VALUE ADDITION AND QUALITY EVALUATION OF WEST INDIAN CHERRY(*Malpighia punicifolia* L.)

By

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Value addition and quality evaluation of West Indian cherry (*Malpighia punicifolia* L.)"** is a bonafide record of research work done by me during the course of research and that it has not been 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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Certified that this thesis entitled **"Value addition and quality evaluation of West Indian cherry (*Malpighia punicifolia* L.)"**is a bonafide record of research work done independently by **Miss. Pokkandath Jyothi** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ABBREVIATIONS

kg - Kilogram
gm - Gram
mg - Milligram
ml - Milliliters
µg - Microgram
cm - Centimeter
% - Percentage
TSS - Total soluble solids
^{o}bx - Degree brix
RTS - Ready to serve beverage
ppm - Parts per million
FPO - Fruit product order
A.O.A.C - Association of Official Analytical Chemists
EDTA - Ethylene diamine tetra acetic acid
HNO_3 - Nitric acid
^{o}C - Degree celcius
nm - Nanometer

Introduction

INTRODUCTION

The diverse agro climatic conditions of our country are a boon to us. That is why we can successfully grow all kinds of fruits and vegetables. A number of fruits have been grown successfully in the arid regions, but still there are a few more to be exploited, which have vast potential in these areas. They withstand all adverse conditions besides providing appreciable returns to the growers.

India produces nearly 46 million tonnes of fruits and 91 million tonnes of vegetables. By converting all our agricultural and allied production into food or value added products, it is possible for us to feed another 117 million population. As on date, we are processing only less than 2 per cent of our farm produce and convert only 7 per cent of them as value added products (Krishnakumar *et al.*, 2005).

Various nutrients are essential in human diet for healthy and active life. Alarming situation of malnutrition is existing in the country particularly in arid, hilly and tribal areas. Fruits are considered as a protective food being rich in vitamins and minerals. Non-traditional fruits, which generally grow in arid, hilly and tribal areas, can provide a solution to the problem of malnutrition. These fruits are easier to cultivate, hardy in nature, producing a crop even under adverse soil and climatic conditions and rich in nutrients. India being rich in bio-diversity has a very large number of non-traditional fruits but the information on the nutritive value is not available for all of them (Rathore, 2001).

As per one estimate, there are more than 3000 edible fruit and nut species. Many have unique taste and are good sources of minerals and vitamins. Only about 25 fruits, which are grown on commercial scale, mainly enter our diet. Several other world's fruits hold great promise and are yet to be recognized and exploited for their potential importance (Jallikop, 2006).

In the present scenario of changing food habits, job profile and health awareness, new and improved processed products are in demand world over. The concept of food is shifting from survival to the value added products. India, a diversified country with wide range of fruits, can play an important role by providing exotically flavoured processed products. It is high time that our country should lay more emphasis to utilize these indigenous fruits and market the processed products world over. It will not only bring significant economic benefits to the country but will also provide nutritious products without much competition in the global trade. Underutilised fruits should be seen as a complement to conventional fruits and not as a substitute.

West Indian cherry is such an under utilized fruit having potentialities for making different types of products and need to be tried to promote its expansion. These fruits, which are rich in vitamin C, are not fully utilized during period of plenty.

With these points in mind, the present study was undertaken with the following objectives:

1. To evaluate the nutritive value of West Indian cherry fruits.
2. To develop value added products from West Indian cherry.
3. To evaluate the chemical, organoleptic and shelf life qualities of products developed.

Review of literature

REVIEW OF LITERATURE

The relevant literature available on the study entitled "Value Addition and quality evaluation of West Indian cherry" has been briefly reviewed here. Wherever sufficient literature is not available on the fruit or the products tried in this experiment, results of experiments conducted on other underexploited fruits or the products are also cited. The literatures are reviewed under the following subtitles.

2.1 Importance of fruits in our diet.
2.2 Need for processing of fruits.
2.3 Significance and value addition of underexploited fruits.
2.4 Shelf life studies on product quality.

2.1 Importance of fruits in our diet:

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). Fruits are no longer considered as a luxury, since they belong to an important class of protective foods, which provide vitamins and minerals, needed for the maintenance of health (George, 1994).

As per the report of Manson (1994) people who eat more fruits and vegetables have a 54 per cent lower risk of getting heart stroke when compared to those who eat the least. Studies showed that women with the highest levels of lycopene in their blood were five times less likely to develop pre-cancerous signs of cervical cancer than women with the lowest levels (Sarma, 2003).

There are some trace elements required by the body like copper, manganese and zinc, which act as enzyme cofactors. These are found in appreciable amounts in fruits. Fruits in general provide dietary fibre essential for bowel movement and possibly for prevention of diseases like appendicitis, colon

cancer, diabetes, gallstones, obesity etc (Roy, 2001a). Studies in large populations suggest that high intake of vitamin C is associated with reduced risk for several chronic diseases. Human beings receiving about 300mg or more of vitamin C per day, on an average, live six years longer than those who receive less than 50mg of vitamin C daily (Kaur and Maini, 2001). Fruits are essential for normal physiological well-being and help in maintaining health status through development of resistance against pathogens. They also contain mineral salts, the deficiency of which can lead to disturbance of metabolism resulting in ill health. Their pectin and cellulose contents help in stimulating the intestinal activity (Bal, 2002).

Fruits have been conferred a status of functional foods owing to their rich content of phytochemicals like ascorbic acid and bioflavonoids. Berries especially coloured like cranberry, strawberry, blackberry, aronia, bilberry and whortle are rich sources of flavanoids and phenolics. According to a breakthrough research at Rutgers University, New Jersey, blueberry is the number one antioxidant fruit. It has been found to be beneficial in fighting off urinary tract infections by blocking or prohibiting the growth of bacteria. Flavanoids and other phenolics present in grape and grape products like wine has been shown to possess anticarcinogenic, antiinflammatory, and antithrombic and antioxidant effects (Kaur and Maini, 2001). It may not be an exaggeration to say that 80-90 per cent of problems arising from under nutrition or malnutrition can be well managed with indigenous medicines, and fruits are an important part of these (Bal, 2002).

Fruits in particular are significantly protective in cancers of oesophagus, and oral cavity and larynx (Raghuram, 1997). Concentrated extracts of anthocyanins also benefits visual activity as well as provide protection against macular degeneration, glaucoma and cataracts (Kaur and Maini, 2001). All fruits contain antioxidants, their high consumption and therefore, high intake of antioxidants is the main advantages of Mediterranean diet (Visioli and Galli, 2003). Among the well known phytochemicals found in fruits, β-carotene and

lycopene are the most powerful antioxidants. Recently, β-carotene has been approved for the general treatment of erythropoetic protoporphyria, a genetically inherited, light sensitive disease (Sarma, 2003).

As most of the fruits are eaten in their fresh form, some of the digestive enzymes such as proteolytic enzymes (papain from papaya, bromelin from pineapple, ficin from figs) may help in better digestion of the nutrients in foods (Singh, 2004).

2.2 Need for processing of fruits

Development of fruit preservation industries in rural areas can help generate employment, support growers, upgrade local nutrition and increase the gross national production (Maini and Anand, 1985). Processing of fruits can be defined as adding value to conventional and innovative fruit items, through various permutations and combinations providing protection, preservation, packaging, convenience, carriage and disposability (Rao, 1989).

Food processing will have to play an increasing market role, as demand created both by population growth and by requirement for improved nutrition, generates a need for an estimated 60 per cent increase in available food stuffs (Walker, 1993). The food industry can provide processed fruit products at reasonable and steady prices throughout the year, meeting the requirements of defense forces in border area and earning foreign exchange for the country by development of exports (Shaw *et al*., 1993).

Fruit processing helps to mitigate the problems of underemployment during off-season in agricultural sector (Poornia *et al*., 1994). Maikhuri *et al.* (1994) have 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 and sauce.

Fruits are perishable and are available in seasonal surpluses during certain parts of the year in different regions and are wasted in larger quantities due to absence of facilities and know-how for proper handling, distribution, marketing and storage. About 35 per cent of the total production is unfortunately wasted due to inadequate facilities for processing (Hemashanker and Bhuvaneshwari, 1999).

India is enriched with a variety of delicious indigenous fruits, which have great potential for processing into nutritious, delicately flavoured products. The processing of the indigenous fruits like the bael, kiwi, phalsa, amla, passion fruit, papaya, jamun, karonda etc could help the even distribution of fruits from places of abundance to the place of scarcity, the availability of fruit products even during off season and at reasonable price thereby improving the per capita availability as well as consumption (Roy and Pal, 2000).

In addition to major fruits, a large number of minor fruits, accounting for about 5.53 million tonnes are also produced in the country but the utilization of fruits by the processing industry is only one per cent (Sethi, 1993). Apart from traditional fruits there are numerous nontraditional fruits such as jackfruit, phalsa, pummelo, wild apricot, amla, bael and jamun which can supplement carotene, vitamin C, riboflavin, calcium and iron which could highly help to satisfy our dietary needs of nutrition (Rathore, 2001).

The annual fruit production in India is estimated to be 45.5 million tonnes (Negi, 2001). Inspite of the highest fruit production the average Indians do not get the basic daily requirement of fruits due to wastage and value destruction. 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, 2001b).

In the present scenario of changing food habits, job profile and health awareness, new and improved processed products are in demand world over. India

accounts for 10 per cent of the total world production of fruits and stands second after China (FAO, 2001). India, a diversified country with wide range of fruits, can play an important role by providing exotically flavoured processed products (Tandon and kumar, 2006). The underutilized fruits like tamarind, amla, karonda, citron, jackfruit etc have the ability to grow under adverse conditions and are known for their therapeutic and nutritive values, However, some of these fruits are not acceptable in the markets in fresh form due to their acidic nature and for their stringent taste. There is a need to create demand for such fruit crops in domestic and international markets. This, to some extent, can be achieved through processing (Gajanana, 2006).

2.3 Significance and Value addition of underexploited fruits:

Underexploited fruits are the several less known fruit species, which have the potential for commercial exploitation (Pareek and Sharma, 1993). Considerable efforts are needed to make a new product from underexploited fruits, competitive in the world market with respect to nutritional and microbial quantity as well as zero level chemical residues (Kumar, 1993). 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, 2001a). Non-traditional fruits also impart diversity and palatability to our food. Tamarind is an important ingredient of recipe of many Indian dishes (Rathore, 2001).

Underutilized fruits have tremendous potential for introducing a variety of new products of commercial and nutritional importance and in turn finding their use in human diet, sheerly for high nutritive value (Hiremath *et al .,* 2006). Small fruit size, high picking frequency of fruits, distant markets, short harvesting period and low market demand are some of the reasons for their low economic value. Therefore product diversification of these underutilized fruit crops will be an effective technological intervention (Choudhary *et al.,* 2006). The lack of processing technologies has never been a limited factor for these minor

fruits but the availability of these crops in substantial quantities have been the main cause (Tandon and Kumar, 2006).

