date product namely date juice date powder and date flakes Additives such as citric acid sodium benzoate or potassium metabisulphite improved the colour of the product and decreased the count of microflora during the processing of the products (Ali 2000)

All of the processed products from date fruits were free from aerobes except for the pickle in oil and chutney samples which had very low total plate counts No moulds coliforms or members of the entero bacteriaceae were detected in any of the products (Sidhu *et al* 1996) Aidoo *et al* (1996) revealed that microbial contamination was measured in prepacked dates and potentially pathogenic bacteria along with lactic acid bacteria yeast and aspergillus was identified and it is suggested that this was due to high moisture content

Shoenfield and Margalith (1962) isolated Bacillus group especially *B lichaniformis* which caused gaseous spoilage in cans of tomato puree Fields *et al* (1977) also isolated the same bacteria from home canned tomatoes Analysis of the spoiled samples of tomato concentrate by Sethi (1994) indicated that spoilage was either by yeast or aspergillus

Bhatnager (1991) found that there was no activity of micro organisms upto six months of storage of watermelon jam Kadam *et al* (1992) observed complete absence of micro organisms in pomegranate wine during storage period of eight months Majeed (1995) reported that there was complete absence of micro organisms in Karonda candy jelly canned karonda and wine during storage Oommen (1995) reported that osmotically dehydrated jackfruit products of soft and firm flesh varieties had a stability of five months

Sethi and Anand (1984) studied the market samples of amla preserve and reported that the micro organisms associated with contamination of preserve are saacharomyces and poly morphus Allien *et al* (1986) reported that spore forming bacilli is the most prevalent one among the bacillus species identified in fruit products

# Materials and Methods

# 3 MATERIALS AND METHODS

The present study entitled Utilization of selected underexploited fruits for product development was undertaken to investigate the suitability of locally grown underexploited fruits for development of various processed products The fruits selected for the study include bilimbi *(Averrhoea bilimbi)* rose apple *(Syzygium jambos* L ) (2 types) and lovi lovi (*Flacourtia cataphracta Flacourtia inermis)* The chemical nutritional organoleptic and shelf life qualities of the fruits as well as products were assessed

## 3 1 SELECTION OF THE FRUIT FOR STUDY

Among the various underexploited fruits bilimbi roseapple and lovi lovi were selected for the study and required quantities of the fruits were collected from the orchard of the college of Horticulture Vellanikkara and from the nearby homesteads

## 3 2 PHYSICO CHEMICAL CHARACTERISTICS OF THE FRUITS

Physico chemical characteristics of the underexploited fruits were studied using visual and standard chemical procedures

### 3 2 1 Physical Characters

Fruit colour pulp colour number of fruits per 100 g firmness and biting qualities were studied

### 3 2 2 Chemical Characters

#### *3 2 2 1 Moisture*

Moisture content was determined by using a method suggested by AOAC (1980)

*3 2 2 2 Fibre*

Fibre content of the samples was estimated by acid alkali digestion method as suggested by Sadasivam and Manikam (1992)

*3 2 2 3 Protein*

The nitrogen content was estimated using the method suggested by Snell and Snell (1967)

*3 2 2 4 Starch*

The starch content was analysed colorimetrically using anthrone reagent as suggested by Sadasivam and Manikam (1992)

*3 2 2 5 Calcium*

The calcium content was estimated by titration using EDTA method suggested by Hesse (1971)

*3 2 2 6 Phosphorus*

The phosphorus content was analysed colorimetrically after preparing a diacid extract by vanedomolybedate yellow colour method using spectrophotometer (Jackson 1973)

*3 2 2 7 Iron*

The iron content was analysed colorimetrically by a method suggested by Ranganna (1986)

*3 2 2 8 Potassium*

The potassium content was estimated by using Flame Photometric method suggested by Jackson (1973)

*3 2 2 9 β-Carotene*

β Carotene content was estimated by the method suggested by Ranganna (1986) using saturated n butanol

*3 2 2 10 Vitamin C*

The vitamin C content of the fresh sample was estimated by the method suggested by Ranganna (1986) using 2 6 dichlorophenol indophenol dye

*3 2 2 11 Total Soluble Solids (TSS)*

Total soluble solids of fresh samples was measured by using a ERMA hand refractometer and expressed as $^{0}$brix

*3 2 2 12 Acidity*

Acidity was estimated by the method suggested by Ranganna (1986)

*3 2 2 13 Total Sugar*

Total sugar was estimated by the method suggested by Ranganna (1986)

*3 2 2 14 Reducing Sugar*

Reducing sugar was estimated by the method suggested by Ranganna (1986)

*3 2 2 15 Non reducing sugar*

The difference between the total sugar and reducing sugar was calculated and expressed as percent of non reducing sugar

## 3 3 SENSORY EVALUATION OF FRUITS

Sensory evaluation of the selected underexploited fruits was conducted at the laboratory level by using the scoring method as suggested by Swaminathan (1974) The major sensory attributes included in the score card were appearance colour flavour texture and taste The scores assigned for each attribute ranged from one to five viz excellent (5) good (4) fair (3) poor (2) and very poor (1) Scores for overall acceptability was obtained by determining the average mean scores for each character The score card for organoleptic evaluation of fruits are given in Appendix III

## 3 4 SELECTION OF THE PRODUCTS PROPOSED

Products selected for development in the present study are

a) Bilimbi jam
b) Bilimbi pickle
c) Roseapple squash (rose type)
d) Roseapple squash (white type)
e) Lovi lovi preserve in sugar (sweet type)
f) Lovi lovi in brine (sour type)

The quantity of ingredients taken for the preparation of products are given in Appendix II

## 3 5 PREPARATION OF THE PRODUCTS

### 3 5 1 Preparation of Bilimbi Jam

The steps followed in the preparation of bilimbi jam are as follows

#### *3 5 1 1 Selection of Fruit*

Fully ripe bilimbi fruits having good colour flavour and aroma were selected Unripe immature or over ripe fruits were not used for this purpose The fruits were thoroughly washed in fresh water and the bruised and blemished portions were removed

#### *3 5 1 2 Preparation of Fruit Pulp*

The bilimbi fruits were pulped by using a mixer

#### *3 5 1 3 Addition of Sugar*

To the sour pulp an equal quantity of sugar by weight was added

#### *3 5 1 4 Mixing*

The ingredients were thoroughly mixed and the mixture was allowed to stand for half to one hour in order to dissolve the sugar in the juice released from the fruit

#### *3 5 1 5 Cooking*

The mixture was cooked slowly with occasional stirring and crushing until the cooking mass approached the desired consistency In order

to get desired consistency pectin was added at the rate of 2g per kg of the fruit Sodium benzoate was added at the rate of 200 PPM When the mass had reached the desired thick consistency a spoon was dipped into it and the product was allowed to fall off through the sides of the spoon After cooling if the product falls off in the form of a sheet instead of flowing readily in a single stream it means that the end point had been reached and the product was ready for filling into the containers Otherwise boiling should be continued until the sheet test attained the satisfactory level

### *3 5 1 6 Filling and Closing*

The hot jam was poured into clean dry jar placed on an insulating material like a wooden board or a thick pad of cloth (for preventing the breakage in the case of glass jars) The screw cap was kept in an inverted position until the setting of the jam The cap was then wiped and closed tightly

### *3 5 1 7 Storage*

The containers were stored in a cool and dry place

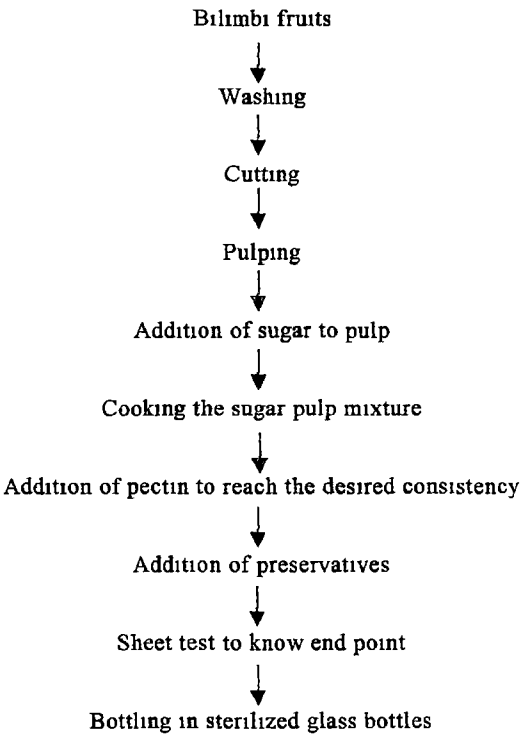


Fig 1 Flowchart for the preparation of Bilimbi jam

### 3 5 2 Preparation of Bilimbi Pickle

The steps followed in the preparation of bilimbi pickle are as follows

#### *3 5 2 1 Selection of Fruit*

The immature tender bilimbi fruits without blemishes and injury were selected The selected fruits were washed thoroughly in running cold water to remove the adhering dirt and other extraneous matter

#### *3 5 2 2 Cutting and Salting*

The fruits were cut into small pieces and 250 g of salt per kg of the fruit was added It was thoroughly mixed

#### *3 5 2 3 Heating*

The asafeotida and fenugreek seeds were roasted powdered and heated with mustard seeds in oil When the mustard seeds starts spluttering the curry leaves were added

#### *3 5 2 4 Mixing*

After spluttering of mustard seeds and addition of curry leaves it was taken off from fire and then masala powder (turmeric powder and chilli powder) was mixed

#### *3 5 2 5 Cooling*

The prepared mixture was cooled and then salted bilimbi fruits were added into the mixture Sodium benzoate was added at the rate of 250

ppm the finished product in order to preserve the product for long shelf life

### *3 5 2 6 Bottling*

The prepared bilimbi pickle was filled in sterilized glass bottles and stored in cool dry place

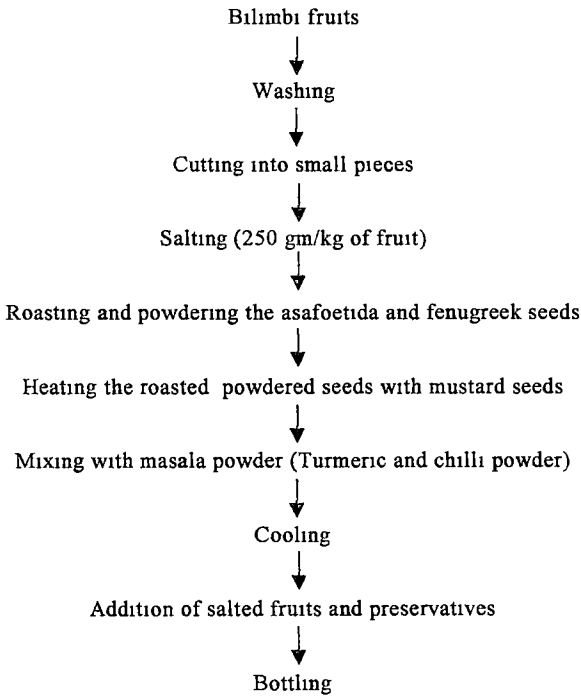


Fig 2 Flowchart for the preparation of bilimbi pickle

### 3 5 3 Preparation of Roseapple Squash (Rose and White Type)

The steps followed in the preparation of roseapple squash are as follows

#### *3 5 3 1 Selection of Fruit*

Fully ripe roseapple fruits without blemishes and injury were used The fruits were washed thoroughly in running water to remove the adhering dirt and other extraneous matter and was drained

#### *3 5 3 2 Extraction of Juice*

Roseapple fruits were cut into two halves with a stainless steel knife to remove seeds For extracting the juice the fruit was crushed thoroughly with a mixer and the juice was strained through muslin cloth to remove coarse pulp

#### *3 5 3 3 Syrup Preparation*

Syrup was prepared by heating the mixture of water and sugar in the ratio 1 2 The syrup prepared was then strained through coarse muslin cloth Five gm of citric acid was added per kg of fruit juice taken for the preparation of roseapple squash

#### *3 5 3 4 Mixing*

After the syrup was cooled the mixing of the roseapple juice with syrup was done The ratio maintained for juice water sugar was 1 1 2 Potassium metabisulphite was added at the rate of 350 ppm of the finished product The potassium metabisulphite was dissolved in small quantity of water and mixed it with the rest of the product

### *3 5 3 5 Bottling*

The prepared roseapple squash was filled in glass bottles that were thoroughly sterilized leaving five cm headspace and was sealed using a cap sealing machine

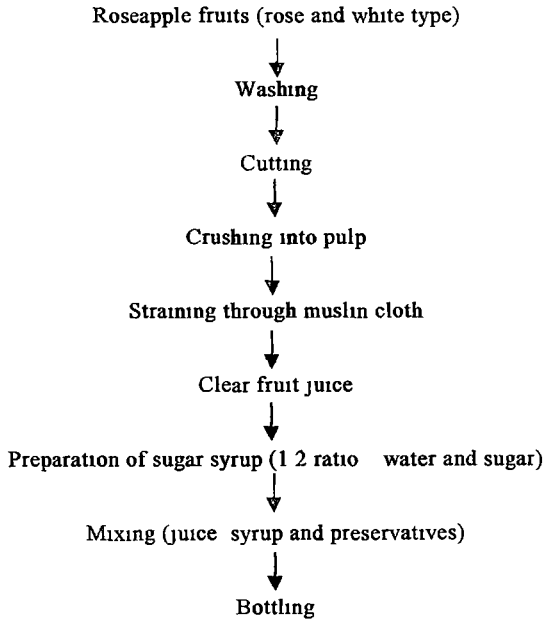


Fig 3 Flowchart for the preparation of roseapple squash (rose and white type)

### 3 5 4 Preparation of Lovi lovi Preserve in Sugar

The steps followed in the preparation of lovi lovi preserve in sugar are as follows

#### *3 5 4 1 Selection of the fruit*

Ripe and firm fruits were washed with ample quantity of fresh water

#### *3 5 4 2 Processing of the fruit*

The washed fruits were pricked with stainless steel forks After pricking the fruit pieces were immersed in dilute lime water for some time before further processing The fruits were blanched for a few minutes in boiling water to make them soft which assisted in absorption of sugar Sugar was added equal to or half the weight of fruits Sugar was spreaded on the blanched fruits in alternate layers Allowed to stand for 24 hours The juice exuding out of the fruits dissolved the sugar Next day the syrup was drained and enough sugar was added to raise the thickness of syrup (60 $^{0}$brix) Sodium benzoate was added at the rate of 200 ppm of the final product Now the fruit was added boiled and kept for 24 hours On the next day the syrup strength was raised by adding the required quantity of sugar so that when drawn between the fingers the syrup gives two to three threads (69 $^{o}$brix) Boiled the mass again for five minutes Left the fruit in the syrup for 3 4 days Boiled the fruit along with the syrup for a few minutes and filled hot into dry wide mouthed jars and air tightly sealed

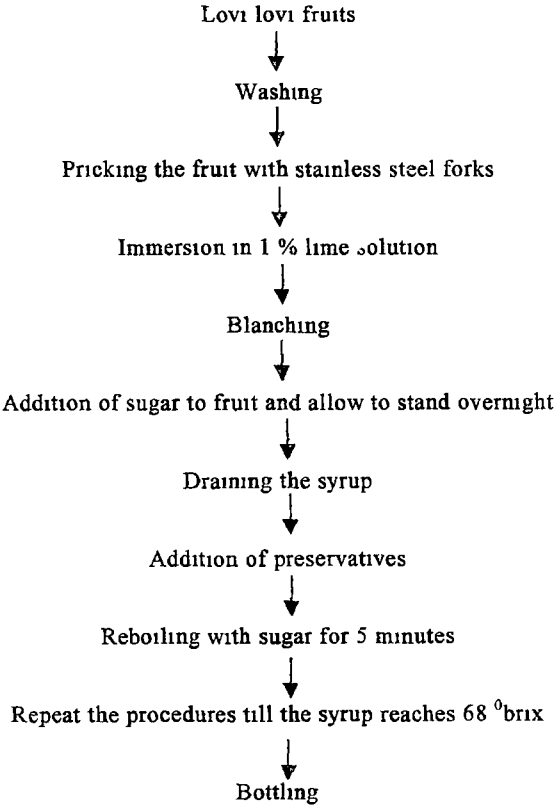


Fig 4 Flowchart for the preparation of lovi lovi preserve in sugar

### 3 5 5 Preparation of Lovi lovi in Brine

The steps followed in the preparation of brine are as follows

#### *3 5 5 1 Selection of Fruit*

Sound and matured lovi lovi fruits were selected and washed with fresh water to make free of impurities The inedible and damaged portions were removed

#### *3 5 5 2 Fruit Preparation and Blanching*

The prepared fruit was wrapped in a piece of muslin cloth and dipped in boiling water for 2 5 minutes The time of blanching depends upon the type of fruit and its maturity Blanching was done to inactivate the enzymes to drive out the air from the tissues etc The muslin cloth was removed and the prepared fruits were immediately dipped in cold water Usually 12 per cent brine was used It was prepared by dissolving 12 g common salt in about 100ml of water and filtered it

#### *3 5 5 3 Filling and Brining*

The blanched fruits were filled into glass jars The inter space was filled in the jar with 12 per cent clear brine leaving a head space of 0 6 1 cm

#### *3 5 5 4 Sealing*

After packing into a clear glass jars it was sealed air tight and stored in a cool dry place

## 3 6 ORGANOLEPTIC QUALITY AND ACCEPTABILITY OF PRODUCTS DEVELOPED

Quality is the ultimate criterion of the desirability of any food product to the consumer Products prepared were assessed for the organoleptic qualities on the basis of various quality attributes For the conduct of sensory evaluation the panel members for sensory analysis at the laboratory level were selected from a group of students These judges were selected through triangle test as suggested by Jellinek (1985) The procedure and evaluation card for triangle test were given in Appendix I

Small highly sensitive panels would usually give more reliable results than large less sensitive groups Thus 10 members were selected as judges for the acceptability trial (Swaminathan 1974)

The sensory analysis of panel members were done using the scoring method Scoring test was used for quality evaluation as suggested by Swaminathan (1974) The products prepared were kept in clear plates so that the judges could see the colour and appearance very clearly Water was given for rinsing the mouth for removal of any aftertaste carried over from sample to sample Judges were permitted to take enough time to score the samples leisurely The score card for organoleptic evaluation of fruit products are given in Appendix IV

## 3 7 ANALYTICAL OBSERVATIONS MADE ON DEVELOPED PRODUCTS

### 3 7 1 Assessment of Chemical Constituents in the Products

By the next day after completing the process of preparation of products the products were analysed for acidity vitamin C TSS total sugar reducing and non reducing sugar by following the same procedure as done for assessment of chemical constituents of fruits All the samples were drawn randomly in required quantities for monthly analysis The sampling procedure are given below

*3 7 1 1 Liquid Sample*

From liquid sample like squash 5 or 10 ml of the sample was taken for analysis

*3 7 1 2 Solid Sample*

From solid sample like jam pickle preserve and brine 5 or 10 g of the sample was weighed and taken for analysis

**3 7 2 Assessment of Ensurance of FPO Requirement in the Products**

Food standards are made to ensure the quality and safety of natural and processed food for human consumption (Swaminathan 1974) According to Ranganna (1977) as the consumer is unable to judge them easily he is protected by stringent government controls in the shape of food laws The standards are meant to provide a uniform and consistently good quality of food products to the consumers

Fruit product order has specified certain standards for fruit products (Siddappa 1967) Specifications are indicated for squash pickle jam preserve and brine The products developed were tested for confirmity to FPO standards