Bael fruits are mildly laxative and the slices of the unripe fruits in the form of murabba are used in chronic cases of diarrhea and dysentery (Singh, 1963). In the after treatment of bacillary dysentery, this minor fruit is a useful adjuvant as it helps to remove constipation, which hinders the healing of ulcerated surfaces of intestine (George *et al*., 2000). It is a rich source of riboflavin and ascorbic acid. The pulp of the fruit contains a large amount of gum and mucilage as a result of which it has the important curative properties as appetizer and is often prescribed for stomach problems (Kaur and Maini, 2001).

Jamun is a very good source of iron apart from minerals and proteins, and can be used as an effective medium against diabetes, heart and liver troubles (Kumar, 1993 and Mehrotra *et al .,* 1996). Dried alcoholic extracts of jamun seeds when given to diabetic patients reduced the level of blood sugar and glycosuria. Jamun seeds are high in phenolics and are prescribed in ringworms and blood pressure (Kaur and Maini, 2001).

Minor fruits like phalsa, bael and wood apple are excellent sources of calcium and phosphorus whereas custard apple, ber and karonda are rich sources of iron (Rathore, 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). The hot water extracts of jack leaves improve the glucose tolerance level of diabetic persons (Krishnankutty, 1998).

About 15g of amla consumed daily could help dietary needs of vital vitamins (Sethi, 1987). Aonla possess expectorant, antiviral, cardiotonic, hypoglyceamic and antioxidant properties (Kalra, 1988). Aonla is the main ingredient of ‘chyavanpras’, which is famous for its therapeutic value in ayurvedic systems of medicines (Chadha, 1994). Bhattacharya *et al.* (1999) studied the

antioxidant activity of tannoid principles of amla, which is rich in polyphenol and vitamin C. Vitamin C content in amla and its products like murabba and chyavanpras ranges from 48-60mg/100g (Dhan, 2000). Amla have antiscorbutic, diuretic, laxative and antibiotic properties that can be highly utilized for combating several diseases such as chronic dysentery, bronchitis, diabetes, fever, diarrhea, jaundice, dyspepsia and cough (Kikani, 2001).

Every part of the pomegranate is used in the treatment of dysentery, diarrhoea, stomachache, dyspepsia and bronchitis. These therapeutic properties are due to the presence of betulic acid and urolic acid and different alkaloids such as pseudopelletierine, pelletierine, isopelletierine and methyl pelletierine. The unripe fruits and flowers are useful in inducing vomiting and the rind of the fruits is given in diarrhoea and dysentery. It is also useful in sore throat and eyes, brain disease and chest problems (Kaur and Maini, 2001). A recent study of people showed that individuals drinking 50 milli litres of pomegranate juice each day enjoyed an average 35 per cent reduction in the extent of their carotid atherosclerosis over the course of a year. A glass full of natural pomegranate juice is said to contain more antioxidants than ten cups of green tea (Premakumari, 2006).

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 carbohydrates are found to be present more in passion fruit (Khurdiya, 1994). Kiwi fruit is a good source of vitamin C and B (Kaushal *et al.,* 1999).

Avocado is the most nutritious fruit on earth in terms of calorific value, minerals and vitamins (Aipe *et al*., 2001). Mulberry fruits can be used for the preparation of antioxidant rich post harvest products (Shivashankara *et al*., 2006). Juice made from the rind of Garcinia indica fruits is being sold in the market and believed to have medicinal value and is significantly superior in

antioxidants and radical scavenging capacities mainly due to higher flavanoids and anthocyanins and phenol contents (Rao *et al*., 2006).

The ripe fruits of lasora or gonda are rich in sugars, protein, calcium and phosphorus (Meghwal, 1997). Wild pomegranate fruits are a potential source of anardhana (dried aril). This species may have commercial potential due to the fact that it is well adapted to adverse soil conditions and could be grown on waste lands (Kher, 1999).

Bilimbi fruit is said to have astringent, stomachic, refrigerant and antiscorbutic properties in traditional medicinal literature. Syrup made by mixing the juice of the ripe fruit with sugar and water at 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 (Morton, 1987).

The emphasis in the past has been given only to the processing of major fruit crops of the country, and the wealth of indigenous fruit has not been brought to the forefront. However, the successful marketing of a number of processed products from therapeutically important aonla fruits have opened new vistas for other underutilized fruits. The processed products like murabba and candy prepared from bael fruit, are fast growing with better market acceptability and popularity (Tandon and Kumar, 2006).

Jackfruit can be utilized for making squash (Sadashivan and Neelakantan, 1976). Jack preserve was found to be an acceptable and appealing product (Amban, 1987). Jackfruits are used for preparation of pickles, dehydrated leather and thin papads (Lavania, 1990). An acceptable quality RTS beverage from jackfruit was developed by Krishnaveni *et al.* (2001).

Studies on processing and utilization of kamkaut 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 kamkaut for processing.

Jamun, an indigenous fruit having an attractive colour and excellent taste can be profitably used for beverage industry. The juice of ripe jamun fruits is used for the preparation of syrup and wine (Khurdiya and Roy, 1984). An acceptable quality RTS beverage from jamun was developed by Khurdiya and Roy (1985). The fruits such as jamun and phalsa, which are rich in nutrients and medicinal values, have been used in several products such as blending in other preserved products like fruit based beverages and powder in ayurvedic preparations (Choudhary *et al*., 2006). A highly acceptable RTS beverage consisting of 14 per cent juice with 0.15 per cent citric acid and TSS of 14ºbx was standardized from jamun (Rokhade *et al*., 2006b).

The pulp of passion fruit can be used in preparation of squashes, cordials, syrups and jellies .It can also be used for flavouring candy, ice cream and cake fillings (Ramdas, 1988). Passion fruit is considered to be an excellent mix for alcoholic beverages such as vodka, gin and rum (Hicks, 1990). A carbonated drink made from passion fruit is reported to be well acceptable (Khurdiya, 1994).

The probability of utilizing peel from watermelon for making pickle with the outer green skin had little astringency in taste, while the one without outer skin was of bitter taste (Kumar, 1985). Peeled watermelon rind was processed alone and in combination with pink berries of grape cultivar by Bhatnagar (1991) and the study resulted in a mixed jam with high acid and pectin content, better consistency, colour and flavour.

Products like syrup, jam and jelly are also prepared from fig other than dried and dehydrated products (Woodroof, 1985). Karonda are used for pickles, chutney, pudding and jelly (Misra and Jaiswal, 1990). Wine and candy were prepared from karonda by Majeed (1995). Persimmons are suitable for preparing jams and marmalade (Ustun *et al*., 1997). Pomegranate was suitable for making

jam, marmalade jellies etc (Artes and Barberan, 2000). Squash was prepared from white and red rose apple and pickle and jam were prepared from bilimbi (Joy, 2003).

Fresh fruits of amla are commonly used for making murabba, pickles, and jelly (Ram, 1975). Amla is grown through out the country and finds use in the manufacture of preserve, pickle, jam, squash, nectar, chutney, candy and various ayurvedic preparations (Jain *et al*., 1986). An alternate product aonla segments in syrup has been developed at Central Institute for Subtropical Horticulture, Lucknow. It takes only 7-8 days for preparation of segments in syrup, against 20-25 days required for aonla preserve. The product has better eating qualities, as it is devoid of any fibre or stone, hence easy to eat. The technology for preparation of aonla candy has been standardized, here the segments are separated from the fruits by blanching (Tandon and Kumar, 2005).

Dehydrated products like aonla supari, a mouth freshner is a spiced product that has been introduced by a few processing units recently. The Central Institute for Subtropical Horticulture, Lucknow has formulated a refined methodology for preparation of aonla supari. The product has improved sensory properties with better nutrition retention. It has good potential to replace health hazardous chewing substances like ghutkha, pan masala etc. Freeze-dried aonla in the form of shreds/flakes or segments may prove to be good stuff with great potential. Aonla powder is another important dried product with multiple purpose. It is prepared by drying plain (unsalted) pieces of aonla as in case of supari and then grinding them to powder form. The powder can be used for preparation of aonla churan, a digestive product, by adding spices in it (Tandon and Kumar, 2005).

Aonla juice is emerging as an important health drink. The juice owing to rich amounts of vitamin C and polyphenols, can also prove to be an important material for blending with other fruit juices containing good aroma and taste .The recipe for preparation of guava-aonla blended RTS, aiming at nutritional enhancement of drink has been standardized. Spiced aonla beverages due to

aromatic components of spices have improved acceptability. Aonla ginger lemon blended squash has also great market potential (Tandon and Kumar, 2005).

A product containing 5-6 per cent alcohol, 3-4 per cent sugar and 0.35 per cent acid can be prepared from litchi, which can be chilled as an appetizing soft drink instead of intoxicating liquors (Vyas and Joshi, 1989). Fruit colour is an important quality trait for consumer preference in litchi. Litchi fruit peel have more than 70 TSS/acidity ratio and more than 35mg/100g anthocyanin which is highly useful for good quality and consumer appeal (Hasan and Chattopadhyay, 1997). Lovilovi being rich in pectin and acid are suitable for making jams, jellies, syrups and preserves (Prasad, 1998).

Laqout fruit are suitable for fresh consumption and processing because they are larger in size, less in astringent taste, have higher percentage of pulp, rich in β-carotene and have lower tannin and total sugar content (Amin *et al* ., 2000).

Bael is a rich source of carbohydrates, vitamins and minerals but owing to its hard shell and mucilaginous texture is not suitable as dessert fruit. It can be suitably utilized for processing into value added products. By adjusting the amount of pulp, brix and acidity, good quality nectar and squash could be prepared from bael fruit (Roy and Singh, 1979). Nectar and squash from bael fruit pulp revealed that bael nectar consisting of 35 per cent pulp, 25^0 bx TSS and 0.3 per cent acidity was ideal combination where as squash having 50 per cent pulp, 1.5 per cent acidity and 50^obx TSS was more acceptable (Bhat and Koul, 2006).

RTS beverage from phalsa fruit was formulated and standardized by Wasker *et al.* (1991). Kinnow fruit was suitable for conversion into RTS beverage (Ranote *et al*., 1992) He further 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. 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 (Adsule *et al*,

1992). Unripe fruits of lasora are widely used for making pickles and vegetable curries. Wood apple makes an excellent chutney and can be used in jelly and squash making (Meghwal, 1997).

Passion fruit powder has been standardized by Pruthi (1960). Study conducted by Sheela *et al*. (2006) revealed the potential of utilizing jackfruit seed flours rich in carbohydrates and minerals for value addition.

2.3.1 West Indian cherry:

West Indian cherry *(Malpighia punicifolia* L*.)* is native of Barbadies, an island in the West Indies. This small tree is variously known as acerola, peurtorican cherry or barbados cherry, native cherry and garden cherry. It is a shrub or small tree, the bushes are evergreen and grow to a height of 15ft height in 10-12 years with numerous branches. The flowers are small pink or red or rose in colour, and appears in April or May. The fruit matures 3-4 weeks after flowering (Tajuddin and Prakash, 1996).