**3 7 3 Assessment of Cost Analysis of the Products**

Cost analysis was carried out based on the prices of different items during the time of preparation of the product The cost analysis of the products was worked out to assess the extent of expense arised to obtain six different products from selected fruits viz bilimbi roseapple (rose and white type) and lovi lovi (sweet and sour type) Prices of many fruits exhibit fairly

regular seasonal variations although at times the seasonal patterns may be obscured by other factors Hence cost analysis is utmost importance in product development

The cost was worked out based on the prices of various commodities needed for the preparation of different products such as cost of fruit sugar chemicals bottles and overhead charges Since the cost varies from product to product it was necessary to find out the actual cost of individual product

### 3 7 4 Fruit Product Yield Ratio

Yield of finished product from a specific unit of raw ingredient is a necessary information to people involved in the production of fruit products Fruit product yield ratio was calculated by taking into account the quantity of fruit used and the final produce obtained This ratio is dependent upon its juice recovery and it also gives us an idea of the amount of fruit that goes as waste which helps us to ascertain the profit ratio Obtaining such information of these commodities is especially challenging because they widely fluctuate in different products and fruits (How 1990)

## 3 8 CONDUCT OF STORAGE STUDY FOR ASSESSMENT OF SHELF LIFE QUALITIES

The shelf life qualities of the six products were ascertained based on the shelf stability changes in the chemical and organoleptic qualities and occurrence of microbial infestation in the product

### 3 8 1 Storage of the Products

Products were stored in ambient conditions as detailed below in Table 1

Table 1 Details of samples kept for storage studies

| Nature of samples | Unit capacity | Quantity stored |
|---|---|---|
| Bilimbi jam | 250 ml | 12 bottles |
| Bilimbi pickle | 250 ml | 12 bottles |
| Roseapple squash (rose) | 200 ml | 12 bottles |
| Roseapple squash (white) | 200 ml | 12 bottles |
| Lovi lovi preserve in sugar | 250 ml | 12 bottles |
| Lovi lovi in brine | 250 ml | 12 bottles |

The different products stored at ambient conditions were assessed at monthly intervals for a period of six months to study the shelf life behaviour of the above products prepared with above fruits The parameters selected to monitor the shelf life qualities of various products are chemical microbial and organoleptic qualities during storage

### 3 8 2 Assessment of Changes in the Chemical Qualities

Monthly analysis was done for assessing the changes that occurred in the chemical qualities of the products under study during storage Changes in the constituents viz acidity TSS vitamin C total sugar reducing and non reducing sugar were ascertained during storage

### 3 8 3 Assessment of Changes in the Organoleptic Qualities

Organoleptic quality is of great importance in the acceptability of any product Changes in the organoleptic qualities of products were ascertained through the panel of judges These tests were conducted at monthly intervals for a period of six months since any deterioration in the products could be identified as and when it occurred

### 3 8 4 Assessment of Microbial Contamination

The products stored were assessed for any occurrence of microbial contamination during storage Nutrient Agar and Martin s Rose Bengal were used as media for the detection of bacteria and fungi respectively using standard plate count method (Martin 1950) The media prepared for microbial count were given in Appendix V These tests were conducted at first third and sixth month after product development

## 3 9 STATISTICAL ANALYSIS OF THE DATA

The observations recorded were tabulated and analysed statistically using Completely Randomized Design (CRD) as prepared by Panse and Sukhatme (1985) The significant difference between the treatments was assessed using the critical difference (CD) at five per cent level

The scores of organoleptic evaluation were analysed by Kruskal Wallace Analysis of Variance Statistically kendals coefficient of concordance (w) which expresses the degree of association among the 10 judges was worked out for each character under study

# Results

# 4 RESULTS

Results of the study entitled Utilization of selected underexploited fruits for product development are preser ted and discussed under the following headings

4 1 Physico chemical characteristics of bilimbi roseapple and lovi lovi

4 2 Sensory evaluation of selected underexploited fruits

4 3 Indepth studies on selected minor fruit products

4 4 Assessment of shelf life

## 4 1 PHYSICO CHEMICAL CHARACTERISTICS OF BILIMBI ROSEAPPLE AND LOVI LOVI

The results on physico chemical characteristics of bilimbi roseapple and lovi lovi are presented in Table 2

### 4 1 1 Physical Chai acte i istics

As detailed in Table 2 on physical exammation the fruit and pulp colour firmness and biting quality and number of fruits per 100 g were noted The colour of the bilimbi fruit was observed as green with pale green pulp colour The rosy red roseapple with pink pulp and creamy white roseapple with cream white pulp were also observed Red and purplish red fruit with pink pulp colour for lovi lovi sweet and lovi lovi sour respectively were also observed /

With regard to firmness and biting quality it was observed that all the fruits had firm and crunchy quality but it was soft in case of lovi lovi sweet

The number of fruits per 100 g was counted The small sized fruit count showed that 16 24 for lovi lovi (both types) and 15 for bilimbi The large sized roseapple fruit count was recorded as seven and nine in case of white and rose roseapple respectively

Table 7 Physico chemical characteristics of bilimbi roseapple and lovi lovi

| Particulars | Bilimbi | Roseapple (rose) | Roseapple(white) | Lovi lovi (sweet) | Lovi lovi (sour) | CD (5%) |
|---|---|---|---|---|---|---|
| I Physical characters | | | | | | |
| Colour of the fruit | Green | Rosy red | Creamy white | Red | Purplish red | |
| Colour of the pulp | Pale green | Pink | Creamy white | Pink | Pink | |
| Firmness and biting quality | Firm and chrunchy | Firm and chrunchy | Firm and chrunchy | Soft | Firm and Chrunchy | |
| No of fruits / 100 g | 15 | 9 | 7 | 24 | 16 | |
| II Chemical characters per 100 g on fresh weight basis | | | | | | |
| Moisture (g) | 94 16 | 87 33 | 85 33 | 84 16 | 85 50 | 0 85 |
| Fibre (g) | 0 61 | 1 16 | 1 63 | 1 10 | 1 23 | 0 16 |
| Protein (g) | 0 60 | 0 52 | 0 70 | 0 51 | 0 35 | 0 03 |
| Starch (g) | 1 69 | 1 59 | 1 53 | 2 97 | 1 61 | 0 03 |
| Calcium (mg) | 3 43 | 36 00 | 41 50 | 40 33 | 34 50 | 0 76 |
| Phosphorus (mg) | 11 16 | 24 33 | 28 16 | 25 20 | 21 00 | 0 95 |
| Iron (mg) | 1 06 | 0 53 | 1 06 | 0 76 | 0 63 | 0 13 |
| Potassium (mg) | 20 33 | 50 33 | 42 50 | 8 16 | 22 16 | 0 85 |
| β carotene (µg) | 19 00 | 137 66 | 121 66 | 0 42 | 0 55 | 1 92 |
| Vitamin C (mg) | 11 41 | 12 26 | 13 06 | 20 26 | 9 40 | 0 63 |
| TSS ($^{0}$brix) | 4 63 | 7 06 | 6 10 | 20 10 | 10 10 | 0 19 |
| Acidity (%) | 2 50 | 1 38 | 1 23 | 1 86 | 1 42 | 0 16 |
| Total sugar (g) | 3 17 | 3 10 | 3 04 | 15 62 | 2 94 | 0 06 |
| Reducing sugar (g) | 1 88 | 1 77 | 1 71 | 10 00 | 1 79 | 0 03 |
| Non reducing sugar (g) | 1 29 | 1 32 | 1 32 | 5 62 | 1 14 | 0 06 |

**4 1 2 Chemical Characteristics**

The chemical characters such as moisture total fibre protein starch calcium phosphorus iron potassium β carotene vitamin C TSS acidity total reducing and non reducing sugar are presented in Table 2 and depicted in figures 6 7 8 9 and 10

*4 1 2 1 Moisture*

The mean moisture content ranged from 84 16 per cent in lovi lovi (sweet) to 94 16 per cent in bilimbi fruit Statistically it was found that bil mbi fruit followed by roseapple (rose) were superior when compared with other fru ts in reference to moisture content Lovi lovi (sour) and roseapple (white) were on par with each other and lovi lovi (sweet) was the most inferior among the selected fruits observed in the study

*4 1 2 2 Total Fibre*

Lov lovi sweet and sour type (1 1 % to 1 23 %) and rose and white roseapple (1 16 % to 1 63 %) were shown h gher fibre value when compared with bilimbi which has less fibre value (0 61%) With regard to fibre content both sweet and sour lovi lovi and roseapple (rose) were on par with each other But roseapple (white) was the superior fruit and bilimb was the inferior fruit observed statistically at five per cent level.

*4 1 2 3 Protein*

The mean protein content varied from 0 35 g 100 g to 0 70 g 100 g Statiscally the superior value was observed in roseapple (white) and the inferior value in lovi lovi (sour)

*4 1 2 4 Starch*

The mean starch content of fruits ranged between 1 53 g 100 g to 2 97 g 100 g $^{1}$ Lovi lovi (sweet) was found to have the highest amount and white roseapple the lowest For the starch content lovi lovi (sweet) followed by bilimbi were superior fruits and roseapple (white) was the inferior fruit noted at five per cent level Roseapple (rose) and lovi lovi (sour) were on par with each other for the same character

*4 1 2 5 Calcium*

From the Table 2 it can be seen that the mean values ranged from 3 43 mg 100 g $^{1}$ in bilimbi to 41 50 mg 100 g in roseapple (white) Statistically roseapple (white) was superior and bilimbi was inferior when compared to all other selected fruits

*4 1 2 6 Phosphorus*

The mean phosphorus content ranged from 11 16 mg 100g (bilimbi) to 28 16 mg 100 g $^{1}$ roseapple (white) With regard to phosphorus content at five per cent level it was observed that roseapple (white) was the superior fruit whereas lovi lovi (sweet) and roseapple (rose) were on par with each other Bilimbi was the inferior fruit observed in the study

*4 1 2 7 Iron*

The iron content of all the fruits are also presented in the Table 2 The mean value ranged from 0 53 mg 100 g $^{1}$ to 1 06mg 100g $^{1}$ The highest value was obtained in both bilimbi and roseapple (white) and the lowest in roseapple (rose) Bilimbi and roseapple (white) were on par with each other and they were the superior fruits when compared to other selected fruits with reference to iron content

*4 1 2 8 Potassium*

The roseapple (rose) has higher potassium content (50 33 mg 100 g $^{1}$) followed by roseapple (white) but sweet lovi lovi has low potassium content (8 16 mg 100 g $^{1}$) It was observed that roseapple (rose) followed by roseapple (white) were the superior fruits and lovi lovi (sweet) was the inferior fruit

*4 1 2 9 β-Carotene*

The mean β carotene content of the fruits estimated on fresh weight basis are furnished in Table 2 The mean content of β carotene in fruits ranged from 0 42 µg 100 g $^{1}$ to 137 66 µg 100 g The highest content was observed in roseapple (rose and white types) whereas in both sour and sweet type lovi lovi the β carotene was lowest The present study showed that roseapple (rose) followed by roseapple (white) were the superior fruits at five per cent level whereas both sweet and sour lovi lovi were on par with each other and were found to be inferior among the selected fruits

*4 1 2 10 Vitamin C*

The mean vitamin C content of the fruits varied from 9 40 mg 100 g $^{1}$ to 20 26 mg 100 g $^{1}$ The highest vitamin C content was found to be 20 26 mg 100 g $^{1}$ on fresh weight basis in sweet lovi lovi which was significantly superior to all other selected fruits and the lowest in sour lovi lovi (9 40 mg 100 g $^{1}$)

*4 1 2 11 Total Soluble Solids (TSS)*

Sweet lovi lovi which was selected for the study had the highest mean TSS (20 1$^{0}$brix) than all other selected fruits Regarding TSS it was

shown that lovi lovi (sweet) and bilimbi were found to be superior and inferior fruits respectively

*4 1 2 12 Acidity*

The mean acidity level ranged from 1 23 per cent to 2 50 per cent The values furnished in Table 2 showed that bilimbi had higher acidity when compared with lovi lovi and roseapple Statistically the superior fruit was bilimbi and inferior fruit was roseapple (white) Roseapple (rose) and lovi lovi (sour) were on par with each other

*4 1 2 13 Total Sugar*

Sweet lovi lovi has higher total sugar (15 62 %) followed by roseapple and bilimbi The total sugar content was found to be superior in lovi lovi (sweet) followed by bilimbi and inferior in lovi lovi (sour)

*4 1 2 14 Reducing and Non reducing Sugar*

The analysis showed that both reducing (10 00 %) and non reducing sugar (5 62 %) was found to be higher in sweet lovi lovi whereas roseapple (rose and white type) bilimbi and sour lovi lovi was found to have more or less similar values Lovi lovi (sweet) was the most superior fruit among the selected fruits in relation to both reducing and non reducing sugar Roseapple (white) and lovi lovi (sour) were the inferior fruit in terms of reducing and non reducing sugar respectively

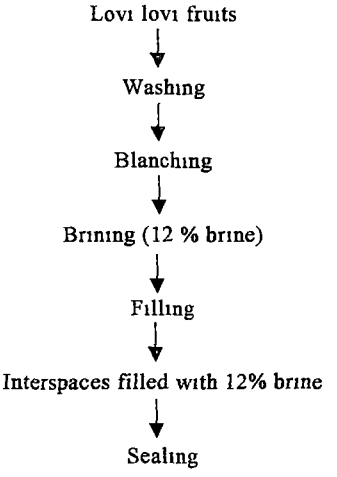


Fig 5 Flowchart for the preparation of lovi lovi in brine

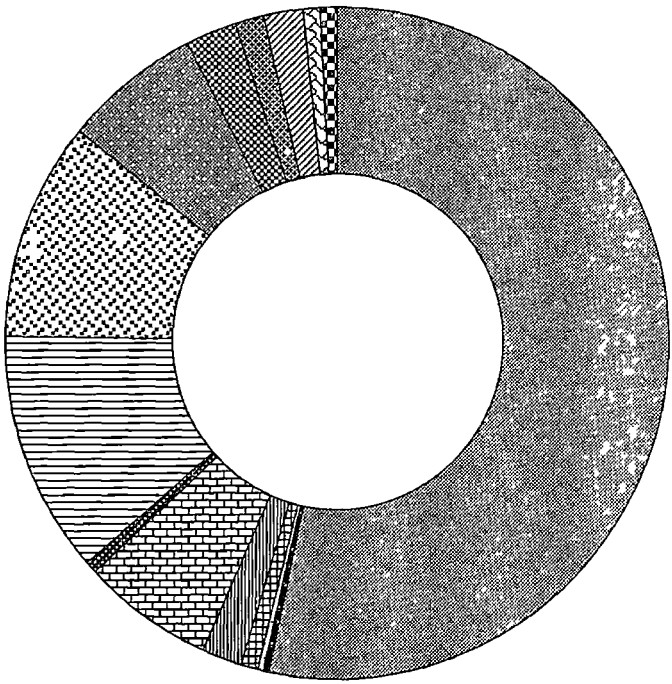

Fig 6 Nutrient composition of bilimbi

| | | |
|---|---|---|
| Moisture | Total Fibre | Protein |
| Starch | Calcium | Phosphorus |
| Iron | Potassium | β Carotene |
| Vitamin C | TSS | Acidity |
| Total Sugar | Reducing Sugar | Non Reducing Sugar |

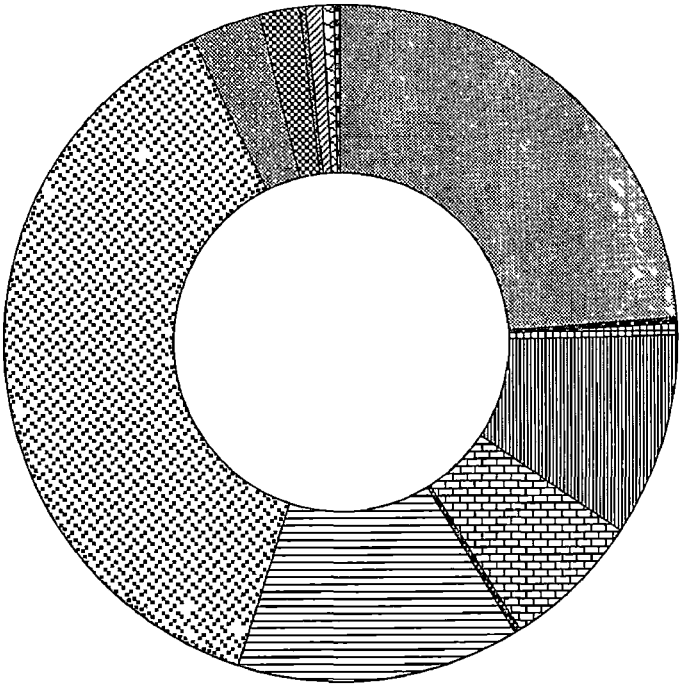

Fig 7 Nutrient composition of roseapple (rose)

| | | |
|---|---|---|
| Moisture | Total Fibre | Protein |
| Starch | Calcium | Phosphorus |
| Iron | Potassium | β Carotene |
| Vitamin C | TSS | Acidity |
| Total Sugar | Reducing Sugar | Non Reducing Sugar |

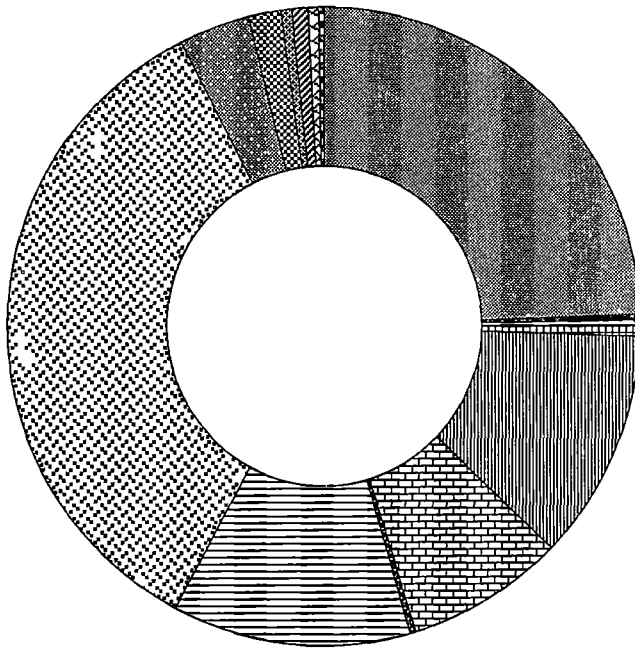

Fig 8 Nutrient composition of roseapple (white)

| | | |
|---|---|---|
| Moisture | Total Fibre | Protein |
| Starch | Calcium | Phosphorus |
| Iron | Potassium | β Carotene |
| Vitamin C | TSS | Acidity |
| Total Sugar | Reducing Sugar | Non Reducing Sugar |

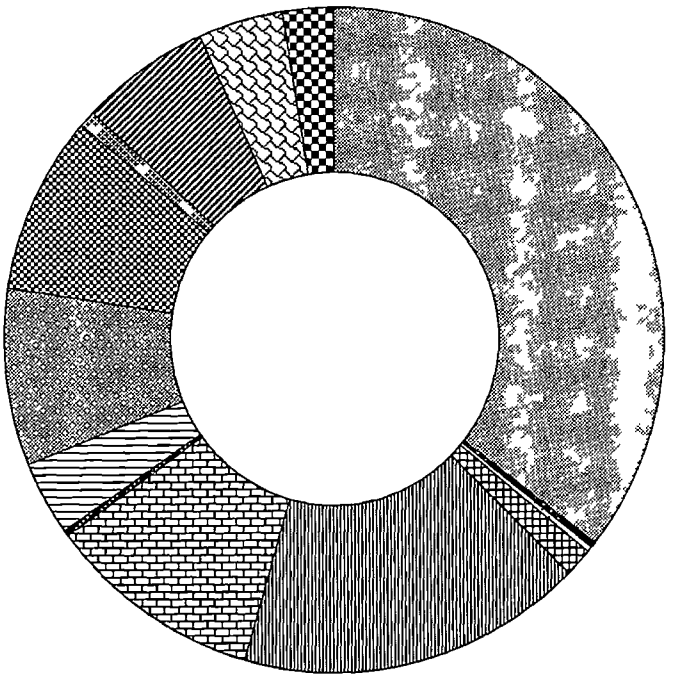

Fig 9 Nutrient Composition of lovi lovi (sweet)

| | | |
|---|---|---|
| Moisture | Total Fibre | Protein |
| Starch | Calcium | Phosphorus |
| Iron | Potassium | β Carotene |
| Vitamin C | TSS | Acidity |
| Total Sugar | Reducing Sugar | Non Reducing Sugar |

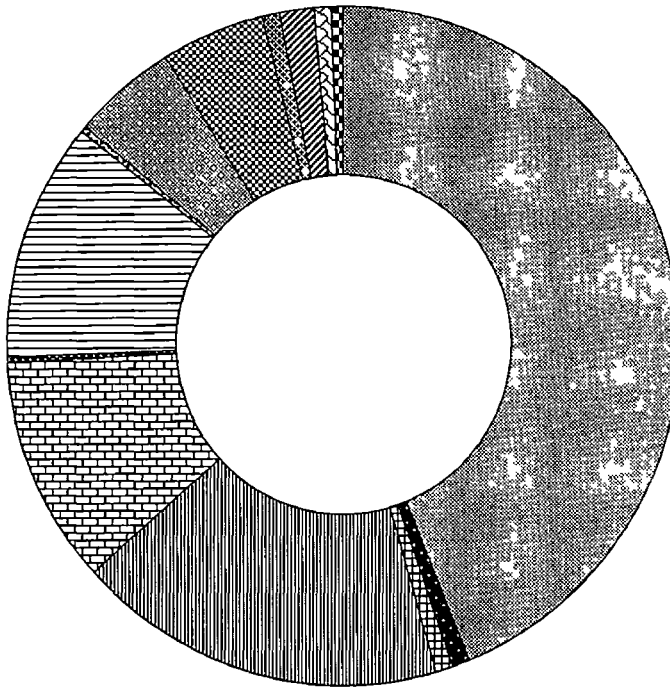

Fig 10 Nutrient composition of lovi lovi (sour)

| | | |
|---|---|---|
| Moisture | Total Fibre | Protein |
| Starch | Calcium | Phosphorus |
| Iron | Potassium | β Carotene |
| Vitamin C | TSS | Acidity |
| Total Sugar | Reducing Sugar | Non Reducing Sugar |

## 4 2 SENSORY EVALUATION OF SELECTED UNDEREXPLOITED FRUITS

The result of the study to evaluate the quality characters of underexploited fruits like bilimbi roseapple and lovi lovi are presented in Table 3 The fruits were assessed by 10 judges for the different characters like appearance colour flavour texture and taste so as to have preliminary evaluation to assess the degree of agreement between the judges to arrive at valid conclusions The judges were asked to rate each fruit on a numerical hedonic five point scale The mean scores of sensory evaluation of fruits are presented in Table 3 and depicted in figure 11

Table 3 Mean scores of sensory evaluation of bilimbi roseapple and lovi lovi

| Fruits | Appearance | Colour | Flavour | Texture | Taste | Overall acceptability |
|---|---|---|---|---|---|---|
| Bilimbi | 4 5 | 3 7 | 3 6 | 3 2 | 2 6 | 3 52 |
| Lovi lovi (sweet) | 4 8 | 4 6 | 3 8 | 4 9 | 5 | 4 62 |
| Lovi lovi (sour) | 4 6 | 4 6 | 3 6 | 4 3 | 4 3 | 4 28 |
| Roseapple (rose) | 4 8 | 4 9 | 4 7 | 4 7 | 4 8 | 4 78 |
| Roseapple (white) | 4 6 | 4 8 | 4 4 | 4 6 | 4 7 | 4 62 |
| W value | 0 09 | 0 55 | 0 53 | 0 56 | 0 82 | |

From the Table 3 it was seen that with respect to appearance lovi lovi (sweet) and roseapple (rose) were found to be the best followed by lovi lovi (sour) and roseapple (white) The least preferred fruit was bilimbi When judged in terms of colour and flavour roseapple (rose) followed by roseapple (white) were found to be best In these aspects again the bilimbi fruit was found to be the least preferred In relation to texture and taste lovi lovi (sweet) followed by roseapple (rose) were found to be best preferred while bilimbi was considered to be less preferred Roseapple (rose) had highest overall acceptability of mean score of 4 78 followed by white roseapple (4 62) lovi lovi sweet (4 62) lovi lovi sour (4 28) and the least bilimbi (3 52)

Statistically kendals coefficient of concordance w which expresses the degree of association among the ten judges was worked out for each character under study

The w value were found to be 0 09 for appearance whereas the w value for colour was 0 55 In the case of flavour the w value was 0 53 The w value for texture and taste were 0 56 and 0 82 respectively Hence with regard to sensory quality as pursued by panelists the judges showed high degree of agreement for all quality characters except appearance

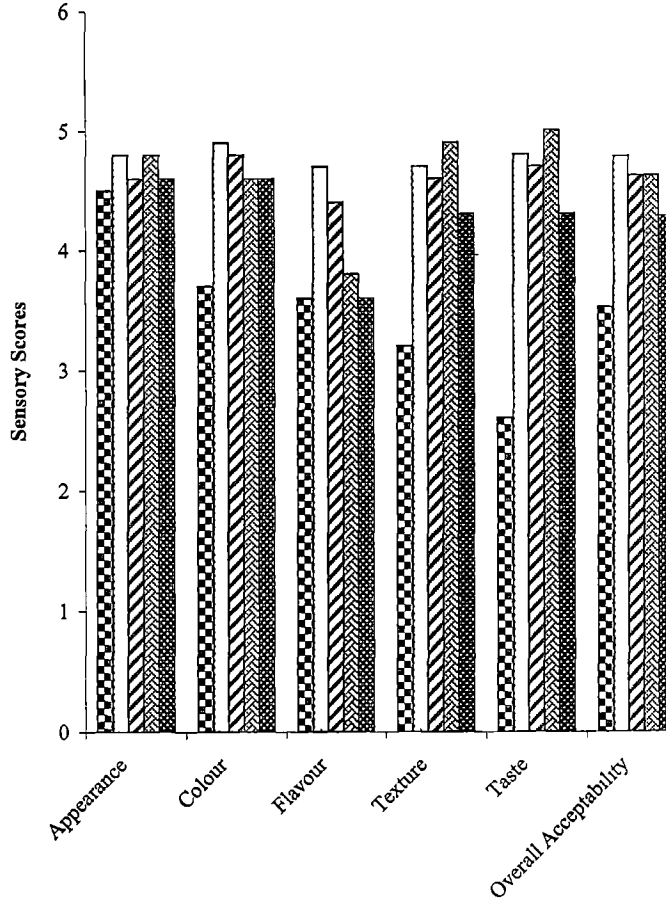


**Fig 11 Sensory evaluation of selected minor fruits**

## 4 3 INDEPTH STUDIES ON SELECTED MINOR FRUIT PRODUCTS

For detailed observations in respect to chemical and shelf life qualities of the products viz jam pickle squash preserve in sugar and brine were prepared in larger quantities following the standardised recipe The prepared products were packed in suitable glass bottles and were stored at room temperature

### 4 3 1 Chemical Composition of Minor Fruit Products

The major components analysed in the six products were TSS acidity vitamin C reducing non reducing and total sugar

Table 4 presents the proximate analysis of fresh minor fruit products studied in detail in the present investigation

Table 4 Chemical composition of minor fruit products

| Parameters | Bilimbi Jam | Bilimbi pickle | Roseapple squash (rose) | Roseapple squash (white) | Lovi lovi preserve in sugar | Lovi lovi in brine |
|---|---|---|---|---|---|---|
| TSS $^0$brix | 76 10 | 25 10 | 45 03 | 48 03 | 70 06 | 15 10 |
| Acidity % | 1 54 | 1 22 | 3 06 | 2 06 | 0 98 | 1 26 |
| Vitamin C mg 100 g $^{-1}$ | 9 65 | 10 13 | 10 13 | 10 46 | 18 56 | 8 26 |
| Reducing sugar g 100 g $^{-1}$ | 36 63 | 1 46 | 26 77 | 30 02 | 30 01 | 1 42 |
| Non reducing sugar g 100 g $^{-1}$ | 28 02 | 1 12 | 14 43 | 13 32 | 30 41 | 1 23 |
| Total sugar g 100 g $^{-1}$ | 64 66 | 2 58 | 41 20 | 43 35 | 60 43 | 2 65 |

The data given in Table 4 reveals that jam prepared from bilimbi had a TSS of 76 10 $^0$brix The prepared jam had an acidity of 1 54 per cent

and vitamin C of 9 65mg 100 $g^{1}$ The product jam obtained a reducing and non reducing sugar of 36 63 per cent and 28 02 per cent The bilimbi jam obtained a total sugar of 64 66 per cent

Bilimbi pickle exhibited 25 10 $^{0}$brix TSS 1 22 per cent acidity 10 13 mg 100 $g^{1}$ vitamin C 1 46 per cent reducing sugar 1 12 per cent non reducing sugar and 2 58 per cent total sugar

As per the Table 4 it was found that both squashes prepared from rose and white roseapple exhibited a TSS of 45 03 $^{0}$brix and 48 03 $^{0}$brix and acidity were recorded as 3 06 per cent and 2 06 per cent respectively The vitamin C content of prepared rose and white squash was found to have more or less similar values (10 13 mg 100 $g^{1}$ and 10 46 mg 100 $g^{1}$) On analysis of squash prepared from rose and white roseapple its composition were observed with reducing sugar of 26 77 per cent and 30 02 per cent whereas non reducing sugar of 14 43 per cent and 13 32 per cent respectively The rose and white squash obtained a total sugar of 41 20 per cent and 43 35 per cent

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The preserve in sugar syrup prepared from lovi lovi fruit showed a TSS of 70 06 $^{0}$brix The acidity content in case of preserve in sugar syrup was 0 98 per cent The vitamin C content of preserve in sugar syrup was 18 56 mg 100 $g^{1}$ On analysis

of preserve in sugar syrup the composition were observed as reducing sugar 30 01 per cent whereas non reducing sugar 30 41 per cent The total sugar content was 60 43 per cent in preserve in sugar syrup

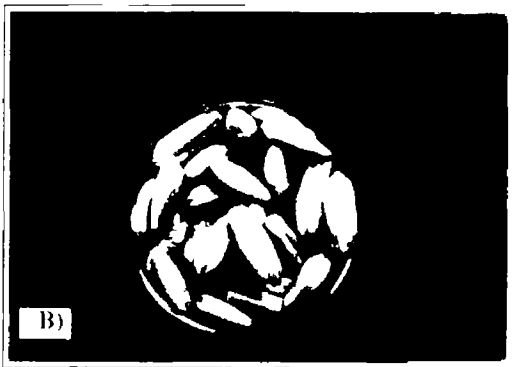
Lovi lovi brine had 15 1 $^{0}$brix TSS 1 26 per cent acidity and 8 26 mg 100 g $^{-1}$ vitamin C The product obtained a reducing and non reducing sugar of 1 42 per cent and 1 23 per cent respectively The total sugar content was 2 65 per cent in case of lovi lovi brine

**4 3 2 Confirmation with FPO Requirements**

The products developed in the present study were compared with FPO specifications in its requirements for particular items The data is presented in Table 5

Table 5 Confirmation of bilimbi products with FPO standards

| Particulars | Bilimbi products | | | | |
|---|---|---|---|---|---|
| | Bilimbi jam | | | Bilimbi pickle | |
| | % of TSS in the final product | % of fresh fruit in the final product | Amount of preservative added (ppm) | Preparation with oil | Amount of preservative added (ppm) |
| FPO value | 68 % | 45 % | 200 | Any edible oil like gingelly oil | 250 |
| Analysed value | 76% | 50% | 200 | Gingelly oil | 250 |


B)


BILIMBI JAM


BILIMBI PICKLE

As per the FPO specifications, a product may be called a jam, if it contains minimum of 68 per cent soluble solids and minimum of fruit on fresh fruit basis in the final product as 45 per cent. The jam prepared from bilimbi contained 76 per cent TSS and 50 per cent fruit on fresh fruit basis. Thus it can be stated that the bilimbi jam in the present study possessed the required characteristics to be considered as a standard jam.

Similarly by FPO special characters indicated for pickle preparation is that it should be prepared only from any edible oil like gingelly oil. The pickle developed from bilimbi is also prepared from gingelly oil and thus it could be confirmed that the bilimbi pickle detailed in the present study are well competent with a standard pickle. Both bilimbi jam and bilimbi pickle satisfied FPO specification in relation to addition of preservative.

Table 6. Confirmation of roseapple products with FPO standards

| Particulars | Roseapple products | | | | | |
|---|---|---|---|---|---|---|
| | Roseapple squash (white) | | | Roseapple squash (rose) | | |
| | % of TSS in the final product | % of fruit juice in the final product | Amount of preservative added (ppm) | % of TSS in the final product | % of fruit juice in the final product | Amount of preservative added (ppm) |
| FPO value | 40% | 25 % | 350 | 40 % | 25 % | 350 |
| Analysed value | 48% | 38% | 350 | 45% | 38% | 350 |

While studying the specifications for squash, the special characters taken were total soluble solids in the final product as well as the percentage of fruit juice present in the product. A reference to the Fruit

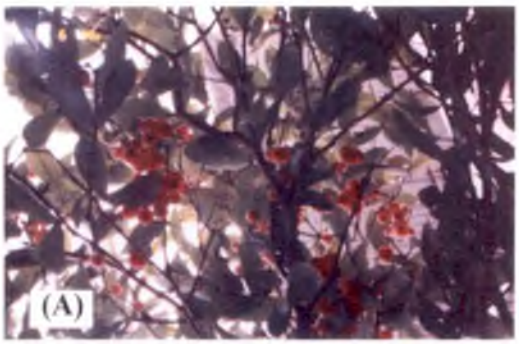






Plate 2. Roseapple fruit (rose and white type) and its products :
(A) Roseapple tree with (rose) fruit
(B) Roseapple (white) fruit
(C) Roseapple (rose) fruit squash
(D) Roseapple (white) fruit squash

Product Order showed a value which ranged from 40per cent and 25 per cent respectively. In the present study, the TSS present in white and rose typed roseapple squash was 48 per cent and 45 per cent respectively whereas the percentage of fruit juice present in white and rose squashes were 38 per cent. Addition of preservative to the products also confirmed to FPO specifications.

Table 7. Confirmation of lovi-lovi products with FPO standards

| Particulars | Lovi-lovi products | | | |
|---|---|---|---|---|
| | Lovi-lovi preserve in sugar syrup | | | Lovi-lovi in brine |
| | % of TSS in the final product | % of fruit portion in the final product | Amount of preservative added (ppm) | Minimum percentage of salt |
| FPO value | 68 % | 55% | 200 | 12% |
| Analysed value | 70% | 58% | 200 | 12% |

With relevant to preserve, FPO prescribes a minimum of 68 per cent total soluble solids and 55 per cent of fruit in the final product as requirements for this product to be considered upto the mark. On analysis of preserve prepared from lovi-lovi indicated that the value obtained was 70 per cent TSS and 58 per cent of fresh fruit in the final product. FPO specified preservative was also added to the product.

With respect to brine, the minimum percentage of salt prescribed by FPO is 12 per cent. The lovi-lovi in brine was prepared with the prescribed salt concentration of 12 per cent. From the above finding, it can be concluded that the prepared lovi-lovi brine satisfies the prescribed FPO standards.

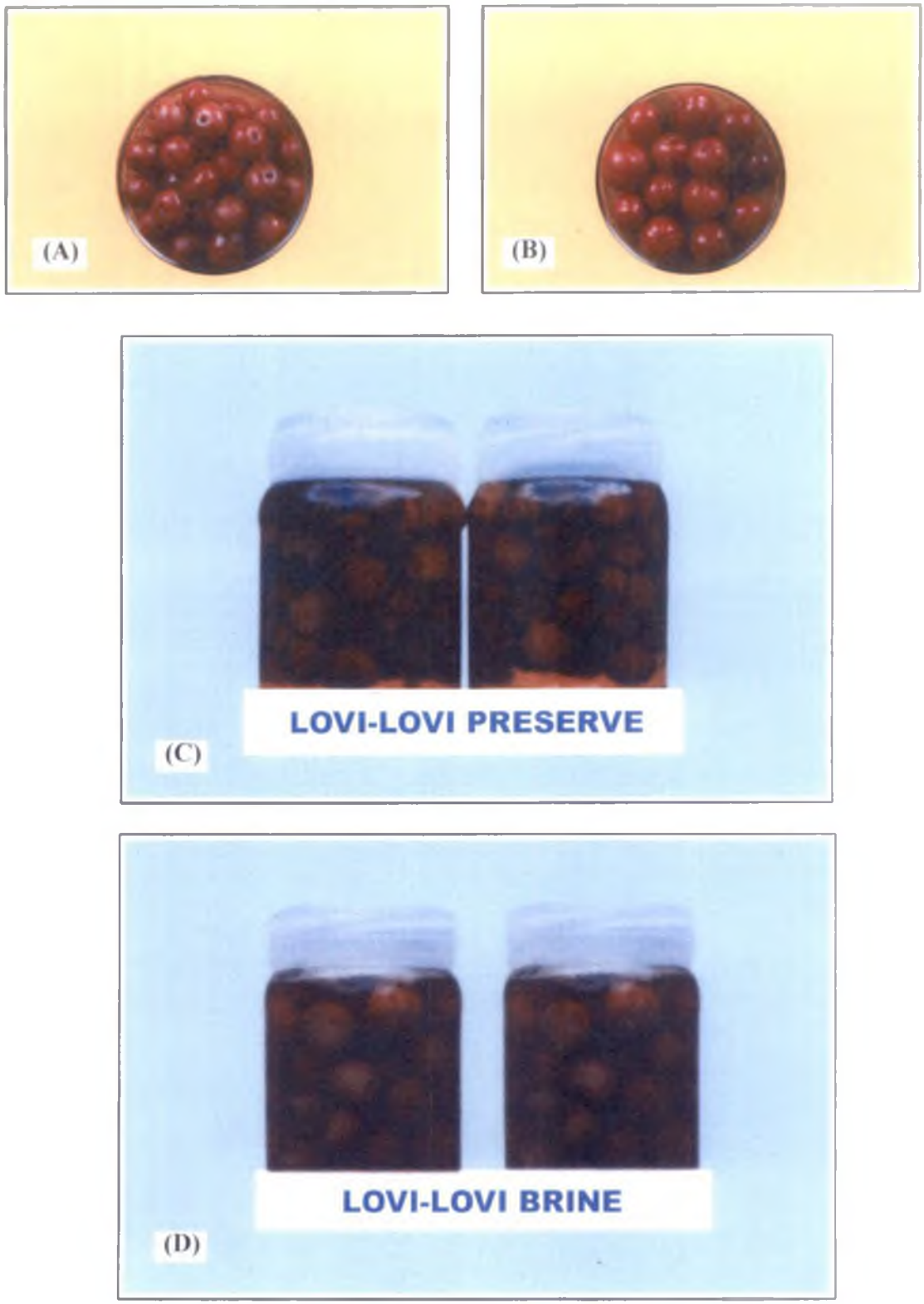



Plate 3. Lovi-lovi fruit (sweet and sour type) and its products :
(A) Lovi-lovi (sweet) fruit
(B) Lovi-lovi (sour) fruit
(C) Lovi-lovi (sweet) fruit preserve in sugar
(D) Lovi-lovi (sour) fruit in brine