West Indian cherry has become a potential economic crop in underdeveloped countries owing to its high vitamin C content. This plant was introduced in South India in 1958.The tree besides bearing fruits, is rich in vitamin C content, is of ornamental value due to dense canopy of dark green leaves and bears flowers and fruits all through the year. Two distinct types, bearing white and pink flowers are met with

Pink flower type: Flowers are pink and born in clusters in leaf axils. Fruits are large in size.

White flower type: Flowers are white and are born in clusters in leaf axils. Fruits are small (about 1g) and orange coloured when fully ripe (Mitra, 2000).

2.3.2 Physicochemical characteristics of West Indian cherry:

All the physical characteristics studied were greater for ripe compared to raw fruits except acidity. Length and girth ratio of ripe fruits was more than raw fruits, the length to girth ratio was less in ripe fruits. Higher pulp seed ratio of fruits can be accounted to increased pulpiness of ripe fruits (Bharati *et al*., 1994a). Two varieties of acerola occur, one bearing purple red fruits and the other pink fruits. Fruit weight range from 2-10g with the seed representing 19-25 per cent of the total weight (Mezquita and Vigao, 2000).

Fruits are harvested when they are beginning to turn pinkish orange or light red. The tree must be picked 5-6 times during the harvesting season. Fruit skin colour is considered as the main maturity index of West Indian cherry. The fruit has attractive bright colour with shallow ridges. For the commercial production of West Indian cherry juice with a high content of vitamin C, it is better to strip the fruits from the tree earlier in the season, instead of waiting to pick them when they are very ripe (Lopez, 1963). It is naturally adapted to both medium and low rainfall regions and can tolerate long periods of drought, though it may not fruit until the coming of rain. The fruits are usually picked manually in the cool of morning and must be handled with care. Harvested fruits should be kept in the shade until transferred from the field, which ought to be done within 3 hours, and collecting lugs are the best, covered with heavy canvas to retard loss of ascorbic acid (Morton, 1987).

For home use, as dessert, the fruits are picked when fully ripe. In case of freezing or processing into pulp or juice, fruit must be red in colour but sufficiently firm to withstand handling. Fruit quality at this stage of maturation is at maximum that is sugar content is high and acidity is low. Fruits that are deeply red in colour contain less vitamin C than those at earlier stages of maturation (Mitra, 2000).

Gomez *et al*. (1999) classified acerola as acid and sweet type. The acid type acerola fruit (pH 3.1-3.3) contained more vitamin C than the sweet type. (pH 3.4-3.6).

2.3.3 Chemical composition:

The partly ripe fruit weighed less, had a smaller diameter, rendered less juice with a slightly higher content of solids, had a higher total acidity, lower reducing sugar content and a higher ascorbic acid content than the ripe fruit. Total moisture and pH were practically the same (Asenjo and Moscoso, 1950). West Indian cherry is an excellent source of ascorbic acid, the contents ranging between 1000 and 2000mg/100g fruit when it is fully ripe, while the mature West Indian cherry has about 4500mg/100g fruit (Maciel *et al.,*1999).

The acid taste in West Indian cherry is produced by levomalic acid, ascorbic acid, dehydro ascorbic acid and citric acids (Matsuura *et al*., 1998). It was possible to identify 31 volatile compounds in the mature (red) fruits, 23 in the intermediate maturity (yellow) fruits and 14 in the immature (green) fruits. In the ripe fruits, four major carotenoids were identified (beta-carotene, beta-cryptoxanthin, lutein, and violaxanthin). β-carotene values are similar to those described in tomatoes and some tropical fruits such as guava and papaya (Mezadri *et al*., 2005)

The effect of stage of maturity (3 stages) on the chemical composition of West Indian cherry harvested during March was investigated by (Vendramini and Trugo, 2000). Stage of maturation was characterised by different indicators such as colour, vitamin C, soluble solids, protein, ash, moisture, titratable acidity, pH and sugars. Titratable acidity, sugars and soluble solids increased, and vitamin C and protein decreased with the progress of maturation.

Physicochemical characteristics of fruit of 12 genotypes of *Malpighia punicifolia* were analyzed by Matsuura *et al.* (2001) and found that the values of ascorbic acid ranged from 835 to 1820 mg/100g pulp, total soluble solids from 6

to 11.6 per cent, total titratable acidity from 0.69 to 1.65 per cent, total soluble solids: total titratable acidity from 4.24 to 11.59 and pH from 3.08 to 3.57.

2.3.4 Nutritional importance:

West Indian cherry competes with Camu-Camu (*Myrocearia paracensis*) both of which showed an ascorbic acid content of about 2.5 per cent. West Indian cherry however is much superior to guava as a potential source of vitamin C and even richer than Indian goose berry (*Phyllanthus embelica*) (Brown, 1967).

One fruit of West Indian cherry can furnish 53-176 mg of ascorbic acid and can thus supply the daily requirement (Tajuddin and Prakash, 1996). Vitamin C is increasingly recognized as a phytochemical with broad biological functions with properties of free radical scavenger (Rani *et al.,* 2001). West Indian cherry is useful for fortifying the ascorbic acid content of other fruit juices. It has been used as a commercial source of vitamin C in dietary supplements as well as of β-carotene, iron, calcium, potassium and vitamin B and enhances the antioxidant activity of other botanical extracts to prevent the oxidation of LDL (Johnson, 2003).

The fruits are considered beneficial to patients with liver ailments, diarrhoea and dysentery, as well as those with coughs and colds. The juice may be gargled to relieve throat pain (Morton, 1987).

The demand for West Indian cherry and its products is increasing due mainly to the presence of vitamins such as β-carotene, vitamin C and fibre. These nutritional elements are associated with the prevention of several diseases like cancer, coronary heart diseases (Maciel *et al*., 1999). There was an increase in the blood levels of vitamin C and hemoglobin levels of preschool children after supplementing a diet with West Indian cherry. Considering these results, this fruit juice should be included in all the feeding programmes for population at risk of anaemia (Costa *et al*., 2001). West Indian cherry is also a rich source of flavanoids and anthocyanins. Flavanoids

and anthocyanins obviously enhanced the effect of ascorbic acid. The effect of natural acerola antioxidants was comparable to that of phenolic antioxidants, such as ferulic acid (Nagamine *et al*., 2004a). The total anthocyanin pigment was 37.5mg/100g of ripe acerola skin. The phenolic pigments identified were pelargonidin, malvidin, 3,5-diglycoside and cyanidin3-glycoside. Quercitin, kaempherol and the phenolic acids like p-coumaric acid, ferulic acid, caffeic and chlorogenic acids were also identified (Vendramini and Trugo, 2004). The protective effects of acerola fruit purees and leaves could be related to their antioxidant activities to neutralize free radicals, to attenuate hepatic lipid peroxidation and thus can protect liver damage in rats (Nagamine *et al.,* 2004b).

Among the 46 compounds identified in the volatile fraction, the alcohols like methyl-but-3-en-1-ol, 3-methyl-butan-1-ol and 2-methyl-butan-1-ol were predominant. Two other classes, aromatic compounds and esters, can contribute to the fresh aroma of the fruit. Among the 42 aglycons identified for the first time in this fruit, aliphatic alcohols and non-isoprenoids were the main compounds (Boulanger and Crouzet, 2001).

2.3.5 Value added products from West Indian cherry

Barbados cherries are eaten out of hand, mainly by children. For dessert use, they are delicious merely stewed with whatever amount of sugar is desired to modify the acidity of the particular type available. The cooked fruits must be strained to remove the seeds and the resulting sauce or puree can be utilized as a topping on cake, pudding, ice cream or sliced bananas, or used in the culinary products (Morton, 1987).

West Indian cherry is a highly perishable fruit and spoils in a few days. Therefore, some harvest techniques are applied to minimize the spoilage and preserve its quality for long periods. The development of West Indian cherry

products is very important to provide foods rich in ascorbic acid and offers a variety of options to the consumers (Maciel *et al*., 1999).

The acerola fruit, which is also rich source of iron, is used in sherbet, ice cream, jelly, baby foods, fruit nectars and soft drinks (Arostegui and pennock, 1956). Studies by Muthukrishnan and Palaniswamy (1972) revealed the suitability of West Indian cherry for the preparation of clarified juice and squash. The fresh juice will prevent darkening of bananas sliced for fruit cups or salads. West Indian cherry besides used as a table fruit is used in the preparation of jelly, sherbet, juice, salad etc (Asenjo, 1980). It can be used for gelatin desserts, punch or sherbet, and has been added as an ascorbic acid supplement to other fruit juices. (Morton, 1987).

Malpighia punicifolia fruits are highly perishable and too acidic for direct consumption and raw fruits of this valuable source of vitamin C for the Indian diet could be successfully converted into pickle where as ripe fruits could be used for preparing squash, jam, chikki (toffee), ketchup and wine (Bharati *et al*., 1994b). West Indian cherry can replace tamarind and tomato in many culinary preparations. Products such as cordial, RTS, squash and milk shake were prepared from West Indian cherry (Parvathi *et al*., 1998). The acerola can be processed easily into jelly, puree, confectionery and sauces (Mezquita and Vigao, 2000).

2.3.6 Organoleptic qualities and acceptablility of West Indian cherry products:

A palatable, nutritious, transparent, pinkish red coloured jelly could be prepared from West Indian cherry juice. This jelly retains appreciable amounts of vitamin C, about 800mg/100g for long periods of time. Thus, one tablespoon of the jelly would liberally provide the RDA requirements (Asenjo, 1980). The acerola jelly obtained by the formulation of 49 per cent sucrose, 1 per cent of pectin and 50 per cent of acerola juice was considered of good quality by both physico-chemical and sensory characteristics. Acerola jelly can be stored for 180

days at 28^{o}C with an ascorbic acid content of 2303.4mg/100g and frozen fruit and pulp for 30 days at –18^{o}C (Maciel *et al*., 1999).

Besides increasing the vitamin C content, the addition of acerola pulp improves the colour and flavour of orange juices with low content of solids (Nieva, 1955 and Ledin, 1958). Studies on the extraction, canning and storage of West Indian cherry juice showed that after pasteurization and canning, both the colour and flavour of the juice underwent rapid deterioration. Storage at room temperature results in swelling of the can due to CO_2 development within a month, and 80 per cent loss of vitamin C within a year. This loss may be reduced by storage at 45^{0}F. During storage, red colour may also disappear and brown pigments may form due to non-enzymatic reactions in which the ascorbic acid takes part (Nieva, 1955, Santini and Huyke, 1956). Reducing sugar increased in acerola juice while the ascorbic acid content, acidity and pH decreased with increase in the period of storage (Muthukrishnan and Palaniswamy, 1972). After juice making, including a pasteurization stage as thermal processing, decrease in carotenoid content were observed (Mezadri *et al*., 2005).

Acerola soft drinks of 10,11 and 12^{0}bx formulation were produced by pasteurisation and addition of chemical preservatives (Bernandino and Venturini, 2002). Low calorie drinks based on acerola were prepared using different sweeteners and stored at 25^{o}C, no significant variations were observed for pH, degrees brix, reducing sugar and non reducing sugar contents and the study revealed that the product containing a combination of aspartame, saccharin and sodium benzoate was the most acceptable (Maia *et al*., 2003).