### 4 3 4 Fruit Product Yield Ratio

Fruit product yield ratio gives an estimation of the amount of product obtained for known quantity of the fruit utilized The Table 9 gives the fruit product yield ratio of different products in the present trial

Table 9 Fruit product yield ratio

| Sl No | Fruit product | Quality | | Ratio |
|---|---|---|---|---|
| | | Fresh fruit | Product yield | |
| 1 | Bilimbi jam | 1000g | 1600g | 1 1 6 |
| 2 | Bilimbi pickle | 1000g | 1250g | 1 1 25 |
| 3 | Roseapple squash (rose) | 1000g | 1800g | 1 1 8 |
| 4 | Roseapple squash (white) | 1000g | 1750g | 1 1 75 |
| 5 | Lovi lovi preserve in sugar | 1000g | 1540g | 1 1 54 |
| 6 | Lovi lovi in brine | 1000g | 1460g | 1 1 46 |

When the fruit product yield ratio was calculated it was found that the highest yield was obtained for both rose and white roseapple squash (1 1 8 and 1 1 75) respectively This is followed by bilimbi jam (1 1 6) lovi lovi preserve in sugar (1 1 54) lovi lovi in brine (1 1 46) and the least yield for bilimbi pickle (1 1 25)

## 4 4 ASSESSMENT OF SHELF LIFE

The shelf life quality of prepared minor fruit products were determined by ascertaining periodically the changes in chemical qualities microflora and also the changes in organoleptic qualities of products during storage

### 4 4 1 Changes in the Chemical Qualities during Storage

A monthly assessment on the chemical components were carried out to assess the storage quality of different minor fruit products studied The major components assessed were TSS acidity vitamin C reducing non reducing and total sugar

#### *4 4 1 1 Changes in the Chemical Qualities of Bilimbi Jam during Storage*

Changes in the chemical components of bilimbi jam during storage was studied and the results are presented in Table 10 Analysis was carried out with respect to TSS acidity vitamin C reducing non reducing and total sugar

Table 10 Compositional changes of bilimbi jam during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^{0}$brix | 76 10 | 76 53 | 77 10 | 77 66 | 78 10 | 78 53 | 0 15 |
| Acidity % | 1 54 | 1 70 | 1 87 | 2 02 | 2 29 | 2 61 | 0 15 |
| Vitamin C mg 100 g $^{1}$ | 9 65 | 8 93 | 8 26 | 7 70 | 6 70 | 6 13 | 0 31 |
| Reducing sugar g 100 g $^{1}$ | 36 63 | 37 54 | 39 52 | 40 59 | 42 92 | 44 18 | 3 35 |
| Non reducing sugar g 100 g $^{1}$ | 28 02 | 27 67 | 26 84 | 26 37 | 25 25 | 24 60 | 1 57 |
| Total sugar g 100 g $^{1}$ | 64 66 | 65 22 | 66 37 | 66 96 | 68 17 | 68 78 | 1 81 |

From the results obtained it was found that TSS of jam slightly increased from 76 10 °brix to 78 53 °brix during storage Highest value of TSS was obtained during the sixth month of storage which was significantly superior to all other storage months

As per the Table 10 the acidity of bilimbi jam was observed to have a steady increase from 1 54 per cent to 2 61 per cent over a period of six months Significantly superior values was found at the sixth month of storage and the least at the first month of storage

Variation noted in the vitamin C of bilimbi jam during six month storage period are presented in Table 10 The change in vitamin C was

observed to be decreased from 9 65 mg 100 $g^{-1}$ to 6 13 mg 100 $g^{-1}$ during storage Vitamin C was significantly superior at first month of storage and declined as the storage period progressed

The change in reducing sugar was observed to be increased from 36 63 per cent to 44 18 per cent during storage Values at fifth and sixth months of storage were on par with each other and significantly superior to all other months

The non reducing sugar of bilimbi jam declined during storage and ranged from 28 02 per cent to 24 60 per cent Non reducing sugar content at fifth and sixth months of storage were on par with each other and significantly superior when compared to all other months

From the result it was found that the total sugar increased with increase in storage period It ranged from 64 66 per cent to 68 78 per cent during storage In the initial four months the total sugar values were statistically inferior Higher total sugar values were found at the fifth and sixth months of storage which were on par with each other

### *4 4 1 2 Changes in the Chemical Qualities of Bilimbi Pickle during Storage*

Changes in the chemical components of bilimbi pickle during storage was maintained over a period of six months The major components analysed were TSS acidity vitamin C reducing non reducing and total sugar The data are presented in Table 11

Table 11 Compositional changes of bilimbi pickle during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^0$brix | 25 10 | 25 93 | 26 83 | 27 56 | 28 30 | 29 10 | 0 15 |
| Acidity % | 1 22 | 1 42 | 1 62 | 1 78 | 1 96 | 2 21 | 0 09 |
| Vitamin C mg 100 g $^{-1}$ | 10 13 | 9 20 | 8 66 | 8 13 | 7 66 | 6 13 | 0 40 |
| Reducing sugar g 100 g $^{-1}$ | 1 46 | 1 42 | 1 40 | 1 38 | 1 36 | 1 33 | 0 003 |
| Non reducing sugar g 100 g $^{-1}$ | 1 12 | 1 14 | 1 14 | 1 15 | 1 15 | 1 17 | 0 03 |
| Total sugar g 100 g $^{-1}$ | 2 58 | 2 56 | 2 55 | 2 53 | 2 51 | 2 50 | 0 003 |

Mean values of TSS during the storage period of six months for bilimbi pickle is presented in Table 11 TSS increases slightly in pickle from 25 10 $^0$brix to 29 10 $^0$brix during storage period TSS was significantly superior at the sixth month and inferior at the first month of storage

The periodical testing for acidity of pickle performed upward trend in the value with the increase in storage period Acidity increase was from 1 22 per cent to 2 21 per cent Statistically the sixth month of storage showed superior acidity

The vitamin C in bilimbi pickle ranged from 10 13 mg 100 g $^{-1}$ to 6 13 mg 100 g $^{-1}$ during storage period The result showed that vitamin C

was statistically superior at the first month and declined with the progress of storage period

The change in reducing and non reducing sugar was not much noticeable Reducing sugar changed with decrease from 1 46 per cent to 1 33 per cent whereas non reducing sugar changed from 1 12 per cent to 1 17 per cent Statistically reducing sugar was superior whereas non reducing sugar was inferior during the first month The non reducing sugar at the second to sixth months of storage were on par with each other

The total sugar decreased from 2 58 per cent to 2 50 per cent during subsequent storage months Higher values of total sugar were found at the first month of storage which was statistically superior to all other months

### *4 4 1 3 Changes in the Chemical Qualities of Roseapple Squash (rose) during Storage*

The chemical parameters of roseapple squash (rose) during consequent storage months were analysed with respect to TSS acidity vitamin C reducing non reducing and total sugar content and the mean values are presented in Table 12

Table 12 Compositional changes of roseapple squash (rose) during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^0$brix | 45 03 | 45 63 | 46 23 | 46 73 | 47 33 | 47 93 | 0 09 |
| Acidity % | 3 06 | 3 24 | 3 45 | 3 56 | 3 71 | 3 88 | 0 06 |
| Vitamin C mg 100 g | 10 13 | 8 93 | 7 93 | 7 30 | 6 56 | 5 53 | 0 25 |
| Reducing sugar g 100 g $^{-1}$ | 26 77 | 27 23 | 28 26 | 28 83 | 30 01 | 30 63 | 1 69 |
| Non reducing sugar g 100 g | 14 43 | 14 20 | 13 63 | 13 30 | 12 59 | 12 22 | 1 23 |
| Total sugar g 100 g $^{-1}$ | 41 20 | 41 44 | 41 89 | 42 14 | 42 61 | 42 85 | 1 01 |

A close exammation on the TSS of roseapple squash (rose) showed slight difference during storage of six months The TSS values increased from 45 03 $^0$brix to 47 93 $^0$brix during storage period TSS was found to be statistically superior with the advancement of storage period

From the data it was found that acidity increased from 3 06 per cent to 3 88 per cent during storage Higher values of acidity was found at the sixth month of storage which was statistically superior than the other months

Pertaining to vitamin C in roseapple squash (rose) a steep decrease was recorded as storage period advanced The variation in vitamin C during six months of storage was from 10 13 mg 100 g $^{-1}$ to 5 53 mg 100 g

Statistically it was inferred that vitamin C was superior at the first month and inferior at the sixth month of storage

An increase in reducing sugar was observed to be from 26 77per cent to 30 63 per cent during storage The values of reducing sugar at fifth and sixth month were on par with each other and statistically superior to all other months

Variation noted in non reducing sugar per cent of roseapple squash during different storage period are presented in Table 12 From the result it was found that non reducing sugar decreased with increase in storage period The range varies from 14 43 per cent to 12 22 per cent The values at the fourth to sixth months of storage were on par with each other and statistically superior to other months

Mean values of total sugars obtained during storage period indicated that total sugar increased with increase in storage period The change in total sugar was observed to be increased from 41 20 per cent to 42 85 per cent The total sugar was found to be higher during last four months which were on par with each other and were statistically superior

### *4 4 1 4 Changes in the Chemical Qualities of Roseapple Squash (white) during Storage*

The roseapple squash (white) was analysed for TSS acidity vitamin C reducing non reducing and total sugars to study the major changes on storage The results of the changes in product at various periods of storage are given in Table 13

Table 13 Compositional changes of roseapple squash (white) during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^0$brix | 48 03 | 48 56 | 49 26 | 49 63 | 50 26 | 50 90 | 0 12 |
| Acidity % | 2 06 | 2 21 | 2 41 | 2 56 | 2 70 | 2 85 | 0 06 |
| Vitamin C mg 100 g 1 | 10 46 | 9 70 | 8 93 | 8 30 | 7 60 | 6 70 | 0 18 |
| Reducing sugar g 100 g 1 | 30 02 | 32 02 | 32 81 | 33 43 | 34 91 | 36 62 | 3 69 |
| Non reducing sugar g 100 g 1 | 13 32 | 12 07 | 11 53 | 11 45 | 11 66 | 10 83 | 3 11 |
| Total sugar g 100 g 1 | 43 35 | 44 10 | 44 35 | 44 88 | 46 58 | 47 46 | 0 83 |

The values obtained on periodical analysis of roseapple squash (white) for TSS is depicted in Table 13 The range of increase was observed from 48 03 $^0$brix to 50 90 $^0$brix Highest value of TSS was obtained at sixth month of storage which was significantly superior to all other storage months

A small rise in acidity of roseapple squash (white) has been observed at the end of storage period Increase was noticed from 2 06 per cent to 2 85 per cent Statistically acidity was inferior at the first month and superior at the sixth month

The results of monthly analysis of vitamin C content of roseapple squash (white) is given in Table 13 Squash recorded a decrease in trend in vitamin C from 10 46 mg 100 $g^{1}$ to 6 70 mg 100 $g^{1}$ Vitamin C was found to be superior during the first month and decreased as the advancement of storage period

Periodical evaluation of the reducing and non reducing sugars showed some changes upto six months storage Reducing sugar was found to increase from 30 02 per cent to 36 62 per cent and non reducing sugar decreased from 13 32 per cent to 10 83 per cent Reducing sugar at fourth to sixth months of storage were on par with each other and significantly superior than other months The non reducing sugar for all the months of storage were on par with each other

The results obtained with regard to total sugars indicated an upward trend from 43 35 per cent to 47 46 per cent Higher values of total sugar was found at the sixth month which was statistically superior to all other months

### *4 4 1 5 Changes in the Chemical Qualities of Lovi lovi Preserve in Sugar during Storage*

The effect of storage on the TSS acidity vitamin C reducing non reducing and total sugars of lovi lovi preserve in sugar are presented in Table 14

Table 14 Compositional changes of lovi lovi preserve in sugar during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^0$brix | 70 06 | 70 53 | 71 83 | 72 53 | 73 10 | 73 93 | 0 12 |
| Acidity % | 0 98 | 0 91 | 0 85 | 0 81 | 0 72 | 0 68 | 0 12 |
| Vitamin C mg 100 g | 18 56 | 17 53 | 16 60 | 15 13 | 13 86 | 12 93 | 0 34 |
| Reducing sugar g 100 g $^1$ | 30 01 | 30 63 | 31 94 | 32 63 | 33 60 | 34 22 | 3 63 |
| Non reducing sugar g 100 g $^1$ | 30 41 | 30 40 | 29 55 | 29 33 | 28 96 | 28 81 | 3 01 |
| Total sugar g 100 g | 60 43 | 61 03 | 61 50 | 61 96 | 62 56 | 63 03 | 3 41 |

It was noticed from the Table 14 that the extend of increase in the TSS content was from 70 06 $^0$brix to 73 93 $^0$brix in preserve during storage It was observed that TSS was statistically superior at the sixth month and inferior at the first month

The monthly evaluation showed that declining values in acidity from 0 98 per cent to 0 68 per cent was observed in lovi lovi preserve in sugar during storage period The acidity of lovi lovi preserve at the fifth and sixth months of storage were on par with each other and statistically superior to all other months

A decreasing trend from 18 56 mg 100 $g^{1}$ to 12 93 mg 100 g with regard to vitamin C was observed in lovi lovi preserve in sugar during storage Vitamin C was found to be superior during the first month and decreased with the advancement of storage

A gradual increase in reducing sugar from 30 01 per cent to 34 22 per cent and decrease in non reducing sugar from 30 41 per cent to 28 81 per cent was noticed in lovi lovi preserve in sugar when stored for a period of six months Reducing sugar of second to sixth month were on par with each other and were statistically superior to first month The first month value of non reducing sugar was superior and were on par with the other months of storage

From the above Table 14 it is clear that total sugar increased from 60 43 per cent to 63 03 per cent in preserve during storage Superior value of total sugar was observed at sixth month and were on par with the other months of storage

### *4 4 1 6 Changes in the Chemical Qualities of Lovi lovi in Brine during Storage*

The results of changes in the observations on TSS acidity vitamin C reducing non reducing and total sugar of lovi lovi in brine during storage is depicted in Table 15

Table 15 Compositional changes of lovi lovi in brine during storage

| Parameters | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | CD |
| TSS $^{0}$brix | 15 10 | 15 96 | 16 83 | 17 53 | 18 23 | 19 00 | 0 12 |
| Acidity % | 1 26 | 1 62 | 2 00 | 2 21 | 2 51 | 2 85 | 0 09 |
| Vitamin C mg 100 g | 8 26 | 7 40 | 6 70 | 6 26 | 5 23 | 4 60 | 0 31 |
| Reducing sugar g 100 g | 1 42 | 1 40 | 1 38 | 1 36 | 1 34 | 1 32 | 0 003 |
| Non reducing sugar g 100 g $^{1}$ | 1 23 | 1 23 | 1 23 | 1 23 | 1 23 | 1 23 | 0 003 |
| Total sugar g 100 g $^{1}$ | 2 65 | 2 63 | 2 61 | 2 59 | 2 57 | 2 55 | 0 003 |

It is clearly evident from the Table 15 that upon storage the TSS increased considerably for 15 10 $^{0}$brix to 19 00 $^{0}$brix Highest value of TSS was obtained during the sixth month of storage which was significantly superior to all other storage months

From the data it was found that acidity varied with respect to storage time The value was observed to be increasing from 1 26 per cent to 2 85 per cent Higher values of acidity was found at the sixth month of storage which was statistically superior than the other months

The range of decrease for vitamin C was from 8 26 mg 100 g to 4 60 mg 100 g in lovi lovi in brine during six months of storage Statistically it was inferred that vitamin C was superior at the first month and inferior at the sixth month of storage

The marginal decrease for both reducing and non reducing sugar was observed from 1 42 per cent to 1 32 per cent and 1 23 per cent to 1 23 per cent respectively in lovi lovi preserved in brine during storage period Reducing sugar at first month of storage was found to be superior than to all other months Same values for non reducing sugar were found in all the six months of storage and hence all were on par with each other

From the result obtained it can be noted that total sugar showed a slight decrease in values from 2 65 per cent to 2 55 per cent during storage Highest value of total sugar was obtained during the first month of storage which was significantly superior to all other storage months

### 4 4 2 Changes in the Organoleptic Qualities of the Products during Storage

#### *4 4 2 1 Changes in the Organoleptic Qualities of Bilimbi Jam during Storage*

The mean scores of the organoleptic qualities of bilimbi jam during the storage period of six months are presented in Table 16 and figure 12

Table 16 Effect of storage on various quality attributes of bilimbi jam

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | w value |
| Appearance | 4 6 | 4 | 3 8 | 3 9 | 3 8 | 3 7 | 0 62 |
| Colour | 4 8 | 4 6 | 4 3 | 4 1 | 4 0 | 3 9 | 0 57 |
| Flavour | 2 5 | 2 9 | 3 0 | 3 1 | 3 3 | 3 4 | 0 50 |
| Texture | 3 0 | 3 1 | 3 3 | 3 5 | 3 6 | 3 8 | 0 49 |
| Taste | 2 4 | 2 5 | 2 7 | 3 3 | 3 5 | 3 8 | 0 83 |
| Overall acceptability | 3 46 | 3 42 | 3 42 | 3 58 | 3 64 | 3 72 | |

From the Table 16 it was found that the scores obtained for appearance decreased over a period of six months The maximum score (4 6) was obtained during the first month (92 per cent) and it was reduced to 80 per cent (score 4) by the second month Only a slight decrease in appearance was noticed from second to sixth month since the score was found lowered from 80 per cent to only 74 per cent (score 4 to 3 7) by the end of six months

The colour of bilimbi jam was proved to be very good upto second month of storage (score 4 6) Only a slight reduction in score (six per cent) was recorded by the third month (score 4 3) Similar trend was noticed till six months of storage period was completed and the score was reduced to 78 percent (score 3 9)

Considering the flavour of jam it could be seen that flavour was highly acceptable as the storage period extended The score per cent progressed from 50 per cent to 68 per cent (score 2 5 to 3 4) at the end of six months of storage period

With regard to texture and taste acceptability increased as the storage period progressed The score per cent increased from 60 per cent to 76 per cent (score 3 to 3 8) and 48 per cent to 76 per cent (score 2 4 to 3 8) with respect to texture and taste

Overall acceptability of the product was evaluated by computing the total scores given for various quality parameters such as appearance colour flavour texture and taste by panel members

In the present study storage had major effect on the overall acceptability of bilimbi jam There was a gradual increase from 69 2 per cent to 74 4 per cent in score level (score 3 46 to 3 72) for overall acceptability after six months of storage

Statistically Kruskal Wallance Analysis of Varience was used to evaluate the sensory agreement of bilimbi jam between the judges

The study revealed that there was notable significant agreement in all sensory characters of the product The highest w value were found to be 0 83 for taste followed by appearance (0 62) colour (0 57) flavour (0 50) and texture (0 49)