An optimized formulation for a mango and acerola nectar contained nine per cent acerola pulp, 15 ^{o}bx, and an ascorbic acid content of 76mg/100g.The addition of acerola pulp upto a limit of 34 per cent to a papaya and acerola nectar did not affect the sensory acceptance of nectar and presented approximately 170mg/100g ascorbic acid. The optimum level of sugar was between 8.5 per cent and 16 per cent. Pineapple juice (20.9 mg/100g ascorbic acid) added to 10 percent

acerola juice (1000 mg /100g ascorbic acid) resulted in product with about five times the vitamin C content of pineapple, and sensorial analysis showed no difference between treatments. A mixed nectar produced with papaya pulp, passion fruit juice, and sucrose in different proportions maintaining the acerola pulp constant revealed that the sensory acceptance of nectars formulated with 37.5 per cent papaya pulp, 7.5 per cent passion fruit juice, and 5 per cent acerola pulp added of 15 per cent sucrose was found to be acceptable (Matsuura *et al*., 2004).

West Indian cherry pickle in oil stored for a period of six months retained the vitamin C to an extent of 860mg/100g of pulp (Muthukrishnan and Palaniswamy, 1972). Wine made from barbados cherries in Hawaii was found to retain 60 per cent of the ascorbic acid (Morton, 1987). Cherry wine had an alcohol content of 8.63 per cent, while grape wine had 7.99 per cent (Bharati *et al.,* 1994a). West Indian cherry squash is delicious but the keeping quality was low compared to the squash under ambient conditions (Parvathi *et al*., 1998).

2.4. Shelf life studies 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 vitamin C, pH, acidity, TSS, and total sugar, physical tests, sensory evaluation and microbial tests.

2.4.1 Nutritional and Chemical changes

Nearly 90 per cent of vitamin C in human diet is obtained from fruits and vegetables as ascorbic acid and dehydroascorbic acids. These acids are sensitive to light and oxygen and may decompose under normal transport and storage conditions resulting in reduction of nutritional value (Zee *et al*., 1991). Exposure to sunlight was a significant factor that affects the ascorbic acid retention in bottled juice (Ranote *et al.,* 1992).

Maximum loss of ascorbic acid occurred in products subjected to continuous boiling, steaming etc (Geetha and Shivaleela, 1982). There was a loss of ascorbic acid in the processed food products under the influence of atmospheric oxygen (Jellinik, 1985). The role of vitamin C in the discoloration of processed products was studied by Pruthi (1985) and reported that there was 10-15 per cent loss of ascorbic acid during storage period. The loss of ascorbic acid was rapid in Kinnow RTS beverage at the initial period of storage but slowed down after six weeks of storage at room temperature (Ranote *et al.,* 1992). Products like preserve and candy from amla retained high amounts of vitamin C (544mg and 522mg/100g respectively) even after processing (Saima, 2002).

Comparatively lower losses were observed in juice samples preserved with KMS than those preserved by pasteurization and sodium benzoate (Mehta and Bajaj, 1983). The retention of ascorbic acid was better in SO_2 preserved juice than heat processed bottled juice of kinnow mandarin (Ranote *et al*., 1992).

Processing the juice by pasteurization reduced ascorbic acid to between 28-46 per cent, while storage in plastic bottles for two months further reduced the ascorbic acid content to between 10-21 per cent (Achienewher and Hart, 1984). A rapid decrease in ascorbic acid was observed in banana, apple, and guava samples and in blends consisting of orange juice-banana-apple or banana-apple blends (Mokady *et al*., 1984). The decrease in ascorbic acid was 28.73 per cent in tomato concentrate stored in glass bottles (Seralathan and Thirumaran, 1990). The ascorbic acid decreased significantly (26.48 per cent) during the six months storage of tomato concentrate (Agarwal *et al*., 1995).

Among the products prepared with amla, Saima (2002) observed that salad had the highest vitamin C content (560mg). The lowest vitamin C content was in samosa (69mg) and also found that the maximum vitamin C retention (38%) was observed in candy stored under refrigerated conditions in glass bottles. Thus, the candy which was a highly acceptable product, could be recommended as a nutritious preserved fruit product even during the off season. The mean β-

carotene and vitamin C contents in candy and tutti-frutti from cashew apple decreased significantly during six months of storage (Suman, 2006).

There was no significant loss of ascorbic acid from the eleven commercial fruit juices kept in a closed container at 4º and 25ºC (Nichabouri *et al*., 1993). Saini and Grewal (1995) reported that loss of ascorbic acid was more pronounced during concentration of unblanched pear juice (60.7 %) than that of blanched pear juice (49.3 %). Stability of blended simarouba and kokum squash at 75:25 ratio was found to be better during storage containing 45^0 brix and recorded maximum ascorbic acid, total sugar and reducing sugars (Ramajayam *et al*., 2006).

Chemical analysis of jackfruit squash by Sadashivan and Neelakantan (1976) showed that the pH did not change during storage. The pH remained stable in the RTS beverage from phalsa fruits during storage at different temperatures (Khurdiya and Anand, 1980). Chemical changes related to storage in amla jam and dehydrated products were studied, by Tripathi *et al.* (1988) and indicated no change in pH. 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 in kinnow juice during storage (Ranote *et al*., 1993) The pH remained constant during storage of sand pear juice concentrate as reported by Saini and Grewal (1995).

There was a decreasing trend in pH during storage of RTS beverages prepared from watermelon (Chakraborthy *et al*., 1993). Similar results were found in storage of jackfruit RTS beverage (Krishnaveni *et al.,* 2001).

A decrease of titritable acidity in lemon juices and squashes were observed by Muthukrishnan and Palaniswamy (1974). A reduction in acidity was noticed in kinnow mandarin, irrespective of the temperature during three months storage (Sandhu *et al.,* 1983). 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 (Joy,

2003). During storage period of four months ber juice showed a decrease in titritable acidity (Rokhade *et al*., 2006a).

An increase in the acidity was observed in mango pulp (Adsule and Roy, 1975). 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 findings were reported in stored litchi juice by Sethi (1985). An increase of 0.86 per cent in acidity was exhibited by amla juice during storage (Tripathi *et al.,* 1988). Analysis of pomegranate juice showed an increase in acidity during storage (Kahtani, 1990). There was an increasing trend in acidity during storage of jackfruit RTS beverage (Krishnanveni *et al.*, 2001). A steady increase of acidity was noted in bilimbi jam and pickle and similar increase was also found in rose apple squash (Joy, 2003).

Acidity did not change significantly during the twelve month storage of mango papaya blended beverage (Kalra *et al*., 1991a). Analysis of kinnow juice over a period of storage of six months indicated negligible change in acidity (Ranote *et al.,* 1993) During storage of watermelon juice there was no change in acidity of the product (Saini and Bains, 1994).

Guava pulp stored at different temperatures showed an increase in TSS content within 45 days of storage (Kalra and Revath, 1981). There was an increase in TSS during storage of kiwi squash (Mehta and Bajaj, 1983). There was a gradual increase in the TSS during the entire period of storage in Bael squash (Jain *et al*., 1984). Storage studies in litchi squash indicated a pattern of progressive increase in TSS content during storage (Sethi, 1985 and Jain *et al*., 1988). There was an increase in TSS during storage in phalsa squash (Wasker and Khurdiya, 1987). Total soluble solids increased with increased period of storage in pomegranate squash (Prasad and Mali, 2000). TSS of rose apple squash showed an increase from 45.03^0 brix to 47.93^0 brix during storage period (Joy, 2003).

Amla jam and preserve exhibited a rise in TSS content during storage (Tripathi *et al*., 1988). Strawberry sauce exhibited only very slight increase in TSS through out the storage period of 3 months (Kumar and Manimegalai, 2001). Changes in the chemical qualities of bilimbi jam during storage revealed that TSS of jam slightly increased from 76.10^{o} brix to 78.53^{o}brix during storage (Joy, 2003). In ber juice the TSS content increased during a storage period of 4 months. (Rokhade, 2006a).

There was a decrease in TSS (3.6 per cent) in tomato concentrate stored in glass bottles (Seralathan and Thirumaran, 1990). In RTS beverages prepared from watermelon, the decrease in TSS was from 15 to 14.5 after storage of 5 months (Chakraborthy *et al*., 1993).

No change in TSS and total sugar was observed in the phalsa beverage during storage as reported by Khurdiya and Anand (1980). Similar results were observed in jamun beverage and watermelon juice by Khurdiya and Roy (1985) and Saini and Bains (1994). Total sugar was found to be decreased in bilimbi pickle from 2.58 per cent to 2.50 per cent during storage (Joy, 2003).

There was a gradual increase in the reducing and total sugars during the entire period of storage in bael squash (Jain *et al*., 1984). An increasing trend in reducing sugar was observed in litchi squash during storage (Jain *et al*., 1986). Reducing and total sugar continued to increase during storage in amla jam and preserve (Tripathi *et al*., 1988). Total sugar was found to be increased in lovi lovi preserve from 60.43 per cent to 63.03 per cent during storage months (Joy, 2003).

2.4.2 Organoleptic changes:

Organoleptic evaluation of stored amla jam indicated an increase in acceptability with storage and organoleptic evaluation of amla candy and dehydrated amla showed that the acceptability decreased with storage (Tripathi *et al*., 1988). The ambient temperature stored amla candy was found to be more

acceptable compared to refrigerated candy. So a well acceptable amla candy with regard to all the sensory qualities can be obtained by the third month of storage under ambient conditions where as for preserve and tutti-frutti maximum acceptability for all the sensory qualities were during the sixth month of storage under both storage conditions (Saima, 2002). The overall acceptability of lovilovi preserve in sugar was also found to be increased during storage (Joy, 2003).

The keeping quality of watermelon jam was reasonably good under ambient storage conditions for a period of six months (Bhatnagar, 1991). Appearance and colour of bilimbi jam was found to be decreased during storage whereas flavour, texture and over all acceptability were found to be increased during the period of storage (Joy, 2003). Jam prepared using 45 per cent simarouba pulp, 68.5^{o} bx TSS rated excellent and was rated superior in organoleptic evaluation after five months of storage period (Ramajayam *et al*., 2006).

Dehydrated blueberry products had a good texture, flavour and over all acceptability and had a shelf life of 16-64 months (Angela *et al*., 1987). The organoleptic evaluation of tutti-frutti made from ber indicated that the products were highly acceptable and over all acceptability score of ber tutti-frutti was better than papaya tutti-frutti due to its superiority in flavour and taste (Chavan *et al*., 1993).

Squashes prepared from apricot pulp were found to be acceptable upto eight months (Manan *et al.,* 1992). The overall acceptability of rose apple squash decreased gradually from fourth month onwards (Joy, 2003). Pomegranate squash was organoleptically acceptable for a period of 3-4 months at room temperature (Prasad and Mali, 2000). Stability of simarouba squash containing 45^{0} bx and 75:25 ratio of kokum blends was found acceptable during a storage period of five months (Ramajayam *et al.,* 2006).