### *4 4 2 2 Changes in the Organoleptic Qualities of Bilimbi Pickle during Storage*

Organoleptic qualities of bilimbi pickle was found to change considerably with respect to quality attribute viz appearance colour flavour texture and taste The data obtained is depicted in Table 17 and figure 13

Table 17 Effect of storage on various quality attributes of bilimbi pickle

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | w value |
| Appearance | 5 | 4 8 | 4 7 | 4 5 | 4 3 | 4 | 0 59 |
| Colour | 5 | 4 8 | 4 6 | 4 4 | 4 2 | 4 | 0 60 |
| Flavour | 5 | 4 7 | 4 5 | 4 1 | 3 8 | 3 6 | 0 55 |
| Texture | 5 | 4 7 | 4 | 3 8 | 3 5 | 3 2 | 0 75 |
| Taste | 5 | 4 8 | 4 6 | 4 4 | 4 | 3 7 | 0 74 |
| Overall acceptability | 5 | 4 76 | 4 48 | 4 24 | 3 96 | 3 7 | |

From the result it was found that the scores obtained for appearance of pickle decreased over a period of six months The maximum score (5) was obtained during the first month (cent per cent) and it was reduced to 80 per cent (score 4) by the sixth month

For colour of pickle highest score (5) was obtained during the first month (cent percent) Only a marginal decrease was noted during the second month (score 4 8) In the third month a slight variation was observed and the score was reduced to 92 per cent (score 4 6) and to 88 per cent (score 4 4) by the fourth month From the fourth month onwards a slow rate of decrease in score value for colour of pickle was noted

When the flavour of sample was assessed on various storage period it was appreciable to note that the flavour of bilimbi pickle scored maximum by first month Score rate was reduced to 94 per cent (score 4 7) by the second month and then 90 per cent (score 4 5) by the third month Further decrease of eight per cent was noticed by the fourth month (score 4 1) On the fifth and sixth month the reduction in score obtained for flavour was 24 per cent (score 3 8) and 28 per cent (score 3 6) respectively

Considering the texture of bilimbi pickle superior score (5) was obtained during the first month (cent percent) Only a slight reduction in score (4 7) was recorded by the second month The score for texture was reduced to 3 2 by the sixth month

In the present study the pickle was found to be good (score 5) at first month and the score reduced to 4 4 during the fourth month On the fifth and sixth month the reduction in score obtained was 20 per cent (score 4) and 26 per cent (score 3 7) respectively

On verifying the values the overall acceptability was good at first month and thereafter a small reduction in score was noted during the progress of storage period

From the study it was clear that there was significant agreement observed in all sensory characters of pickle The highest w value were found to be 0 75 for texture followed by taste (0 74) colour (0 60) appearance (0 59) and flavour (0 55)

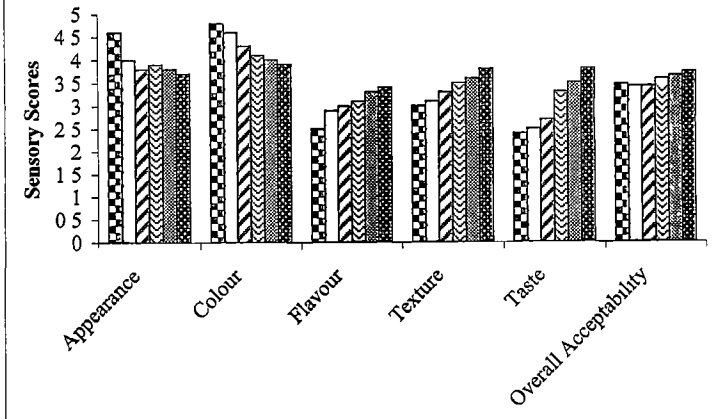



**Fig 12 Changes in the organoleptic qualities of bilimbi jam during storage**

**Storage period (Months)** I II III IV V VI

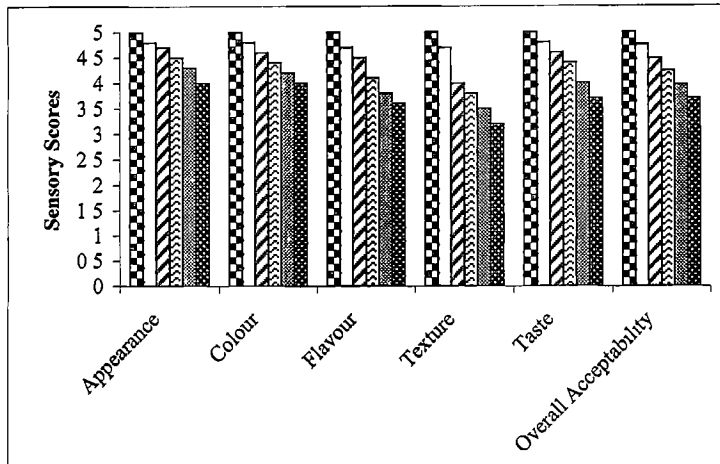



**Fig 13 Changes in the organoleptic qualities of bilimbi pickle during storage**

**Storage period (Months)** I II III IV V VI

### *4 4 2 3 Changes in the Organoleptic Qualities of Roseapple Squash (rose) during Storage*

The data obtained on monthly observation related to the roseapple squash (rose) on storage is presented in the Table 18 and figure 14

Table 18 Effect of storage on various quality attributes of roseapple squash (rose)

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | w value |
| Appearance | 5 | 4 8 | 4 6 | 4 4 | 4 1 | 3 7 | 0 70 |
| Colour | 5 | 4 8 | 4 6 | 4 3 | 4 | 3 7 | 0 71 |
| Flavour | 5 | 4 7 | 4 4 | 4 | 3 3 | 3 | 0 88 |
| Texture | 4 8 | 4 4 | 4 1 | 3 8 | 3 6 | 3 3 | 0 70 |
| Taste | 5 | 4 7 | 4 1 | 3 8 | 3 2 | 3 | 0 88 |
| Overall acceptability | 4 96 | 4 68 | 4 36 | 4 06 | 3 64 | 3 34 | |

The results presented in Table 18 revealed that the mean panellist score for appearance and colour of roseapple squash decreased on storage The highest score (5) was obtained during the first month (cent percent) Only a slight reduction in score (4 8) was observed in the second month A linear decrease was observed further and the score was 88 per cent (score 4 4) and 86 per cent (score 4 3) at fourth month for appearance and colour respectively and both attained 74 per cent (score 3 7) by the end of storage period

The mean scores for flavour intensity of roseapple squash (rose) was maintained at the higher level during the first two months The percentage score for flavour was reduced from 80 per cent to 60 per cent (score 4 to 3) during fourth to sixth month of storage

Coming to the texture of squash highest score (4 8) was obtained during the first month (96 percent) The score was reduced to 88 per cent (score 4 4) by the second month From the third month onwards a moderate rate of decrease was noted and stood at a level of 66 per cent (score 3 3) during the sixth month

From the result it could be seen that the taste of squash was highly acceptable with score 5 at first month and reduced to score 4 1 during third month It could be observed that even in the sixth month of storage the score for taste was maintained to 60 percent (score 3)

The overall acceptability of roseapple squash (rose) was described as having only a gradual decrease from 99 per cent to 66 percent (score 4 96 to 3 34) Superior score was maintained even on the fourth month the percentage of score obtained being 80 percent (score 4) From the fourth month onwards a slow rate of decrease in overall acceptability was noted reflecting the slight reduction in various qualities tested

Significant agreement was noticed between the judges in all the sensory characters of the product The highest w value were found to be 0 88 for both flavour and taste followed by 0 71 for colour The w value obtained for appearance and texture were 0 70 each

#### *4 4 2 4 Changes in the Organoleptic Qualities of Roseapple Squash (white) during Storage*

The results of periodical examination of roseapple squash (white) pertaining to the different sensory characters are depicted in Table 19 and figure 15

Table 19 Effect of storage on various quality attributes of roseapple squash (white)

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | w value |
| Appearance | 5 | 4 7 | 4 5 | 4 3 | 4 | 3 6 | 0 74 |
| Colour | 4 6 | 4 4 | 4 2 | 4 | 3 3 | 3 | 0 79 |
| Flavour | 5 | 4 8 | 4 3 | 3 9 | 3 4 | 3 | 0 87 |
| Texture | 5 | 4 3 | 4 | 3 8 | 3 5 | 3 3 | 0 78 |
| Taste | 4 9 | 4 | 3 7 | 3 5 | 3 2 | 3 | 0 80 |
| Overall acceptability | 4 9 | 4 44 | 4 14 | 3 9 | 3 48 | 3 18 | |

The periodical evaluation of squash recorded a fluctuation in appearance during the storage period The percentage score decreased from 100 per cent to 72 per cent (score 5 to 3 6) by the end of sixth month of storage

The colour of squash was superior during the first two months being scored 92 per cent (score 4 6) and 88 per cent (score 4 4)respectively Acceptability score with respect to colour was reduced to 60 per cent (score 3)by the end of storage period

Flavour and texture attribute was studied to be varying during storage Highest score (5) was obtained during the first month (cent per cent)

and it was gradually lowered to 60 per cent (score 3 ) and 66 per cent (score 3 3) with respect to flavour and texture by the end of sixth month

The taste score was maximum (score 4 9) during the first month (98 per cent) and it was reduced to 80 per cent (score 4) during the second month Gradual decrease was noted on the subsequent months The score at the end of the storage period was observed to be 60 per cent (score 3)

As per the result obtained from judges for sensory evaluation the overall acceptability of squash varied from 98 per cent to 62 per cent (score 4 9 to 3 18) during the storage period It was noticed from the Table 19 that there was moderate noticeable reduction in scores in the overall acceptability during the consequent months

The study revealed that there was notable significant agreement in all sensory characters of the product The highest w value were found to be 0 87 for flavour followed by taste (0 80) colour (0 79) texture (0 78) and appearance (0 74)

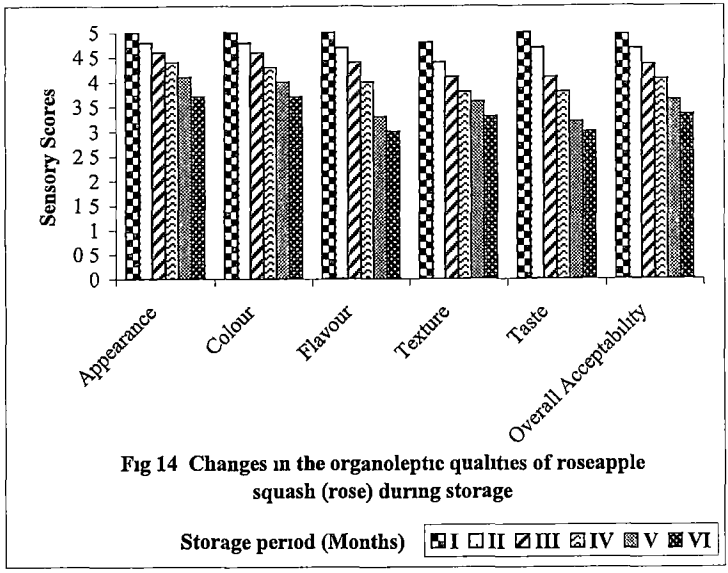



**Fig 14 Changes in the organoleptic qualities of roseapple squash (rose) during storage**

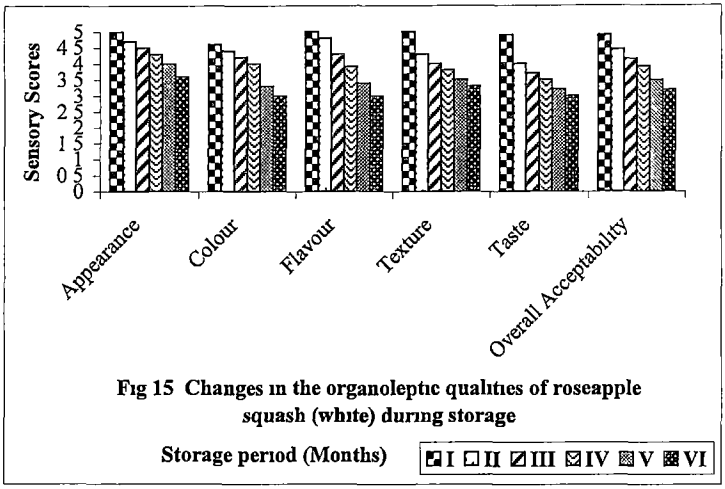



**Fig 15 Changes in the organoleptic qualities of roseapple squash (white) during storage**

### *4 4 2 5 Changes in the Organoleptic Qualities of Lovi lovi Preserve in Sugar during Storage*

Influence of storage on the organoleptic qualities of lovi lovi preserve in sugar was assessed through sensory evaluation tests Table 20 and figure 16 depicts the mean scores of the organoleptic qualities of preserve during the storage period of six months

Table 20 Effect of Storage on Various Quality Attributes of Lovi lovi Preserve in Sugar

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | w value |
| Appearance | 5 | 4 8 | 4 6 | 4 3 | 4 | 3 7 | 0 72 |
| Colour | 5 | 4 8 | 4 6 | 4 4 | 4 | 3 7 | 0 73 |
| Flavour | 2 8 | 3 | 3 2 | 3 5 | 3 7 | 4 | 0 67 |
| Texture | 2 7 | 3 | 3 2 | 3 5 | 3 8 | 4 | 0 70 |
| Taste | 2 8 | 3 | 3 2 | 3 4 | 3 7 | 4 | 0 67 |
| Overall acceptability | 3 66 | 3 72 | 3 76 | 3 82 | 3 84 | 3 88 | |

The maximum score (5) of cent per cent was obtained for both appearance and colour during the first month This value was reduced to 74 per cent (score 3 7) at the end of storage study for both characters

Coming to flavour and texture of preserve as depicted in Table 20 both attained maximum score (4) in the sixth month The percentage score

for flavour was enhanced from 56 per cent to 80 per cent (score 2 8 to 4) while for texture the increase was from 54 per cent to 80 per cent (score 2 7 to 4)

From the Table 20 it is evident that the taste value increased on storage The increase was from 56 per cent (score 2 8) on the first month to 80 per cent (score 4)on the sixth month The maximum score for taste was retained at the sixth month also

In accordance with the trend exhibited by the various quality attributes the overall acceptability of preserve also increased making a variation from 72 per cent to 76 percent (score 3 66 to 3 88) There was a sharp increase right from the first month itself with maximum score being attained during the sixth month and was maintained well

The study revealed that there was notable significant agreement in all sensory characters of the product The highest w value were found to be 0 73 fo colour followed by appearance (0 72) and texture (0 70) The least w value was obtained for taste and flavour (0 67)

### *4 4 2 6 Changes in the Organoleptic Qualities of Lovi lovi in Brine during Storage*

Variation in score pertaining to the various sensory qualities of lovi lovi in brine during storage is presented in Table 21 and depicted in figure 17

Table 21 Effect of storage on various quality attributes of lovi lovi in brine

| Quality attributes | Storage period (Months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | W value |
| Appearance | 5 | 4 7 | 4 5 | 4 3 | 4 | 3 7 | 0 69 |
| Colour | 5 | 4 8 | 4 6 | 4 3 | 4 | 3 7 | 0 71 |
| Flavour | 4 | 3 8 | 3 6 | 3 2 | 3 | 2 7 | 0 73 |
| Texture | 4 | 4 3 | 5 | 4 6 | 3 5 | 3 3 | 0 76 |
| Taste | 4 | 4 3 | 4 8 | 4 6 | 3 4 | 3 1 | 0 77 |
| Overall acceptability | 4 4 | 4 38 | 4 5 | 4 2 | 3 58 | 3 3 | |

Concentrating on the score level for appearance and colour of brine it could be seen that the maximum highest score (5) was maintained at the first month (cent percent) A slight reduction in score (six per cent) and (four per cent) with respect to appearance and colour (score 4 7 and 4 8) was observed by the second month respectively A score of 74 per cent (score 3 7) for appearance and colour was obtained by the end of storage period during the sixth month

Coming to the flavour highest score was obtained during the first month (score 4) The score was reduced to 76 per cent (score 3 8)by the second month There was a gradual decrease in flavour from first month to sixth month and stood at a level of 54 per cent (score 2 7) by sixth month

As per the result obtained from the judges for sensory evaluation the score count for both texture and taste was 80 per cent (score 4)

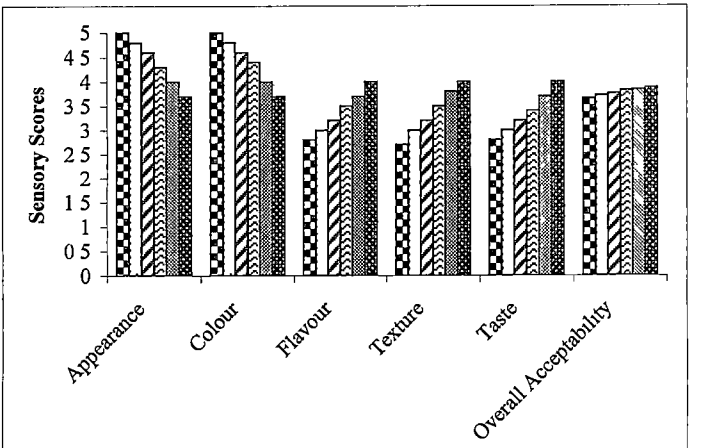



**Fig 16 Changes in the organoleptic qualities of lovi lovi preserve in sugar (sweet) during storage**

**Storage period (Months)**

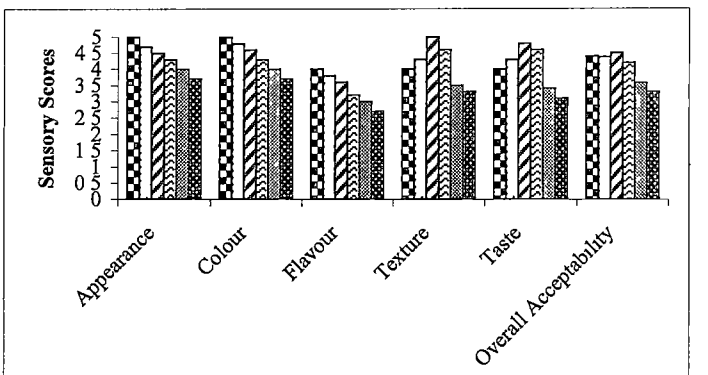



**Fig 17 Changes in the organoleptic qualities of lovi lovi in brine (sour) during storage**

**Storage period (Months)**

during the first month and it was increased by six per cent (score 4 3) during the second month Further increase in scores were noted and the scores were found to be cent per cent (score 5) and 96 per cent (score 4 8) for texture and taste respectively during the third month Gradual decrease was noted on the subsequent months The score at the end of the storage period was observed to be 66 per cent (score 3 3) and 62 per cent (score 3 1) for texture and taste respectively

On assessing the organoleptic qualities of lovi lovi in brine it was found that all the quality attributes except texture and taste attained maximum scores (5) during the first month The overall acceptability varied from 88 per cent to 66 per cent (score 4 4 to 3 3) during the storage period It was noticed from the Table 21 that there was initial increase in score from the first month to third month and further decrease in score upto the sixth month of storage

Significant agreement was noticed between the judges in all the sensory characters of the product The highest w value were found to be 0 77 for taste followed by texture (0 76) flavour (0 73) colour (0 71) and appearance (0 69)

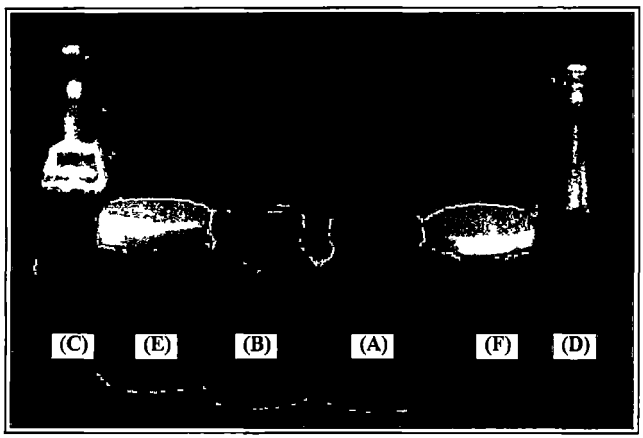



Plate 4 Selected products prepared from different underexploited fruits
(A) Bilimbi jam
(B) Bilimbi pickle
(C) Roseapple (rose) fruit squash
(D) Roseapple (white) fruit squash
(E) Lovi lovi (sweet) fruit preserve in sugar
(F) Lovi lov (sour) fruit in brine

### 4 4 3 Assessment of Microbial Contamination of the Stored Products

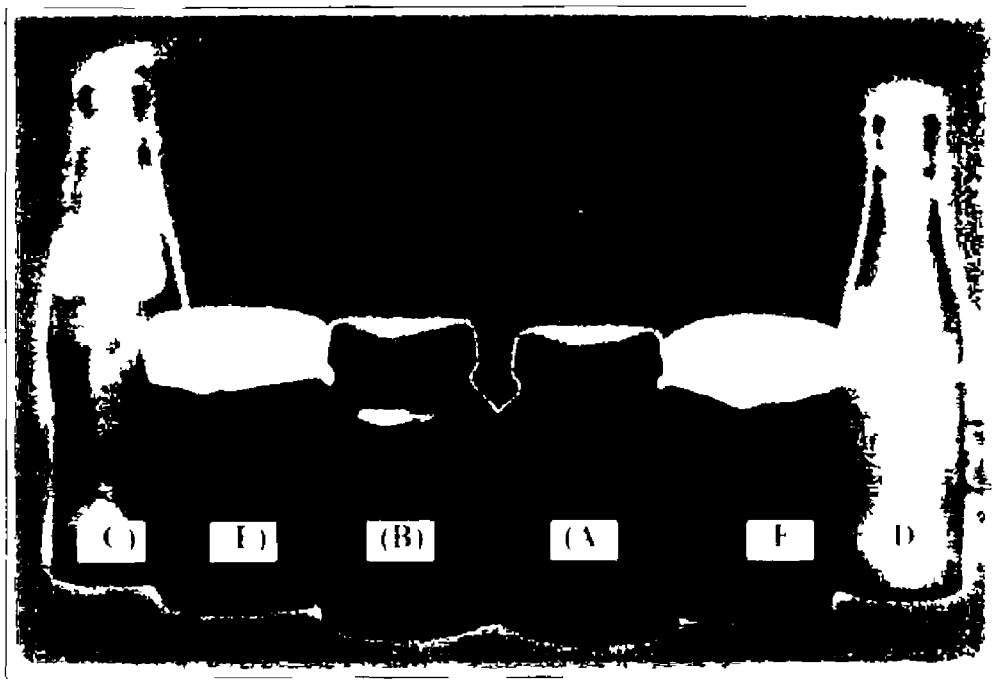
The microbial examination of the products prepared from bilimbi such as jam and pickle failed to show the presence of micro organisms even at the end of sixth month of storage (Table 22) This is a positive indication for the safe use of bilimbi products over six months under ambient storage conditions

The periodical testing for microbial count for both types of roseapple squash revealed complete absence of microbial counts during the entire period of storage This results offer a good outlet for roseapple to be converted into a shelf stable relishing product

No visible presence of microflora was observed in lovi lovi preserve in sugar and lovi lovi in brine which confirmed the safety of the products

Table 22 Assessment of Microbial Contamination of the Stored Products

| Fruit products | Microbial count during storage | | |
|---|---|---|---|
| | First month of storage | Third month of storage | Sixth month of storage |
| Bilimbi jam<br>Bilimbi pickle<br>Roseapple squash (rose)<br>Roseapple squash (white)<br>Lovi lovi preserve in sugar<br>Lovi lovi in brine | Nil | Nil | Nil |


C
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# Discussion

# 5 DISCUSSION

Many underexploited fruits are of enormous economic value either as fresh or after processing These minor fruits posses immense nutritional importance which are also important for food industry Many of these minor fruits are highly perishable Therefore emphasis should be given to these underexploited minor fruits which are not easily marketed in the fresh form These should be processed and preserved so that the growers get a remunerative price and consumers all over the world get the opportunity to enjoy the fruit in the form of its products

The fruits of bilimbi are very sour and can be used for making pickles preserves etc Roseapple is a spongy and aromatic fruit which has a creamy white or pinkish red colour The fruit does not have much of commercial value but can be used for developing value added products The fruits of lovi lovi are either sour or sweet as well as astringent

Hence the study is proposed to evaluate the quality characters nutritive value and to develop value added products of selected fruits (bilimbi roseapple and lovi lovi) and to study their keeping qualities The research programme was conducted and the results of which are discussed below

## 5 1 PHYSICO CHEMICAL CHARACTERISTICS OF BILIMBI ROSEAPPLE AND LOVI LOVI

The physico chemical characteristics of selected under exploited fruits were analysed to study the nature of the fruits

Bilimbi is a small cucumber shaped fruit used for edible purpose On physical examination the colour of the bilimbi fruit was

observed to be green with pale green pulp colour Morton (1987) reported that fruit is crisp when unripe turns from bright green to yellowish green when ripe He further reported that the outer skin of bilimbi is glossy very thin soft and tender and the flesh green jelly like juicy and extremely acidic in nature The number of fruits per 100 g was counted as fifteen and the count shows that bilimbi is a small sized fruit

The chemical composition of the fresh fruit reveals that bilimbi is a juicy fruit having moisture content of 94 16 per cent The calcium and potassium contents in bilimbi was 3 43 mg 100 $g^{1}$ and 20 33 mg 100 g respectively These values were found to be almost similar to the value reported by Morton (1987)

The analysis showed that bilimbi fruit had low fibre (0 61 g 100 g ) protein (0 60 g 100 $g^{1}$) starch (1 69 g 100 $g^{1}$) phosphorus (11 16 mg 100 g ) iron (1 06 mg 100 $g^{1}$) β carotene (19 00 µg 100 $g^{1}$) The results of chemical composition were found to be in accordance with the report of Gopalan *et al* (1989) in bilimbi fruit

Singh *et al* (1998) found that 13 5 mg 100 $g^{1}$ vitamin C 7 2 $^{0}$brix TSS 0 81 per cent acidity and 7 1 per cent total sugar were found in bilimbi fruit But in the present study bilimbi fruit had lesser vitamin C content (11 41 mg 100 $g^{1}$) TSS (4 63 $^{0}$brix) lesser total sugar (3 17 %) and higher acidity (2 50 %) The difference in content may be due to the variation in local soil or climatic conditions Further 1 88 per cent of reducing sugar and 1 29 per cent of non reducing sugar were found in bilimbi fruit which were in accordance with results reported by Lima *et al* (2001)

Roseapple is almost round or a little longer fruit used for edible purpose The rosy red roseapple with pink pulp and creamy white roseapple with cream white pulp were observed Firm and crunchy qualities

of large sized roseapple had a count value of seven and nine fruits per 100 g in case of white and rose roseapples respectively Popenoe (1974) reported pink pulp in round roseapple He also observed the crunchy quality of roseapple

On chemical analysis roseapple (rose and white) had nutritional content of protein (0 52g 100 $g^{1}$ to 0 70 g 100 g ) calcium (36 mg 100 g to 41 5 mg 100$g^{1}$) iron (0 53 mg 100 g to 1 06 mg 100 g ) βcarotene (121 66 µg 100 $g^{1}$ to 137 66 µg 100 $g^{1}$) vitamin C (12 26 mg 100 g to 13 06 mg 100 $g^{1}$) and fibre (1 16 g 100 g to 1 63 g 100 $g^{1}$) These findings were in accordance with the values reported by Gopalan *et al* (1989) except for calcium and vitamin C With regard to calcium and vitamin C Gopalan *et al* (1989) reported that roseapple had low calcium and vitamin C content (10 mg 100 $g^{1}$ and 3 mg 100 $g^{1}$) Mandal (1997) observed fairly high ratios of sugar and acid in roseapple fruits In the present study it was found that roseapple contains acidity (1 23 % to 1 38 %) total sugar (3 04 % to 3 10 %) reducing sugar (1 71 % to 1 77 %) and non reducing sugar (1 32 % to 1 32 %)

The present finding suggest that starch (1 53 g 100 g to 1 59 g 100 $g^{1}$) moisture (85 33 % to 87 33 %) phosphorus (?4 33 mg 100 $g^{1}$ to 28 16 mg 100 g ) potassium (42 50 mg 100 g to 50 33 mg 100 g ) and TSS (6 10 $^{0}$brix to 7 06 $^{0}$brix) were found in roseapple This report is again in accordance with the result of Popenoe (1974)

Lovi lovi a minor fruit of Kerala homesteads having very attractive red to purplish red colour with pink coloured pulp is suitable for various product formulation The soft small sized lovi lovi fruit has a count of 16 24 fruits per 100 g The above observations are in accordance with the study of Prasad (1998)

From the chemical examination it was noted that lovi lovi fruit had a moisture content of 84 16 per cent to 85 5 per cent fibre content of 1 1 g 100g $^{1}$ to 1 23 g 100 g and protein content of 0 35 g 100 g to 0 51 g 100 g $^{1}$ These values were more or less similar to the report of CSIR (1956) In the present study good amount of TSS (10 10 $^{0}$brix to 20 10 $^{0}$brix) total sugar (2 94 % to 15 62 %) reducing sugar (1 79 % to 10 00 %) and non reducing sugar (1 14 % to 5 62 %) were found in lovi lovi Prasad (1998) studied that lovi lovi contained TSS (10 5 $^{0}$brix to 20 4 $^{0}$brix) total sugar (2 96 % to 16 64 %) reducing sugar (1 8 % to 10 43 %) and non reducing sugar (1 16 % to 6 21 %) which were more or less similar to the values obtained from the findings

## 5 2 SENSORY EVALUATION OF SELECTED UNDEREXPLOITED FRUITS

The sensory evaluation of the fruit is assumed to be of great significance as this provides information which can be utilized for product development and its improvement Sensory quality is one of the criteria for acceptability of any fruit by consumers (Srilakshmi 1997) The acceptability of fruits were studied in detail by conducting sensory evaluation test

According to Ranganna (1986) appearance is one of the major factors leading to the increasing demand of the fruit With regard to appearance lovi lovi (sweet) and roseapple (rose) were having best sensory score followed by lovi lovi (sour) and roseapple (white) The least preferred fruit was bilimbi

The first impression of the fruit is usually visual and major part of our willingness to accept a fruit depends upon its colour (Francis 1977) Colour is used as an index to the quality of a number of foods

Colour increases the attractiveness of fruit and in most cases it is used as a maturity index (Srivastava and Sanjeev 2002)

Ranganna (1986) stated that flavour is a unique character of odour and taste of fruit which ultimately determines the quality and acceptability of fruit In the present study roseapple (rose) due to its attractive rosy red colour were found to be best followed by roseapple (white) when judged in terms of colour and flavour Bilimbi fruit was again found to be the least preferred

According to Ranganna (1986) texture is the property of fruit which is associated with sense of feel or touch experienced by the fingers or the mouth which requires considerable trained personal Taste is another major attribute which determines the acceptability of fruit With regard to texture and taste bilimbi was found to be less preferred due to its acidic taste Morton (1987) reported that bilimbi is generally regarded as too acidic in nature Present study shows that lovi lovi (sweet) followed by roseapple (rose) were found to be best preferred George *et al* (1999) reported that pleasant tart flavour and medium sweetness of sweet lovi lovi makes it more acceptable by the consumers

Overall acceptability of fruit depend upon the above mentioned sensory attributes In this aspect roseapple (rose) had highest overall acceptability followed by roseapple (white) lovi lovi (sweet) lovi lovi (sour) and the least bilimbi

Hence with regard to different sensory qualities as persued by panelists the judges showed high degree of agreement at one percent level for all sensory qualities except appearance Since appearance is a phenomenon which is of a complex nature involving all the individual characteristics studied and hence appearance showed less degree of agreement The fruits that were considered for the study also varied widely

with regard to the shape size colour taste texture and flavour Hence it is immaterial that appearance be judged on a uniform rating But other parameters like colour texture flavour and taste have to suit the consumer which when only presented in an attractive colour flavour texture taste etc will be of much use

## 5 3 DEVELOPMENT OF PRODUCTS USING BILIMBI ROSEAPPLE AND LOVI LOVI

Vaidehi *et al* (1977) opined that for proper utilization of fruit products available in our country necessary study for utilization of any product should be conducted Fruit products from certain unfamiliar fruits have been developed successfully by earlier workers (Majeed 1995 Pal 1995 and Hema 1997) Therefore as an effort towards utilization and popularisation of different fruit products from bilimbi roseapple and lovi lovi were attempted Accordingly the fruit products developed in the present study are

a) Bilimbi jam
b) Bilimbi pickle
c) Roseapple squash (rose)
d) Roseapple squash (white)
e) Lovi lovi preserve in sugar (sweet)
f) Lovi lovi in brine (sour)

## 5 4 INDEPTH STUDIES ON SELECTED MINOR FRUIT PRODUCTS

### 5 4 1 Chemical Composition of Minor Fruit Products

It is always considered better to observe the nutrient quality of fruit products and necessary measures to maintain them at optimum possible levels are also important With this aim the freshly prepared products were analysed for its chemical composition and are discussed below

The chemical composition of bilimbi jam in the present study were in accordance with the values reported by Tripathi *et al* (1988) in amla jam The prepared jam had a composition of 76 1 $^{0}$brix TSS 1 54 per cent acidity 9 65 mg 100 g $^{1}$ vitamin C 36 63 per cent reducing sugar 28 02 per cent non reducing sugar and 64 66 per cent total sugar

On analysis of the pickle prepared from bilimbi its composition was observed with a TSS of 25 10 $^{0}$brix acidity (1 22 %) vitamin C (10 13 mg 100 g $^{1}$) total sugar (2 58 %) reducing sugar (1 46 %) and non reducing sugar (1 12 %) The above result support to the findings of Bhasin and Bhatia (1981)

The prepared roseapple squash from rose coloured fruits contained a TSS (45 03 $^{0}$brix) acidity (3 06 %) vitamin C (10 13 mg 100 g $^{1}$) total sugar (41 20 %) reducing sugar (26 77 %) and non reducing sugar (14 43%) The results thus obtained support to the findings of Wasker and Khurdiya (1987) who reported that phalsa squash had a TSS (40 73 $^{0}$brix) acidity (1 51 %) total sugar (36 60 %) reducing sugar (22 25 %) and non reducing sugar (14 35 %)

From the analysis it was found that white roseapple squash exhibited a TSS of 48 03 $^{0}$brix acidity 2 06 per cent vitamin C (10 46 mg 100 g $^{1}$) total sugar (43 35 %) reducing sugar (30 02 %) and non reducing sugar of 13 32 per cent These values are in agreement with the levels reported for squash prepared from bael fruit by Jain *et al* (1984) The bael squash contained a TSS of 50 $^{0}$brix acidity 0 48 per cent total sugar (57 42 %) reducing sugar (38 53 %) and non reducing sugar (18 89 %)

As per the analysis it was found that lovi lovi preserve in sugar exhibited TSS 70 06 $^{0}$brix 0 98 per cent acidity 18 56 mg 100 g $^{1}$ vitamin C reducing sugar 30 01 per cent non reducing sugar

30 41 percent total sugar 60 43 percent These analysed values are in agreement with the levels reported for preserve prepared from amla by Tripathi *et al* (1988) In these study amla preserve gave TSS 72 $^{0}$brix 0 92 per cent acidity 112 28 mg 100 g $^{1}$ vitamin C reducing sugar 34 56 per cent non reducing sugar 31 02 percent and total sugar of 65 58 per cent

As per the result it was found that lovi lovi in brine exhibited a TSS of 15 10 $^{0}$brix acidity (1 26 %) vitamin C (8 26 mg 100 g $^{1}$) total sugar (2 65 %) reducing sugar (1 42 %) and non reducing sugar (1 23 %) This result support the findings of Kalra (1988) in brine prepared from amla

**5 4 2 Confirmation with FPO Requirements**

The present study satisfied the FPO requirements for all products prepared from selected underexploited fruits Similar FPO confirmations were reported by several workers for different minor fruit products (Sheeja 1994 Majeed 1995 Pal 1995 and Hema 1997)

**5 4 3 Cost Analysis of the Products**

In relation to cost analysis the present investigation pointed out that lovi lovi in brine was the cheapest product (Rs 25 6) followed by bilimbi pickle (Rs 35 44) bilimbi jam (Rs 37 47) both roseapple squashes (Rs 39 21) and lovi lovi preserve in sugar (Rs 50 45) The above result shows that the maximum expense was observed for production of lovi lovi preserve in sugar Saima (2002) also observed the same expense (Rs 50) for the production of amla preserve Karonda jelly and candy prepared by Majeed (1995) showed cost value of Rs 26 and Rs 19 respectively Hema (1997) reported the cost of squash prepared from

jamun as Rs 33 30 This value will be comparable to roseapple squash prepared in the present study

### 5 4 4 Fruit Product Yield Ratio

In present study fruit product yield ratio showed highest yield for both rose and white roseapple squash (1 1 8 and 1 1 75) respectively and the lowest yield for bilimbi pickle (1 1 25) Majeed (1995) reported fruit product yield ratio of 5 4 and 20 17 with respect to Karonda jelly and candy Pal (1995) found fruit product yield ratio of 1 1 2 and 1 0 60 for passion fruit RTS beverage and passion fruit rind jelly Hema (1997) got 1 0 9 for jamun squash and 1 1 6 for jamun RTS beverage

### 5 4 5 Changes in the Chemical Qualities of Minor Fruit Products during Storage

#### *5 4 5 1 Changes in Chemical Qualities of Bilimbi Jam during Storage*

The various chemical changes related to processing of bilimbi jam were studied and it was observed that most of the chemical constituent increased in jam product during storage period

In the present study there was increasing trend for TSS from 76 1 $^{0}$brix to 78 53 $^{0}$brix during storage which was similar to the finding reported by Tripathi *et al* (1988) The increase in acidity from 1 54 per cent to 2 61 per cent was observed in bilimbi jam during storage This may be due to the formation of organic acid by ascorbic acid degradation (Sheeja 1994)

The value of vitamin C was observed to be descending with the advancement of storage period from 9 65 mg 100 g to

7 89 mg 100 g Tripathi *et al* (1988) reported similar change in vitamin C in amla jam during storage

Variation in reducing sugar and total sugar in a stored fruit product is reported to be an index of acid hydrolysis of sucrose by Labuza *et al* (1970) Increase in reducing sugar along with total sugar was observed from 36 63 per cent to 44 18 per cent and 64 66 per cent to 68 78 per cent respectively during storage of bilimbi jam These changes might be attributed to increased degree of inversion of sugar on account of higher fixed acidity

While studying the non reducing sugar of bilimbi jam it revealed that non reducing sugar decreased with increase in storage period The decrease varied from 28 02 per cent to 24 6 per cent during storage Similar findings were reported in amla jam by Tripathi *et al* (1988)

Thus it could be observed that jam developed using bilimbi possessed standard qualities with respect to chemical attributes and was comparable with similar established products in its shelf life