Passion fruit RTS was acceptable during its five weeks of storage (Pal, 1995). Majeed (1995) reported the organoleptic stability of karonda products during its eight months of storage. Jackfruit RTS beverage was highly acceptable even after storing for six months at room temperature (Krishnaveni *et al.,* 2001).

Appearance, colour and flavour of bilimbi pickle decreased over a period of six months (Joy, 2003). Carambola pickles with ascorbic acid and citric acid were brighter and greener after pickling and remained least dark after a storage period of eight weeks (Kumar *et al.,* 2006).

2.4.3 Microbial aspect

Additives such as citric acid, sodium benzoate or potassium meta bisulphite improved the colour of the product and decreased the count of microflora during the processing of the products (Ali, 2000).

Market samples of amla preserve revealed that the microorganisms associated with contamination of preserve are *Saccharomyces* and *polymorphus* (Sethi and Anand, 1984). Spore forming bacilli is the most prevalent one among the bacillus species identified in fruit products (Allien *et al.,* 1986).

There was no activity of micro organisms upto six months of storage of water melon jam (Bhatnagar, 1991). Complete absence of micro organisms in pomegranate wine was observed during storage period of eight months (Kadam *et a l*., 1992). Similar results was given by Majeed (1995) that there was complete absence of micro organisms in karonda candy, jelly, canned karonda and wine during storage.

Osmotically dehydrated jackfruit products of soft and firm flesh varieties had a stability of five months (Oommen, 1995). Jam and pickle prepared from bilimbi remained stable for a period of six months without any microbial contamination (Joy, 2003).

The sauce prepared from strawberry recorded zero microbial count initially and showed a low count of micro organisms after a storage period of three months (Kumar and Manimegalai, 2001). Jam, squash and RTS prepared from simarouba and kokum showed no spoilage during the storage period of 5 months (Ramajayam *et al.,* 2006).

Materials and Methods

MATERIALS AND METHODS

The study entitled "Value addition and quality evaluation of West Indian cherry" was undertaken to investigate the nutritive value of West Indian cherry fruits and to find out its suitability for development of various processed products. The materials and methods used in the study are given under the following headings.

1.Collection of the fruits for the study
2. Physical characteristics of West Indian cherry fruits
3. Chemical constituents in West Indian cherry fruits
4. Preparation and storage of the products
5. Organoleptic evaluation of the products
6. Chemical composition of the products
7. Microbiological study
8. Benefit cost analysis of developed products
9. Statistical analysis of the data

3.1 Collection of the fruits for the study

West Indian cherry fruits were collected from the orchard of the college of Horticulture, Vellanikkara. Fruits were collected in their fully mature stage where there was only a tinch of red colour in the fruit skin and also in their red ripe stage.

3.2 Physical characteristics of West Indian cherry fruits

The following physical characteristics were observed in the fruits at fully mature stage and red ripe stage.

3.2.1 Fruit colour

Colour of ten fruits was observed and noted in their fully mature stage and red ripe stage

3.2.2 Fruit firmness

Firmness of ten fruits in their fully mature stage and red ripe stage was measured using a penetrometer.

3.2.3 Number of fruits per hundred grams

Hundred grams of fruits in both fully mature stage and red ripe stage was weighed using an electronic balance.

3.2.4 Fruit weight

The weight of ten fruits in their fully mature stage was taken after harvest using an electronic balance. The weight of ten fruits in red ripe stage was recorded and average fruit weight was calculated in grams.

3.2.5 Fruit pulp ratio

Hundred grams of fruits in their mature and red ripe stage were taken and were made into pulp. Weight of the pulp was taken in both stages. The weight of the pulp is expressed in percentage.

3.2.6 Fruit weight upon ripening in room temperature after harvest

The weight of ten fruits in their fully mature stage was taken after harvest using an electronic balance. The weight of this same ten fruits in red ripe stage was recorded and average fruit weight was calculated in grams.

3.1 Chemical constituents in West Indian cherry fruits

Triplicate samples of West Indian cherry fruits in their fully mature stage and red ripe stage were analysed for the following constituents.

3.3.1 Moisture

Moisture content of the mature and red ripe fruits was estimated using the method of A.O.A.C (1980).

To determine the moisture content, ten grams of the fresh sample was weighed into a weighed moisture box and dried in an oven at 100ºC to 105ºC and cooled in a dessicator. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying.

3.3.2 Fibre

The fibre content was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978).

Two grams of the dried and powdered sample was boiled with 200ml of 1.25 per cent sulphuric acid for thirty minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200ml of 1.25 per cent sodium hydroxide for thirty minutes. Again, it was filtered through a muslin cloth and washed with sulphuric acid, water and alcohol. The residue was transferred to a pre weighed ashing dish, dried, cooled and weighed. The residue was then ignited for thirty minutes in a muffle furnace at 600^{o}c, cooled in a dessicator and reweighed. The fibre content of the sample was calculated from the loss in weight on ignition and then converted to fresh weight basis.

3.3.3 Calcium

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

One gram of dried and powdered sample was pre digested with 12ml of 9:4 diacid and volume made up to 100ml.One ml of aliquot was taken and added 10ml water, 10 drops of five per cent hydroxylamine, 10 drops of triethanolamine

and 2.5 ml of 10 per cent sodium hydroxide and 10 drops of calcon. Then it was titrated using EDTA till the appearance of permanent blue colour. It was expressed in mg per 100g of sample and converted to fresh weight basis.

3.3.4 Phosphorus

The phosphorus content was analysed colorimetrically after preparing a diacid extract, by vanadomolybdophosphoric yellow colour method in nitric acid medium (Jackson, 1973).

One gram of the sample was digested in diacid, was made up to 100ml. Five ml of the aliquot was pipetted into a 25ml volumetric flask, and added 5ml of HNO_3 vandate molybdate reagent and made up to 25 ml. After 10 minutes the intensity of yellow colour was read at 470nm in a spectrophotometer. A standard graph was prepared using serial dilutions of standard phosphorus solution. From the graph, the phosphorus content of the sample was estimated and converted to fresh weight basis.

3.3.5 Iron

The iron content was analysed colorimetrically using ferric iron, which gives a blood red colour with potassium thiocynanate (Raghuramulu *et al*., 2003)

To an aliquot of the mineral solution, enough water was added to make up to a volume of 6.5ml followed by one ml of 30 per cent sulphuric acid, one ml of potassium per sulphate solution and 1.5ml of 40 per cent potassium thiocyanate solution. The intensity of the red colour was measured within 20 minutes at 540nm.A standard graph was prepared using serial dilutions of standard iron solution. From the standard graph, the iron content of the sample was estimated and converted to fresh weight basis.

3.3.6 Potassium

The potassium content was estimated using flame photometer as suggested by Jackson (1973).

Powdered one gram of dry sample was digested in diacid and made up to 100ml.One ml of the sample solution was made up to 25 ml and read directly in flame photometer.

3.3.7 β-carotene

β-carotene was estimated by the method of A.O.A.C (1970) using saturated n-butanol.

Five gram of powdered and dried sample was placed in a 125ml glass flask and added 50ml water saturated n-butanol from pipette .The flask was stoppered tightly, shook well for one minute and kept overnight, protected from sunlight. Decanted the supernatant, pipetted 0.5 ml of the supernatant and diluted with 10 ml water saturated n-butanol and read the colour intensity in a spectrophotometer at 435.8 nm. β-carotene content of the sample was calculated from the reading and converted to fresh weight basis.

3.3.8 Vitamin C

The vitamin C content of the fresh sample was estimated by the method of A.O.A.C (1955)

One gram of the fresh sample was extracted in four per cent oxalic acid using a mortar and pestle and made up to 100 ml. Five ml of the extract was pipetted, added 10 ml of 4 per cent oxalic acid and titrated against the dye (2,6 dichlorophenol indophenol). Ascorbic acid content of the fresh sample was calculated from the titer value.

3.3.9 Total soluble solids

The TSS content was estimated using the hand refractometer.

3.3.10 Acidity

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

Ten grams of the sample was digested with boiling water. An aliquot of the digested sample was titrated with standard alkali using phenolphthalein as an indicator. Acidity was expressed in terms of citric acid as percentage.

3.3.11 Reducing and Total sugar

The content of reducing sugar and total sugar was estimated by adopting the method given by Lane and Eynon (Ranganna, 1986).

To 25g of sample, an amount of distilled water was added and then clarified with neutral lead acetate. The excess lead acetate was removed by adding potassium oxalate. The volume was then made up to 250ml. An aliquot of this solution was titrated against a mixture of fehling's solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

To estimate total sugar content, 25ml of the clarified solution was boiled gently after adding citric acid and water. It was later neutralized with sodium hydroxide and the volume made up to 250ml.An aliquot of this solution was titrated against a mixture of fehling's solution A and B. The total sugar content was expressed as percentage.

3.4. Preparation and storage of the products

Products selected for the present study are:

(a) Squash (Red ripe stage)

(b) Sauce (Red ripe stage)

(c) Pickle (Fully mature stage)

(d) Preserve (Fully mature stage)

Quantity taken for the preparation of the products was given in Appendix 2

3.4.1 Preparation of West Indian cherry squash

The steps followed in the preparation of West Indian cherry squash is as follows:

Selection of fruits:

Fully ripe West Indian cherry fruits without blemishes and injury were collected. The fruits were washed thoroughly in running water to remove the adhering dirt and other extraneous matter and were drained.

Extraction of juice:

For extracting the juice, the fruits were crushed thoroughly with a mixer and the juice was strained through a muslin cloth to remove coarse pulp.

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 grams of citric acid was added per kg of fruit juice taken for the preparation of West Indian cherry squash.

Mixing:

After the syrup was cooled the West Indian cherry juice was mixed with this. The ratio maintained for juice: water: sugar was 1:1:2. Sodium benzoate was added at the rate of 600mg/kg of the finished product. Sodium benzoate was dissolved in small quantity of the squash and mixed it with the rest of the product.

Bottling:

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

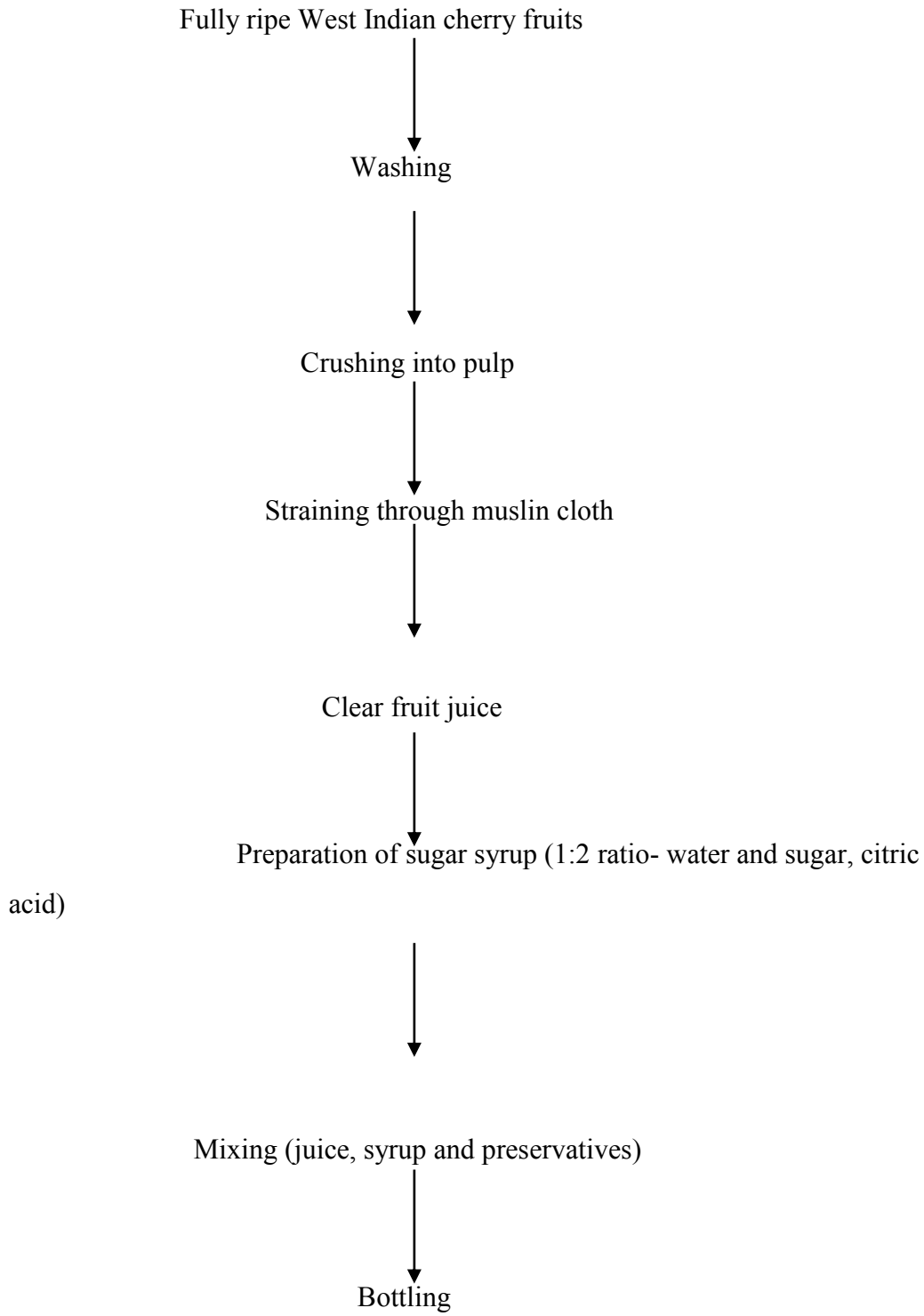


Fig.1 Flow chart for the preparation of West Indian cherry squash

3.4.2 Preparation of West Indian cherry sauce

The steps followed in the preparation of West Indian cherry sauce is as follows:

Selection of fruit:

Mature, sound ripe fruits were selected, washed in clean water and surface dried. The calyx of the fruit was removed.

Extraction of pulp:

The fruit was pulped by using a mixie. The fruit pulp was passed through the hand pulper to filter the debris.

Cooking:

Mixed the fruit pulp, salt and sugar and cooked on medium flame with spices tied in a muslin bag. Cooking was continued till the final TSS reached 37^0brix.

Cooling:

Cooled at room temperature and Sodium benzoate was added at the rate of 750mg/kg of the final product.

Bottling:

The prepared sauce was filled in glass bottles that were thoroughly sterilized and stored.

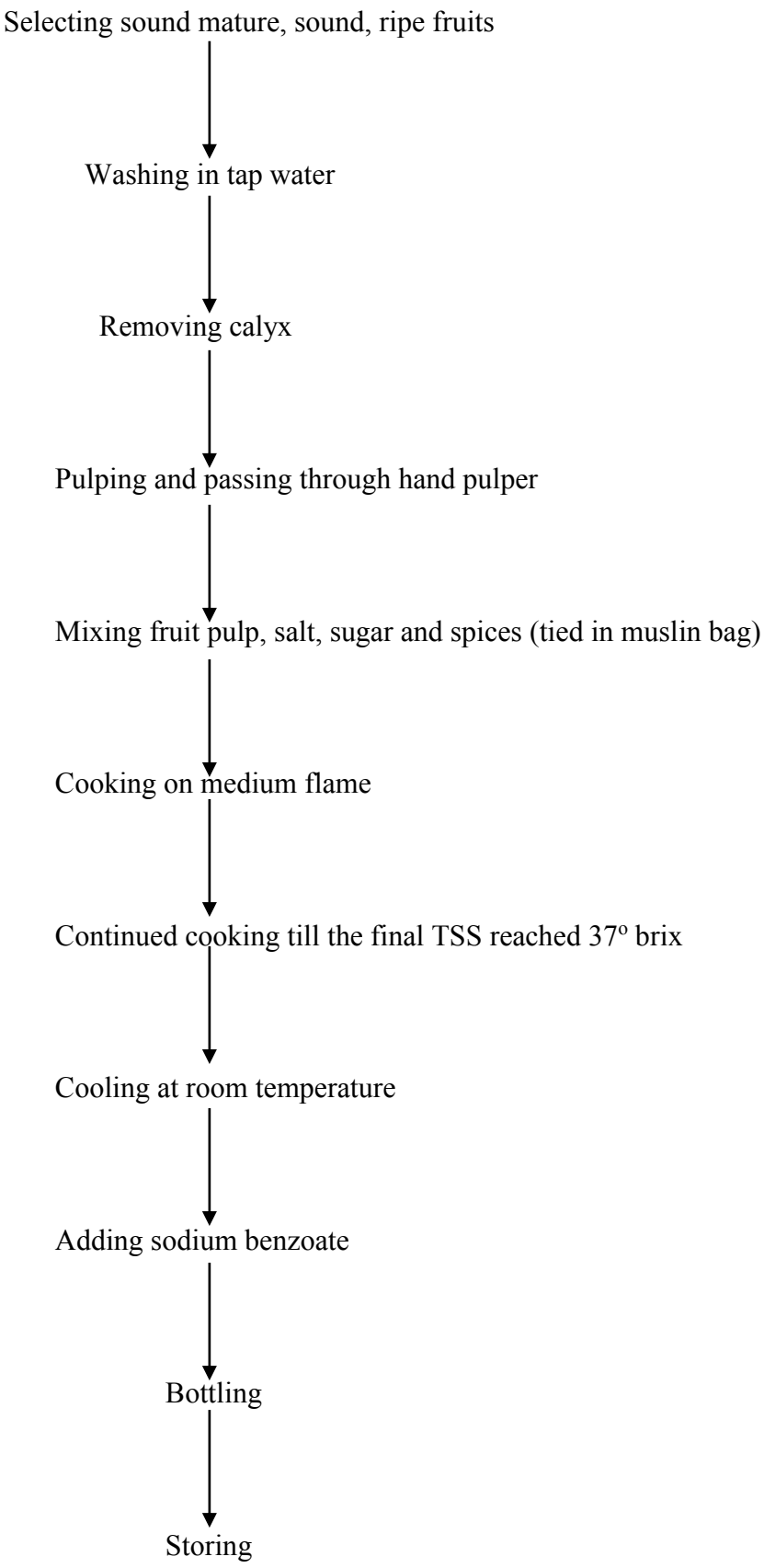


Fig.2 Flow chart for the preparation of West Indian cherry sauce

3.4.3 Preparation of West Indian cherry pickle

The steps followed in the preparation of West Indian cherry pickle is as follows.

Selection of fruit:

Fully mature West Indian cherry 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.

Blanching:

The fruits were blanched for 2 minutes in water at 80^0C.

Cooking:

Heated gingelly oil, seasoned split green chillies and added ginger, garlic pastes and stirred till oil separated from the mixture. To this added chilli powder, salt, vinegar, fenugreek powder, asafoetida powder and mustard powder.

Mixing:

Blanched fruits were then added to this paste and mixed thoroughly.

Preservative:

Sodium benzoate was added at the rate of 250mg/kg of the finished product.

Bottling:

The prepared West Indian cherry pickle was filled in sterilized glass bottles and stored in cool, dry place at ambient temperature.

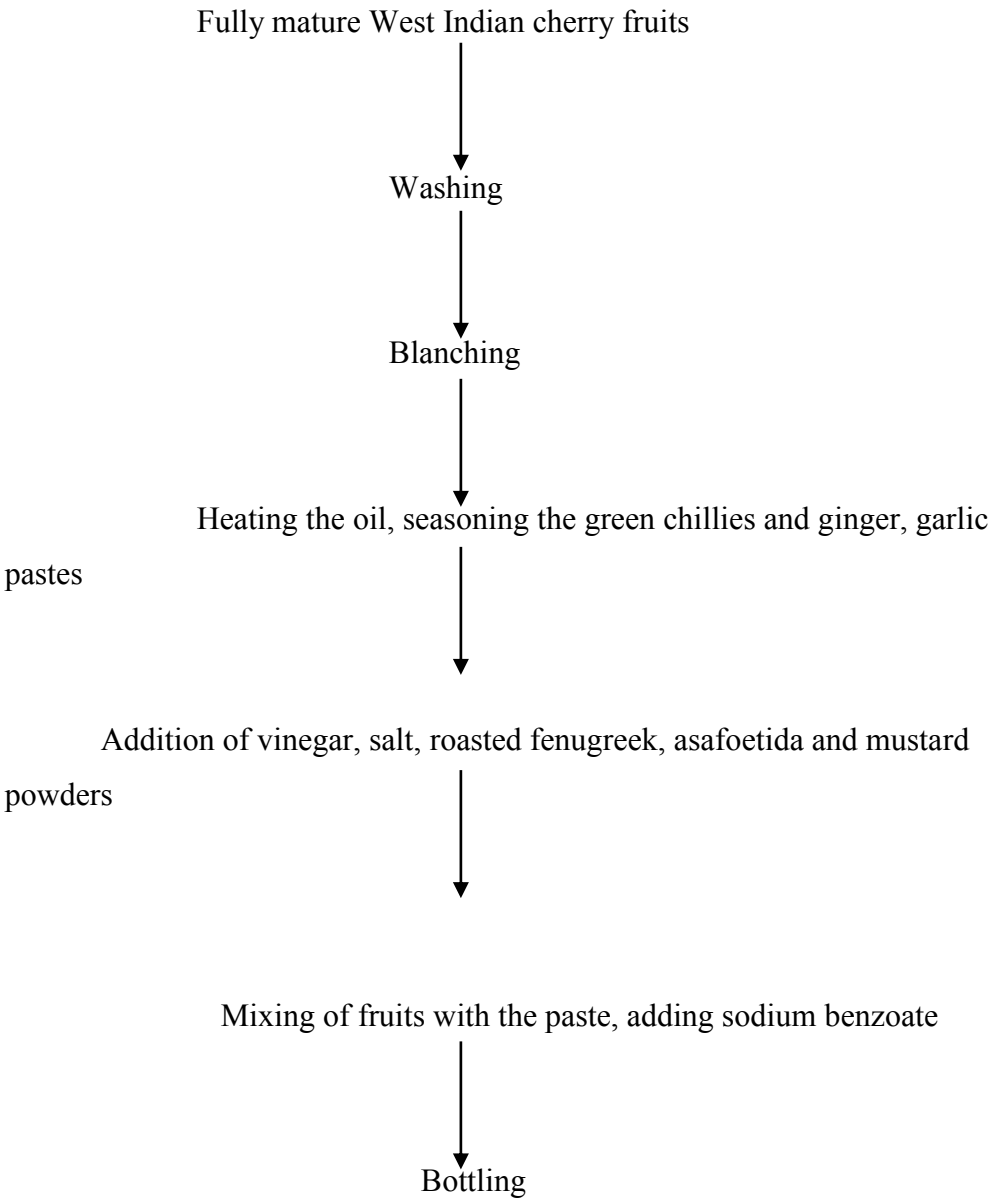


Fig.3 Flow chart for the preparation of West Indian cherry pickle

3.4.4 Preparation of West Indian cherry preserve in sugar

The steps followed in the preparation of West Indian cherry preserve in sugar is as follows.