### *5 4 5 2 Changes in Chemical Qualities of Bilimbi Pickle during Storage*

Pickling is one of the oldest method of preserving fruits or vegetables in common salt oil vinegar and citrus juice Variations noted in the various chemical constituents of bilimbi pickle during different storage period are discussed below

Pertaining to total soluble solids in bilimbi pickle an increase was recorded as storage period advanced The value increased from 25 10 $^{0}$brix to 29 10 $^{0}$brix

An increase in acidity was observed from 1 22 per cent to 2 21 per cent in pickle during storage This change may be due to fermentation of pickle which was reported by Bhasin and Bhatia (1981)

The reduction in vitamin C content was observed from 10 13 mg 100 $g^{1}$ to 6 13 mg 100 g during different storage period This result was similar to the findings reported by Kalra (1988)

While examining the results of total sugar of pickle it was revealed that total sugar decreased from 2 85 per cent to 2 50 per cent with increase in storage period This observation was found to be almost similar to the result reported by Bhasin and Bhatia (1981)

In the present study there was a decrease in reducing sugar from 1 46 per cent to 1 33 per cent and an increase in non reducing sugar from 1 12 per cent to 1 17 per cent This observation was found to be almost similar to the findings reported by Kalra (1988)

Thus the performance of different chemical constituents in bilimbi pickle showed clear indication that no undesirable changes had taken place upto six months of storage

### *5 4 5 3 Changes in Chemical Qualities of Roseapple Squash (rose) during Storage*

Changes in major chemical components of roseapple (rose) squash during storage were analysed over a period of six months

The periodical testing for TSS of squash showed upward trend in the value with the increase in storage period TSS increase was from 45 03 $^{0}$brix to 47 93 $^{0}$brix This increased value in TSS on storage might be due to hydrolysis of polysaccharides and concentration due to

dehydration Similar increase in TSS during storage was reported in jamun squash by Hema (1997)

Acidity in squash showed gradual and steady increase during storage from 3 06 per cent to 3 88 per cent This increase in acidity may be due to the interaction of organic acids present in the squash Storage studies conducted by Sethi and Maini (1991) had revealed similar findings in mango squash

There was decline in the vitamin C content of squash during storage from 10 13 mg 100 g to 5 53 mg 100 g Since vitamin C is a strong antioxidant and it oxidises itself resulting in the high decline of vitamin C during storage Kalra *et al* (1991) reported that during storage vitamin C content decreased by 50 per cent in all marked drinks except guava in which the vitamin C retention was better

The total sugar reducing sugar and non reducing sugar of squash upto six months of storage was studied A small rise in total sugar and reducing sugar and a small fall in non reducing sugar of the prepared squash have been observed at the end of storage period This report during storage have been observed earlier by many workers Wasker and Khurdiya (1987) has observed a gradual increase in the total sugar and reducing sugar and decrease in non reducing sugar in phalsa squash during storage Similar findings were reported by Hema (1997) during the entire storage period of jamun squash

On analysing the changes in the chemical components of roseapple squash during the storage period of six months there was decrease in vitamin C and non reducing sugar whereas TSS acidity reducing sugar total sugar was found to have an increase Thus the keeping quality of squash improved on storage and possessed good quality on six months storage

### *5 4 5 4 Changes in Chemical Qualities of Roseapple Squash (white) during Storage*

The compositional changes in roseapple (white) squash under study was assessed for a period of six months at regular intervals The assessment revealed an increase in TSS from 48 03 $^{0}$brix to 50 9 $^{0}$brix during entire storage period The possible reason for this increase could be the degradation of starch into simple sugars Mehta and Bajaj (1983) reported and confirmed the same reason in kiwi fruit squash Such upward trend in TSS of phalsa squash was also observed by Wasker and Khurdiya (1987)

The data pertaining to the acidity of squash under study indicated a slow and linear increase from 2 06 per cent to 2 85 per cent This finding in acidity changes of squash during storage is exactly in tune with that reported by Hema (1997)

A decrease in vitamin C content from 10 46 mg 100 $g^{1}$ to 6 7 mg 100 g was observed through out the entire storage period Kalra *et al* (1991) had revealed similar findings in many market drinks Jain *et al* (1984) reported that the decrease in vitamin C during storage period which might be assigned to the actions of temperature and oxidative processes

In the present study there was increase in total sugar from 43 35 per cent to 47 46 per cent reducing sugar from 30 02 per cent to 36 62 per cent and decrease in non reducing sugar from 13 32 per cent to 10 83 per cent during storage The increase in total sugar and reducing sugar content during storage period could be attributed to gradual inversion of non reducing sugars Jain *et al* (1988) observed the same aspect for increase in total sugar and reducing sugar in litchi squash

As a result of experiment conducted it could be observed that the quality of roseapple (white) squash improved on storage

### *5 4 5 5 Changes in Chemical Qualities of Lovi lovi Preserve in Sugar during Storage*

During storage various changes occured in the major chemical constituents in lovi lovi preserve These changes are discussed below

Monthly evaluation for TSS of lovi lovi preserve performed increasing trend in the value with increase in storage period The increase in TSS was from 70 06 $^{0}$brix to 73 93 $^{0}$brix Similar increase in TSS during storage was reported in amla preserve by Singh *et al* (1999)

The data pertaining to the acidity of preserve under study indicated a decrease from 0 98 per cent to 0 68 per cent during storage period This finding on acidity changes in preserve during storage is similar to the result reported by Tripathi *et al* (1988) in amla preserve

There was decline in the ascorbic acid content of preserve during storage from 18 56 mg 100 g $^{1}$ to 12 93 mg 100 g $^{1}$ Tripathi *et al* (1988) also reported that during storage of amla preserve vitamin C content decreased from 112 28 mg 100 g $^{1}$ to 84 60 mg 100 g Similar decline in vitamin C was observed in amla preserve by Saima (2002)

In the present study there was increase in total sugar from 60 43 per cent to 63 03 per cent and reducing sugar from 30 01 per cent to 34 22 per cent during storage This increase might be attributed to increased degree of inversion of sugar on account of higher fixed acidity which was reported by Tripathi *et al* (1988) A decrease trend in non reducing sugar was noticed during different storage periods The above findings with reference to changes in sugar level were similar to the result reported by Tripathi *et al* (1988) and Saima (2002) in amla preserve

In a nutshell considering the chemical changes in preserve there was increase in TSS reducing sugar and total sugar during storage in contrast to decrease in acidity vitamin C and non reducing sugar Thus the preserve remained highly sound for a period of six months as there was no description of undesirable changes in chemical constituents

### *5 4 5 6 Changes in Chemical Qualities of Lovi lovi in Brine during Storage*

Brine product are more susceptible to changes in the chemical components during storage Changes in storage studied in lovi lovi preserved in brine are discussed below

Pertaining to TSS in lovi lovi brine it was found to increase from 15 1 $^{0}$brix to 19 0 $^{0}$brix during different storage period

The present study indicates that an increase in acidity was observed from 1 26 per cent to 2 85 per cent during storage According to Kalra (1988) brine treatment of the fruit increase the acidity during storage

The value of vitamin C was found to be decreasing from 8 26 mg 100 $g^{1}$ to 4 60 mg 100 $g^{1}$ with advancement of storage period Kalra (1988) reported that brine treatment of the fruit destroy the ascorbic acid content during storage

On analysing the changes in the sugar level of brine during the storage period of six months there was decrease in reducing sugar (1 42 % to 1 32 %) non reducing sugar (1 23 % to 1 23 %) and total sugar (2 65 % to 2 55 %) Reducing sugar content was found to be decreased in brine product which was observed by Kalra (1988) From the observations the brine product prepared from underexploited lovi lovi (sour) remained

highly good for a period of six months as there was no description of undesirable changes in chemical constituents

### 5 4 6 Changes in the Organoleptic Qualities of Fruit Products during Storage

After physical chemical and microbial examinations have been performed on a finished product with a satisfactory result the product in considered ready for distribution but only after its palatability or sensory quality has been assessed The ultimate criterion for the desirability of a fruit product to consumer is its eating quality

Palatability or sensory quality is of great importance to both processes and consumers Sensory quality is a combination of different senses of perception which come into play in choosing and eating a food (Srivastava and Sanjeev 2002) The principle sensory properties which affect the palatability of fruit product are appearance colour flavour texture taste and overall acceptability

According to Srivastava and Sanjeev (2002) the overall eye appeal of a fruit product is more important than dependence on taste and odour and may determine acceptance or rejection without a trial testing Appearance therefore deserves much consideration in fruit processing

Colour is the first quality attribute in which consumer perceives in food Change of colour is generally accompanied by flavour changes (Srilakshmi 1997)

Ranganna (1986) stated that flavour is an important factor which enriches consumer s preference to a particular product

Texture and taste are the major attributes which determines the acceptability of fruit products Taste is not only a sensory response but also an aesthetic appreciation of the mouth feel towards soluble materials (Ranganna 1986)

Overall acceptability depends on the different sensory attributes of a fruit product

### *5 4 6 1 Changes in the Organoleptic Qualities of Bilimbi Jam during Storage*

Quality in the most important criterion on which the acceptability of any product depends The variations on different sensory attributes upto six months of storage period are discussed below

Appearance of any product is of primary importance in its acceptability In the present study the score obtained for appearance was found to be decreasing from 4 6 to 3 7 with the advancement of storage period Majeed (1995) also observed decrease in appearance value in karonda jelly during storage period Concentrating on the score level for colour of bilimbi jam it could be seen that there was decrease in score from 4 8 to 3 9 This change in colour and appearance may be attributed to oxidation reduction of pigment In an earlier study conducted by Bhatnagar (1991) the colour of watermelon jam was found decreasing with increase in storage period

With reference to flavour of bilimbi jam there was increase in trend of score from 2 5 to 3 4 at the end of storage period This flavour change may be attributed to oxidation in chemical composition Tripathi *et al* (1988) also observed increase in flavour percentage with advancement in storage period in amla jam

The texture and taste of bilimbi jam was found to be increasing in value with increase in storage period The results are in accordance with the findings of Tripathi *et al* (1988) who reported that texture and taste of amla jam was found increasing with increase in storage period These change might be assigned due to the increase in the total sugar content with advancement in storage period

The overall acceptability of the product was ascertained through the scores given for various quality parameters and there was increase in score from 3 462 to 3 72 at the end of sixth month storage Organoleptic evaluation in papaya jam conducted by Thirumaran *et al* (1986) revealed that the product was acceptable with a mean score of 3 75 at the end of storage period Gothwal *et al* (1998) also reported that jam prepared from plum were acceptable for a period of nine months with respect to sensory quality attributes

Assessment of organoleptic qualities of bilimbi jam during different storage periods showed an increase in trend for all quality attributes except appearance and colour The overall acceptability also maintained at a reasonable good score Thus the product was rated and accepted reasonably good even after six months of storage

### *5 4 6 2 Changes in the Organoleptic Qualities of Bilimbi Pickle during Storage*

The organoleptic qualities were found to change during storage The organoleptic qualities of bilimbi pickle were assessed till the end of shelf life details of which are discussed below Appearance and colour were the most important characteristics which add aesthetic values to the products Poor products of deteriorated colour are not accepted by the consumers In the present study the appearance and colour scores of bilimbi pickle was found to decrease from score five to four during storage

Bhasin and Bhatia (1981) reported that best pickles were obtained at early maturity of fruits in order to get good colour and appearance

The flavour and texture attribute score decreased during storage from score 5 to 3 6 and 5 to 3 2 respectively at the end of storage period These changes might be due to the increase in acidity content with the advancement of storage period Verma *et al* (1986) investigated and reported that pickles prepared from medium acidity mangoes were poor in flavour

With reference to taste in present study there was decline in score from 5 to 3 7 during storage When compared to pickled apples Bhasin and Bhatia (1981) reported that taste and aroma were entirely different in fresh apple These changes might be due to reduction of total sugar in pickle during advancement of storage This reduction may also happen in the present study for the decrease in taste value

The general analysis of scores obtained for various quality attributes showed cent per cent score during first month of preparation and started declining slightly at the end of storage period So the overall acceptability score of the product was five at the initial month and slightly declined to 3 7 at the end of storage period Thus the monthly evaluation of the bilimbi pickle revealed its stability with respect to chemical constituents and the product also confirmed its safety as per the organoleptic evaluation

### *5 4 6 3 Changes in the Organoleptic Qualities of Roseapple Squash (rose) during Storage*

The maintenance of the organoleptic qualities of squash during storage is very important as it influences the acceptability of the beverage The product prepared are susceptible to change in its storage

due to various factors like temperature packing system etc In order to check whether storage had any negative influence in the acceptability the squash prepared was assessed monthly for variation in sensory qualities

In the present study a gradual decrease was observed in the appearance and colour of squash during storage The decrease was from score of 5 to 3 7 at the end of storage This change may be due to the deterioration of pigment in fruit Wasker and Khurdiya (1987) noted that the squash prepared from phalsa beverages was acceptable upto 180 days as there was maximum retention of anthocyanins in phalsa beverages kept in cool store

Colour of squash marked a decreasing change in score from 5 to 3 7 with storage upto six months Hema (1997) stated that decrease in colour value of jamun squash may be due to colour bleaching by light rays that had passed through colourless glass containers

Flavour and taste values were same during the first month and then there was a considerable decrease in score from 5 to 3 at the end of storage The squash developed was found to have decreasing trend in score from 4 8 to 3 3 with respect to texture The possible reason for decrease in values could be the loss of volatile aromatic substances Thakur and Barwal (1998) also stated that there was loss in flavour and taste values in kiwi fruit squash due to loss of volatile aromatic substances

The percentage of decrease in the overall acceptability was from 4 96 to 3 34 at the end of six months storage period The fall in overall acceptability was also observed in bael squash by Jain *et al* (1984)

Thus it could be stated that squash developed using roseapple (rose) possessed standard qualities with respect to sensory attributes and was comparable with similar established products in its acceptability and shelf life

### *5 4 6 4 Changes in the Organoleptic Qualities of Roseapple Squash (white) during Storage*

The data on storage behaviour of the sensory parameters of squash prepared from roseapple (white) are discussed below The decline in appearance value in the squash was form 5 to 3 6 which may be due to the oxidation reduction reaction of pigments Findings of Hema (1997) agrees and support the same above fact

Fading of colour value was observed from 4 6 to 3 during end of storage The colour deterioration may be due to the passage of light through the walls of the container The decrease in colour value was also observed in bael squash by Jain *et al* (1984) due to the same reason and it can be prevented by storing in coloured glass jars

The squash developed was observed to have good initial score of 5 with respect to flavour and texture and 4 9 for taste At the end of sixth month storage there was decrease in value to 3 for flavour and taste and 3 3 for texture According to Hema (1997) browning reaction was a major reason for the loss of flavour in jamun squash This may be the case in present study also The loss of volatile aromatic substances may be responsible for fall in the score value of taste and texture which decreased acceptability in storage Study conducted by Jain *et al* (1986) revealed that reduction in scores for taste and texture of phalsa and kaphal squash in its storage period of six months was negligible Another report by the same authors showed that twelve months storage of litchi squash could not develop any off taste in the product Similarly in the present study no perceptible off taste was found in the squashes even after six months while a slight reduction in the taste had occurred which is quite natural when certain fruit products are stored

Storage exhibited a small degrading influence in the overall acceptability of squash from 4 9 to 3 18 which confirmed that the squash were acceptable after six months

It was evident from the result that organoleptic qualities of roseapple (white) squash during different storage periods showed reduction in score values in all the quality attributes Initially the variation was slow which was subsequently found building up However no quality deterioration that would adversely influence the product acceptability by panelists was observed in all the characters The product had reasonably good acceptability even after six months of storage

### *5 4 6 5 Changes in the Organoleptic Qualities of Lovi lovi Preserve in Sugar during Storage*

Organoleptic qualities of lovi lovi preserve was found to change considerably with respect to different quality attributes The change in the different attributes of lovi lovi preserve during storage are discussed below

Appearance and colour are strong indicators of flavour Colour change is the major factor that usually occurs in the processed products which affect the appearance Both appearance and colour showed good score (5) during initial month and started slight decline in score upto 3 7 at the end of sixth month storage period Since the natural pigments are highly susceptible to chemical changes it might be the reason for the fall in score Tripathi *et al* (1988) and Saima (2002) observed the colour and appearance attributes in amla preserve during different intervals of storage

Flavour is the unique character of odour and taste The appearance was found to decrease during the final stages of shelf life

indicating a change in flavour and taste as well There was improved trend in scores from 2 8 to 4 with respect to both flavour and taste The products were stored at room temperature which might have lead to deterioration in flavour during shelf life Thorner and Herzaberg (1978) reported that the lower the temperature the slower will be the flavour and taste deterioration He further adviced to store fruit products in the coolest available area An increase in score for flavour and taste in amla preserve during the progress of storage period was reported by Saima (2002)

With reference to texture in the present study there was increase in score from 2 7 to 4 This type of increase in score for texture was observed by Tripathi *et al* (1988) in amla preserve Saima (2002) also observed increase in texture score in amla preserve

The overall analysis of score obtained for various quality attributes showed increase in trend from 3 66 to 3 88 at the end of storage period Tripathi *et al* (1988) also reported that the acceptability of amla preserve increased with storage period From the discussion it could be concluded that product prepared was reasonably good upto six months of storage and well comparable with similar established products

Thus the storage favoured almost all the sensory attributes of different products from selected underexploited fruits and this study highlighted the scope for successful exploitation of these fruits

### *5 4 6 6 Changes in the Organoleptic Qualities of Lovi lovi in Brine during Storage*

Fruit in brine is a product which improves texture of the fruit and makes pickling possible in a shorter time than when pickled directly Variation in the different organoleptic qualities with monthly intervals are discussed below The appearance and colour are the important factors

which influence consumer s inclination while buying fresh fruits as well as processed products The appearance and colour score were observed to be inconsistent throughout the storage period In the initial month the product showed good score (5) with respect to appearance and colour and started showing slight declining trend in score from 5 to 3 7 upto the end of storage period Bhasin and Bhatia (1981) reported that natural fermentation resulted in less satisfactory colour and appearance

Scores obtained for flavour decreased during storage from 4 to 2 7 The flavour change might be due to the increase in acidity content with the advancement in storage period Product prepared from medium acidity mangoes in brine were poor in flavour which was investigated by Verma *et al* (1986)

The changes in the taste and texture attributes with storage in lovi lovi in brine shows that there was a decreasing trend from 4 to 3 1 and 4 to 3 3 respectively Taste and texture changes may occur in brine due to plasmolysis of tissues and reorganisation of cell wall materials Pectic substances were gradually degraded but cell wall materials were not markedly affected This might be the reason for the declining trend The same reason was reported by Bhasin and Bhatia (1981)

As per the observations the overall scores of lovi lovi in brine decreased slightly during the storage period The decrease was found from 4 4 to 3 3

From the following discussion on organoleptic qualities of lovi lovi in brine it is evident that different quality attributes maintained reasonable scores during storage Thus it could be concluded that the lovi lovi brine possessed standard qualities with respect to sensory attributes and was well comparable with similar established product in its acceptability and shelf life

### 5 4 7 Assessment of Microbial Contamination of the Stored Products

The shelf life quality of the processed product is one of much importance because the need for improving different processing techniques is influenced by shelf life quality

The shelf life of any product is dependent on the absence of harmful micro organisms The microbial growth or microbial damage of a product is dependent upon certain factors both chemical and physical which are favourable for their growth (Frazier and Westhoff 1974) Therefore routine analysis of the product is necessary to find out whether the product has any quality deterioration