Selection of the fruit:

Fully mature and firm fruits were washed with ample quantity of fresh water.

Processing of the fruit:

The washed fruits were pricked with stainless steel forks. After pricking, the fruits were immersed in 10 per cent lime water for one hour before further processing. After washing in water the fruits were blanched for three minutes in boiling water and drained. Sugar was added as half the weight of the fruits. Sugar was spreaded on the blanched fruits in alternate layers. Allowed to stand for 24 hours. Next day, the syrup was drained and sugar was added to raise the thickness of syrup (60^0 brix). A small quantity of citric acid (62-125g/100kg of sugar initially taken) is also added to invert a portion of the cane sugar. The syrup with the fruits were boiled and kept for 24 hrs. On the next day, the syrup strength was raised to 68^0 brix by adding sugar. Boiled the mass for five minutes. Sodium benzoate was added at the rate of 200mg/kg of the final product. Left the fruits in the syrup for 3-4 days. Finally the strength of the syrup was raised to 70^obx, boiled the fruits along with the syrup for a few minutes and filled hot into dry, wide mouthed jars and air tightly sealed.

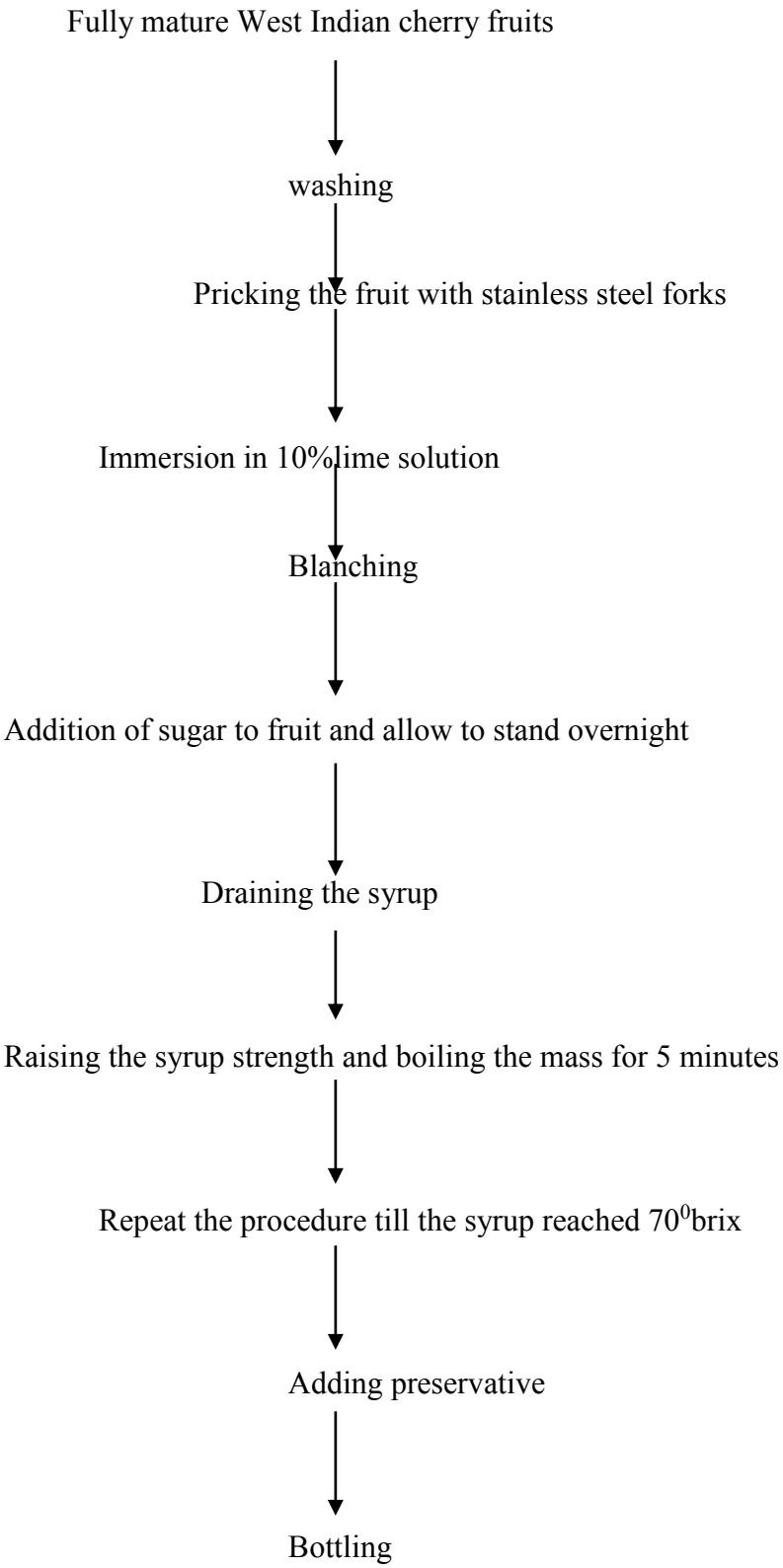


Fig 4.Flow chart for the preparation of West Indian cherry preserve

All the products prepared were stored in sterilised glass bottles for 6 months in ambient temperature.

3.5 Organoleptic evaluation of the products

3.5.1. Evaluation panel

Evaluation panels of 10 persons were selected between the age group of 18-35 years as suggested by Jellenik (1985). Sensory evaluation of the products was carried out using scorecard method (Swaminathan, 1974).

Organoleptic evaluation was done initially, at three months and at the end of storage period (6 months). 5 quality attributes like appearance, colour, flavour, texture and taste were evaluated for each sample. Overall acceptability of the product was also done for each sample. Each of the above mentioned quality attribute was assessed with a hedonic scale. The scorecard for organoleptic evaluation of fruit products is given in Appendix I.

3.6. Chemical composition of the products

The products stored in glass bottles were analysed initially, during the third month and at the sixth month of storage to find out the changes in the constituents such as vitamin C, acidity, TSS, total sugar and β-carotene.

3.7. Microbiological study

The keeping quality of the West Indian cherry products stored under ambient conditions was determined by assessing their microbial load during initial, third month and sixth of storage.

The method used for the evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). Ten grams of sample was added to 90ml sterile Ringer's solution and shaken for ten minutes. One ml of this

solution was transferred to a test tube containing 9ml sterile Ringer's solution to get 10^{-2} dilution and similarly 10^{-3},10^{-4},10^{-5} and 10^{-6} dilutions were prepared.

Enumeration of total microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi, and sabourad's dextrose agar media for yeast. The dilution used for bacteria was 10^{-6} and for fungi and yeast 10^{-3} dilution was used.

3.8. Benefit cost analysis of developed products.

The benefit cost analysis of the products was worked out to assess the extent of expense aroused to prepare the products and to calculate benefit cost ratio.

The cost was worked out based on the prices of various commodities needed for the preparation of the product. The final product yield was computed by taking into consideration the quantity of West Indian cherry fruits and other ingredients required to prepare a definite quantity of the product. The market price of similar popularly available fruit products was compared with the West Indian cherry products, since West Indian cherry products are not available in the market for comparison and benefit cost ratio was calculated thereafter.

3.9. Statistical Analysis of the data.

The data was analysed using paired t-test and Kendall's Coefficient of Concordance.

Results

RESULT

Results of the study entitled "Value addition and quality evaluation of West Indian cherry" are presented under the following headings.

4.1 Physical characteristics of West Indian cherry fruits
4.2 Chemical constituents of West Indian cherry fruits
4.3 Organoleptic changes
4.4 Chemical composition of the products
4.5 Confirmation of the products with FPO standards.
4.6 Microbiological count
4.7 Benefit cost analysis

4.1. Physical characteristics of West Indian cherry fruits

The physical characteristics of West Indian cherry fruits in fully mature stage and red ripe stage are presented in Table 1.

The colour of the fully mature fruits was green with pink tint and that of red ripe stage was full red colour. (Plate 1c)

The firmness of the fully mature fruits was 3.8 pressure in kg/cm^2 and for ripe fruits it was 1.6 pressure in kg/cm^2.

The number of fruits per 100g in fully mature stage was 21 and in red ripe stage it was 16.

Fruit pulp ratio of the fruits was 60 per cent in red ripe stage and in mature stage the ratio was 40 per cent.

The mean weight of a fully mature fruit was 4.76g and the weight of ripe fruit was 6.25g.

The mean weight of a fruit in fully mature stage was 4.76g and upon ripening in room temperature, the mean fruit weight was reduced to 3.3g.

Table 1. Physical characteristics of West Indian cherry

Sl.no	Physical characters	Fully mature	Red ripe
1	Fruit colour	Green colour with pink tint.	Red colour
2	Firmness	3.8 pressure in kg/cm^2	1.6 pressure in kg/cm^2
3	No. of fruits per 100g	21	16
4	Fruit pulp ratio (%)	40	60
5	Weight of fruit (g)	4.76	6.25
6	Weight of fruit upon ripening in room temperature (g)	4.76	3.3

4.2 Chemical constituents in West Indian cherry

The chemical constituents in West Indian cherry fruits in fully mature stage and red ripe stage along with the results of statistical analysis is presented in Table 2.The statistical analysis was done using Paired t test. The results are also presented in Figure.5 and Figure.6.

4.2.1 Moisture

The mean moisture content ranged from 83.7 per cent in mature stage to 87.13 per cent in red ripe stage. The moisture content of red ripe fruits was not significantly high when compared to fruits in fully mature stage.

4.2.2 Fibre

The fibre content was found to be 1.13g in mature stage and 0.55g in red ripe stage. A significant reduction in fibre content was observed upon ripening of fruits.

4.2.3 Calcium

The mean values for calcium ranged from 11.73mg/100g in red ripe stage to 12.04mg/100g in fully mature stage. The reduction in calcium content of cherry fruits upon ripening was not significant.