Microbiological examination of bilimbi jam at regular intervals of storage showed complete absence of deteriorative organisms over six months of storage period The same result was observed in watermelon jam during the storage period of six months by Bhatnager (1991)

No microbial activity was observed upto six months of storage which confirmed the successful storage behaviour and shelf life span of bilimbi pickle Addition of preservative to the product may be useful for the successful storage behaviour The results are in accordance with the findings of Sidhu *et al* (1996) who had reported similar findings on dates products during the storage period

The microbiological examination of the squashes at regular intervals of storage failed to show the presence of micro organisms even at the end of sixth month The added preservative in squashes may help to increase the shelf life This is a positive indication for the safe use of squashes over six months under ambient storage Similar results were observed in jamun squash studied by Hema (1997)

The periodical testing for microbial count of preserve in sugar and brine prepared from lovi lovi revealed complete absence of micro organisms during the entire period of storage This result enables us to speculate that high sugar concentration and addition of preservative in preserve was the main reason for absence of micro organisms during entire period of storage Absence of micro organisms was observed at the end of storage period by Saima (2002) in amla preserve Due to high salt concentration in lovi lovi brine no microbial attack was found

The present study entitled Utilizaton of selected underexploited fruits for product development showed that the products prepared from bilimbi roseapple and lovi lovi resulted excellent in terms of chemical and organoleptic characters for the storage period of six months and it will be highly useful if we go for further utilization of many underexploited fruits in a highly fruitful manner

# Summary

# 6 SUMMARY

The present study entitled Utilization of selected underexploited fruits for product development was undertaken with the aim of developing products for the utilization of the underexploited fruits like bilimbi (*Averrhoea bilimbi)* roseapple (*Syzygium jambos* L) and lovi lovi (*Flacourtia cataphracta Flacourtia inermis*) The investigation also aimed to study the organoleptic nutritional and shelf life qualities of the developed products

In the present study an attempt was made to develop products by utilizing the underexploited fruits and the products prepared were bilimbi jam bil mbi pickle roseapple squash with rose and white types lovi lovi preserve in sugar and lovi lovi in brine

The physical examination of the fruits revealed that bilimbi was a cucumber shaped green coloured fruit with very low percentage of waste portion Roseapple was a spongy and aromatic fruit Rose coloured roseapple had rosy red colour whereas the white coloured roseapple had creamy white colour Physical examination of lovi lovi fruits revealed that sweet lovi lovi was red coloured whereas sour lovi lovi was purplish red coloured fruit

Chemical examination of the present study revealed that bilimbi had higher moisture iron and acidity content High potassium and β carotene content were observed in roseapple (rose) where as fibre protein and calcium were found to be more in roseapple (white) In case of lovi lovi (sweet) starch vitamin C TSS reducing non reducing and total sugar were observed to be high where as all the chemical characters analysed were at moderate level in case of lovi lovi (sour)

Regarding the sensory evaluation of fruits it was observed that roseapple rose had highest overall acceptability with a mean

score of 4 78 followed by roseapple white (4 62) lovi lovi sweet (4 62) lovi lovi sour (4 28) and the least acceptable was bilimbi (3 52) The sensory quality as pursued by the panellists showed high degree of agreement for all quality characters except appearance

The major chemical components analysed in the six products were TSS acidity vitamin C reducing non reducing and total sugars The chemical analysis of the prepared products in the present study showed that bilimbi jam had 76 10 $^{0}$brix TSS 1 54 per cent acidity 9 65 mg 100 g$^{-1}$ vitamin C 36 63 per cent reducing sugar 28 02 per cent non reducing sugar and 64 66 per cent total sugar Bilimbi pickle exhibited 25 10 $^{0}$brix TSS 1 22 per cent acidity 10 13 mg 100 g$^{-1}$ vitamin C 1 46 per cent reducing sugar 1 12 per cent non reducing sugar and 2 58 per cent total sugar

It was found that both the squashes prepared from rose and white roseapple had 45 03 $^{0}$brix and 48 03 $^{0}$brix TSS 3 06 per cent and 2 06 per cent acidity 10 13 mg 100 g$^{-1}$ and 10 46 mg 100 g vitamin C 26 77 per cent and 30 02 per cent reducing sugar 14 43 per cent and 13 32 per cent non reducing sugar and 41 20per cent and 43 35 per cent total sugar

The preserve in sugar syrup prepared from lovi lovi fruit showed a TSS of 70 06 $^{0}$brix The acidity content in case of preserve in sugar syrup was 0 98 per cent The vitamin C content of preserve in sugar syrup was 18 56 mg 100 g$^{-1}$ On analysis of preserve in sugar syrup the composition were observed as reducing sugar 30 01 per cent whereas non reducing sugar 30 41 per cent The total sugar content was 60 43 per cent in preserve in sugar syrup Lovi lovi brine had 15 1 $^{0}$brix TSS 1 26 per cent acidity and 8 26 mg 100 g$^{-1}$ vitamin C The product obtained a reducing and non reducing sugar of 1 42 per cent and 1 23 per cent respectively The total sugar content was 2 65 per cent in case of lovi lovi brine

The fruit product yield ratio calculated revealed that the highest yield was obtained for both rose (1 1 8) and white roseapple squash (1 1 75) This was followed by bilimbi jam (1 1 6) lovi lovi preserve in sugar (1 1 54) lovi lovi in brine (1 1 46) and the least yield for bilimbi pickle (1 1 25)

The products developed in the present study were compared with the FPO specifications in its requirements for particular items The bilimbi jam in the present study possessed the required FPO specifications with 76 per cent TSS and 50 per cent fruit on fresh fruit basis to be considered as a standard jam The bilimbi pickle was considered as standard pickle which was prepared from gingelly oil In the present study the TSS present in roseapple squashes (both white and rose types) was 48 per cent and 45 per cent respectively whereas the percentage of fruit juice present in white and rose types of squashes were 38 per cent On analysis of preserve prepared from lovi lovi indicated a TSS content of 70 per cent and fresh fruit of 58 per cent in the final product which confirmed FPO standard All these products satisfied the FPO prescribed level of preservatives The lovi lovi in brine was prepared with the prescribed salt concentration of 12 per cent Thus all prepared products confirmed with FPO specifications

Cost analysis of the products like jam pickle squash preserve in sugar and brine as computed per kg of the finished product pointed out that lovi lovi in brine was the cheapest product which had a cost of Rs 25 60 per kilogram followed by bilimbi pickle (Rs 35 44) and bilimbi jam (Rs 37 47) Cost per kg of squashes prepared from both rose and white types of roseapple were Rs 39 21 The maximum expense was observed for the preparation of lovi lovi preserve in sugar

Monthly assessment on the chemical components were carried out to assess the storage quality of different minor fruit products

and the components assessed were TSS acidity vitamin C reducing non reducing and total sugars

Changes in the chemical qualities of bilimbi jam during storage revealed that TSS of jam slightly increased from 76 10 $^{0}$brix to 78 53 $^{0}$brix during storage Regarding the acidity it was observed that a steady increase of acidity from 1 54 per cent to 2 61 per cent over a period of six months Variation was noted in the vitamin C of bilimbi jam during six months of storage Reducing sugar was observed to be increased from 36 63 per cent to 44 18 per cent during storage Non reducing sugar was found to be declined from 28 02 per cent to 24 60 per cent during storage Total sugar was increased about 4 12 per cent during storage

In the case of bilimbi pickle TSS increased from 25 10 $^{0}$brix to 29 10 $^{0}$brix acidity increased from 1 22 per cent to 2 21 per cent whereas vitamin C was found to be decreased and it ranged from 10 13 mg 100 g $^{1}$ to 6 13 mg 100 g $^{1}$ during storage period Reducing sugar changes with a slight decease from 1 46 per cent to 1 33 per cent whereas non reducing sugar changes with a slight increase from 1 12 per cent to 1 17 per cent Total sugar was found to be decreased from 2 58 per cent to 2 50 per cent during storage months

TSS of roseapple squash (rose) showed an increase from 45 03 $^{0}$brix to 47 93 $^{0}$brix during storage period An increase from 3 06 per cent to 3 88 per cent was observed in acidity The variation in vitamin C during six months of storage varied from 10 13 mg 100 g $^{1}$ to 5 53 mg 100 g $^{1}$ Reducing sugar was found to be increased from 26 77 per cent to 30 63 per cent Non reducing sugar decreased and the range varies from 14 43 per cent to 12 22 per cent whereas total sugar was observed to be increased from 41 20 per cent to 42 85 per cent during storage

TSS of roseapple squash (white) was observed to be increased with a range of 48 03 $^{0}$brix to 50 90 $^{0}$brix Acidity was increased from 2 06 per cent to 2 85 per cent during the storage Squash recorded a decrease in trend in vitamin C from 10 46 mg 100 g $^{1}$ to 6 70 mg 100 g Reducing sugar was found to be increased from 30 02 per cent to 36 62 per cent and non reducing sugar decreased from 13 32 per cent to 10 83 per cent Total sugars indicated an upward trend from 43 35 per cent to 47 46 per cent

During the storage study TSS content of lovi lovi preserve in sugar was increased to about 70 06 $^{0}$brix to 73 93 $^{0}$brix Declining values from 0 98 per cent to 0 68 per cent in acidity was observed in lovi lovi preserve in sugar during storage period A decreasing trend of 18 56 mg 100 g $^{1}$ to 12 93 mg 100 g $^{1}$ was observed for vitamin C in lovi lovi preserve in sugar A gradual increase in reducing sugar from 30 01 per cent to 34 22 per cent and decrease in non reducing sugar from 30 41 per cent to 28 81 per cent was noticed in lovi lovi preserve in sugar during the storage period of six months Total sugar was found to be increased from 60 43 per cent to 63 03 per cent

Regarding the TSS of lovi lovi in brine considerable increase from 15 10 $^{0}$brix to 19 00 $^{0}$brix was noted The acidity of the product was observed to be increased from 1 26 per cent to 2 85 per cent The range of decrease for vitamin C was 8 26 mg 100 g $^{1}$ to 4 60 mg 100 g $^{1}$ in lovi lovi preserved in brine The reducing and non reducing sugar was found to be decreased from 1 42 per cent to 1 32 per cent and 1 23 per cent to 1 23 per cent respectively during storage period Slight decrease in total sugar with a range of 2 65 per cent to 2 55 per cent was observed during storage

Changes in the organoleptic qualities of the products like appearance colour flavour texture taste and overall acceptability were observed during storage period

Appearance of bilimbi jam was found to be decreased during storage A slight reduction in colour was noticed whereas flavour texture taste and overall acceptability were found to be increased during period of storage

Appearance colour and flavour of the bilimbi pickle decreased over a period of six months Similarly texture of the bilimbi pickle was superior during the first month Only a slight reduction in score was recorded during the following months Reduction in score was obtained in the case of taste of pickle Overall acceptability was found to be reduced after third month of storage study

Appearance and colour of roseapple squash (rose) was found to be decreased as storage period progresses The intensity of flavour of roseapple squash was found to be decreased gradually from the third month Similarly a moderate rate of decrease in texture was noted from third month onwards A decrease in taste could be observed as the storage period progresses The overall acceptability of roseapple squash decreased gradually from fourth month onwards

The periodical evaluation of roseapple squash (white) recorded a diminishing appearance during the storage period Colour of the squash was found to be decreased from second month onwards Similarly flavour texture and taste of roseapple squash (white) was found to be reduced during subsequent months

A decrease in appearance and colour of lovi lovi preserve in sugar was observed throughout the storage period Flavour texture and

taste of preserve was increased as the storage period progresses The overall acceptability of lovi-lovi preserve in sugar was also found to be increased during storage

The appearance and colour of lovi lovi in brine was decreased during the storage period Flavour of the brine was high during the first month and it reduced during subsequent storage months The texture and taste of the product attained maximum score during the third month and it reduced gradually during subsequent months The overall acceptability was found to be increased initially and decreased gradually during storage period

In the present study products were analysed for the assessment of microbial contamination for the first month third month and sixth month after product formulation No visible presence of microflora was observed in all products upto the end of storage period which confirmed the safety of the products

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* Original not seen

# Appendices

## APPENDIX I

### PROCEDURE FOR THE TRIANGLE TEST

In the triangle test three sets of sugar solutions of different concentrations were used Of the three sets two solutions were of identical concentrations and the women were asked to identify the third sample which is of different concentration

### EVALUATION CARD FOR THE TRIANGLE TEST

Name of the product Sugar solution

Note Two of the three samples are identical

**Identify the odd sample**

| Sl No | Code No of samples | Code No of the identical samples | Code No of the odd sample |
|---|---|---|---|
| 1 | A B C | | |

## APPENDIX II

## RECEIPES OF SELECTED PRODUCTS PREPARED FROM DIFFERENT UNDEREXPLOITED FRUITS

### BILIMBI JAM (1 KG)

**Ingredients**

| | |
|---|---|
| Bilimbi | 500 g |
| Sugar | 500 g |
| Pectin | 1 g |
| Sodium benzoate | 200 ppm |

### BILIMBI PICKLE (1 KG)

**Ingredients**

| | |
|---|---|
| Bilimbi | 720 g |
| Salt | 180 g |
| Chilli powder | 80 g |
| Mustard seeds | 10 g |
| Fenugreek | 15 g |
| Asafoetida | 10 g |
| Turmeric powder | 5 g |
| Gingelly oil | 150 ml |
| Curry leaves | 15 no |
| Sodium benzoate | 250 ppm |

### ROSEAPPLE SQUASH (ROSE) (1 KG )

**Ingredients**

| | |
|---|---|
| Roseapple juice | 390 g |
| Sugar | 780 g |
| Citric acid | 2 g |
| Potassium metabisulphite | 350 ppm |

## Roseapple Squash (White) (1 Kg)

**Ingredients**

| | |
|---|---|
| Roseapple juice | 390 g |
| Sugar | 780 g |
| Citric acid | 2 g |
| Potassium metabisulphite | 350 ppm |

## Lovi Lovi Preserve in Sugar (1 Kg)

**Ingredients**

| | |
|---|---|
| Lovi lovi (sweet) | 580 g |
| Sugar | 696 g |
| Sodium benzoate | 200 ppm |

## Lovi Lovi in Brine (1 Kg)

**Ingredients**

| | |
|---|---|
| Lovi lovi (sour) | 666 g |
| Salt | 50 g |
| Water | 400 ml |

## APPENDIX III

## SCORE CARD FOR ORGANOLEPTIC EVALUATION OF FRUITS

**Name** **Name of the fruit**

**Date**

| Sl No | Character | Description | Sample |
|---|---|---|---|
| I | Appearance | Excellent | |
| | | Good | |
| | | Fair | |
| | | Poor | |
| | | Very poor | |
| II | Colour | Excellent | |
| | | Good | |
| | | Fair | |
| | | Poor | |
| | | Very poor | |
| III | Flavour | Excellent | |
| | | Good | |
| | | Fair | |
| | | Poor | |
| | | Very poor | |
| IV | Texture | Excellent | |
| | | Good | |
| | | Fair | |
| | | Poor | |
| | | Very poor | |
| V | Taste | Excellent | |
| | | Good | |
| | | Fair | |
| | | Poor | |
| | | Very poor | |

Signature

## APPENDIX IV

**SCORE CARD FOR ORGANOLEPTIC EVALUATION OF FRUIT PRODUCTS**

**Name** **Name of the fruit product**

**Date**

| Sl No | Character | Description | Storage period (6 months) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| I | Appearance | Excellent | | | | | | |
| | | Good | | | | | | |
| | | Fair | | | | | | |
| | | Poor | | | | | | |
| | | Very poor | | | | | | |
| II | Colour | Excellent | | | | | | |
| | | Good | | | | | | |
| | | Fair | | | | | | |
| | | Poor | | | | | | |
| | | Very poor | | | | | | |
| III | Flavour | Excellent | | | | | | |
| | | Good | | | | | | |
| | | Fair | | | | | | |
| | | Poor | | | | | | |
| | | Very poor | | | | | | |
| IV | Texture | Excellent | | | | | | |
| | | Good | | | | | | |
| | | Fair | | | | | | |
| | | Poor | | | | | | |
| | | Very poor | | | | | | |
| V | Taste | Excellent | | | | | | |
| | | Good | | | | | | |
| | | Fair | | | | | | |
| | | Poor | | | | | | |
| | | Very poor | | | | | | |

Signature

## APPENDIX V

### MEDIA PREPARED FOR MICROBIAL COUNT

**I Martin's Rose Bengal media for fungus**

| | |
|---|---|
| Dextrose | 10g |
| Peptone | 5 g |
| $KH_2PO_4$ | 1g |
| $MgSO_4$ $7H_2O$ | 0 5 g |
| Agar | 15g |
| Rose Bengal | 0 035 g |
| Streptomycin | 30 mg |
| Distilled water | 1 litre |

**II Nutrient Agar media for Bacteria**

| | |
|---|---|
| Peptone | 5 g |
| Beef extract | 3 g |
| Agar | 15 g |
| Distilled water | 1 litre |

### PROCEDURE FOR MICROBIAL COUNT

Sterilised petridishes were used for the microbial enumeration One gram of prepared product were used as the sample Considering the low count of micro organisms one gram of sample was directly used without further serial dilution In culture room the sample were spread in the sterilised petridish over which melted and cooled culture media was poured, and kept for three days for the development of colonies The number of colonies formed in the culture media were analysed and is taken as the microbial count

# Abstract

# UTILIZATION OF SELECTED UNDEREXPLOITED FRUITS FOR PRODUCT DEVELOPMENT

By

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**(2000 - 16 - 05)**

## ABSTRACT OF THE THESIS

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**(FOOD SCIENCE AND NUTRITION)**

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**2003**

## ABSTRACT

In the present study entitled Utilization of selected underexplotied fruits for product development include developing products from underexploited fruits like bilimbi roseapple (rose and white types) and lovi lovi (sweet and sour type) The products prepared from these fruits were bilimbi jam bilimbi pickle roseapple squash (rose) roseapple squash (white) lovi lovi preserve in sugar and lovi lovi in brine

Physico chemical examination of the fruits indicated wide difference in characters among the selected fruits

Regarding the sensory evaluation of the fruits roseapple (rose) had highest overall acceptability followed by roseapple (white) lovi lovi (sweet) lovi lovi (sour) and the least bilimbi

All the products developed in the present study confirmed with FPO specifications

Cost analysis of the products indicated lowest cost for lovi lovi in brine and the maximum expense for lovi lovi preserve in sugar

Roseapple (rose and white) squashes exhibited high fruit product yield ratio followed by bilimbi jam lovi lovi preserve in sugar lovi lovi in brine and bilimbi pickle

The major chemical components analysed in the products developed from the selected fruits were TSS acidity vitamin C reducing non reducing and total sugar During the storage period of six months TSS acidity reducing and total sugars were found to be increased gradually in bilimbi jam and rose and white roseapple squashes while

vitamin C and non reducing sugar were reduced With the progress of storage period TSS acidity and non reducing sugar were found to be increased in case of bilimbi pickle TSS reducing sugar total sugar were found to be increased in lovi lovi preserve in sugar while acidity vitamin C and non reducing sugar were decreased But in lovi lovi preserved in brine acidity was increased gradually while other chemical constituents decreased as the storage proceeds

Regarding the organoleptic qualities of the products during storage characters like appearance and colour were decreased whereas flavour texture taste and overall acceptability were found to be gradually increased in bilimbi jam and lovi lovi preserve in sugar In products like bilimbi pickle roseapple squashes and lovi lovi in brine all the characters were found to be decreased during storage

No microbial count was observed in all the products throughout the storage study