4.2.4 Phosphorus

The phosphorus content was found to be 21.56mg/100g in mature stage and 20.53mg/100g in red ripe stage. Statistically there was no significant difference with reference to phosphorus content between the two maturity stages.

4.2.5 Iron

The mean value for iron ranged from 0.39mg/100g in red ripe stage to 1.03 mg/100g in fully mature stage. Iron content was significantly high in fully mature fruits.

4.2.6 Potassium

The mean potassium content ranged from 143.3mg in red ripe stage to 143.6 mg in fully mature stage. There was no significant difference between the two stages of maturity with reference to potassium.

4.2.7 β-carotene

The mean β-carotene content of West Indian cherry fruits ranged from 117.65µg/100g in mature fruit to 210.63µg/100g in red ripe fruit. β-carotene content was significantly high in red ripe fruits.

4.2.8 Vitamin C

The mean Vitamin C content of the fruits varied from 522mg/100g in red ripe stage to 890.86mg/100g in mature stage. Fully mature West Indian cherry fruits contained significantly higher levels of Vitamin C than in red ripe stage.

4.2.9 Total soluble solids (TSS)

Total soluble solids ranged from 5.43^{o} brix in fully mature stage to 7.4^{o} brix in red ripe stage. TSS in red ripe fruits was significantly higher than in fully mature fruits.

4.2.10 Acidity

The mean acidity ranged from 1.23 per cent in red ripe fruits to 1.8 per cent in fully mature fruits. There was no significant variation in acidity between fully mature fruits and red ripe fruits.

4.2.11 Total sugar

Fully mature West Indian cherry fruits had a total sugar of 4.34 per cent and for ripe fruits it was 5.71 per cent. Total sugar content was not found to be significantly high in red ripe fruits than in fully mature fruits.

4.2.12 Reducing sugar

Reducing sugar was found to be 5.04 per cent in red ripe fruits and 4.41 per cent in fully mature fruits. There was no significant difference in reducing sugar content between the two maturity stages.

Vitamin C and β-carotene content of West Indian cherry in their fully mature and red ripe stage is depicted in Figure 7 and Figure 8.

Plate 1a. West Indian cherry flowers

Plate 1b. West Indian cherry fruits

Plate 1c. West Indian cherry in two maturity stages

Table 2.Chemical constituents in West Indian cherry (fresh weight basis).

Sl.no	**Constituents**	**Fully mature stage**	**Red ripe stage**	**t stat**	**Prob level of sig(%)**
1	Moisture (%)	83.7	87.13	1.47	21
2	Fibre (g)	1.13	0.55	2.5	6
3	Calcium (mg)	12.04	11.73	0.336	75
4	Phosphorus (mg)	21.56	20.53	0.0989	92
5	Iron (mg)	1.036	0.396	4.293	1.3
6	Potassium (mg)	143.6	143.3	0.116	91
7	β carotene (μg)	117.65	210.63	6.7	0.0025
8	Vitamin C (mg)	890.86	522	74.043	0.0001
9	TSS (^{0} brix)	5.43	7.4	5.5	0.53
10	Acidity (%)	1.8	1.23	1.668	17
11	Total sugar (%)	4.34	5.71	1.737	16
12	Reducing sugar (%)	4.41	5.04	0.986	38

Footnote: Significant difference of the various parameters at the two stages of ripeness may be taken at a probability level less than or equal to10%.

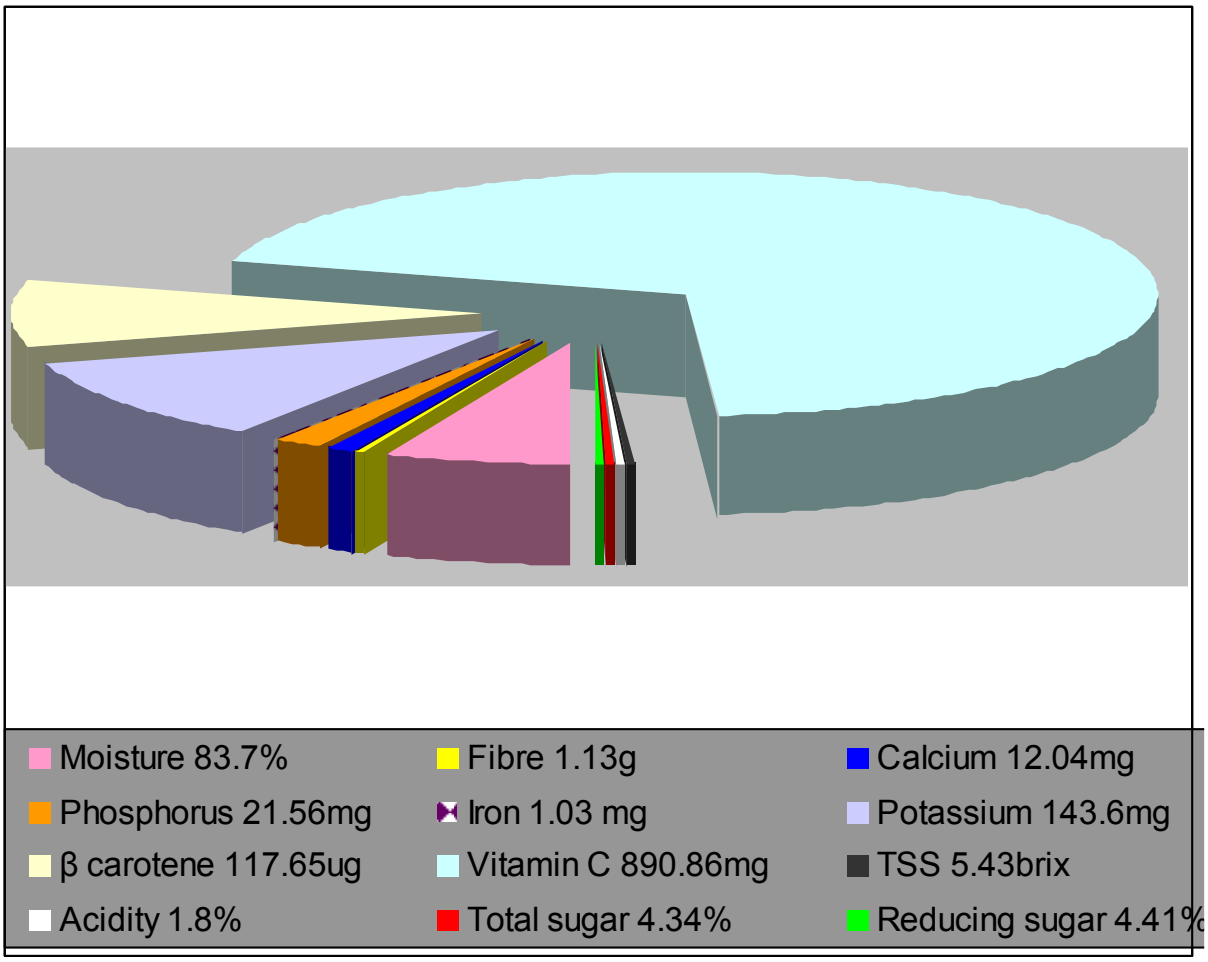


Fig.5 Chemical composition of fully mature West Indian cherry fruits

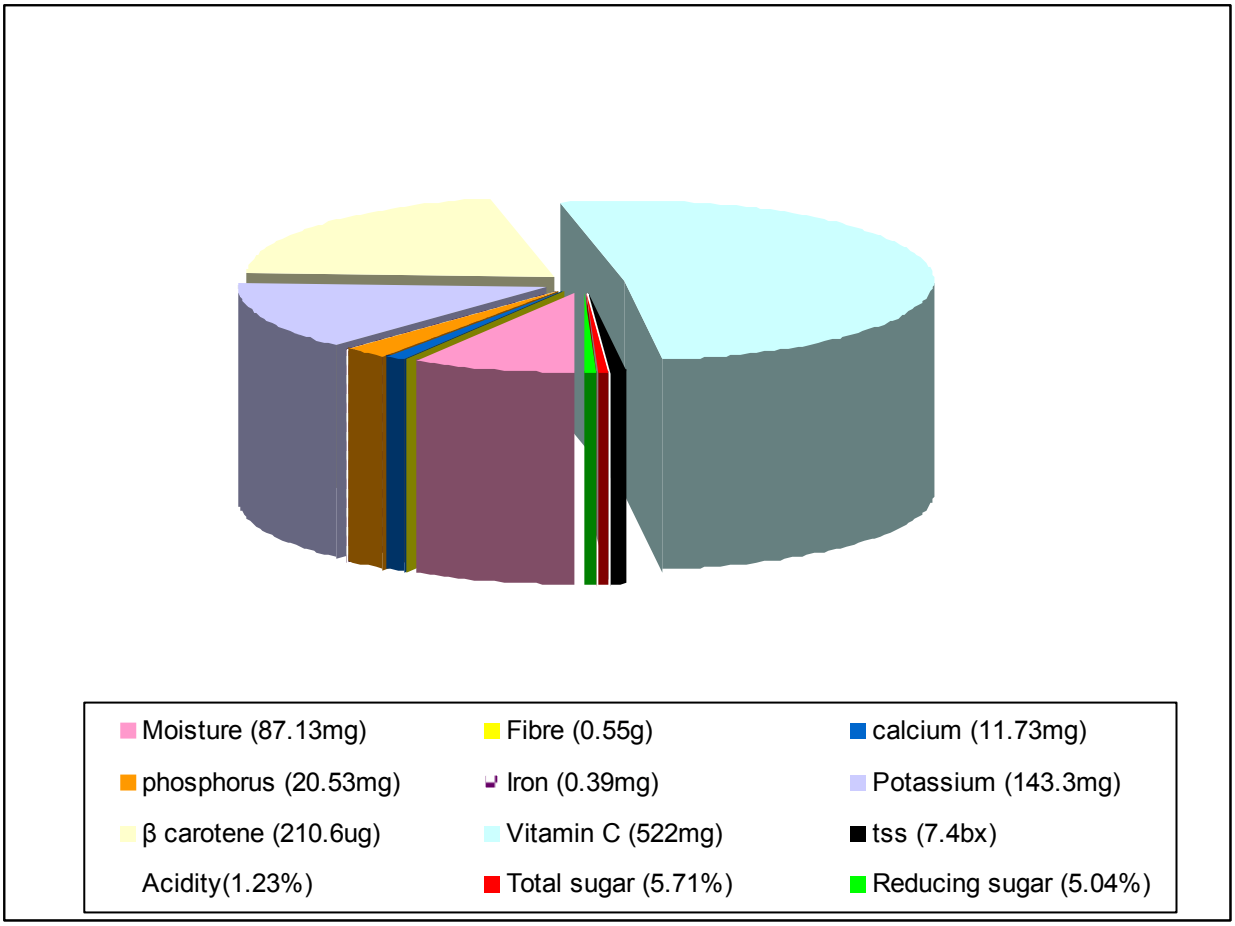
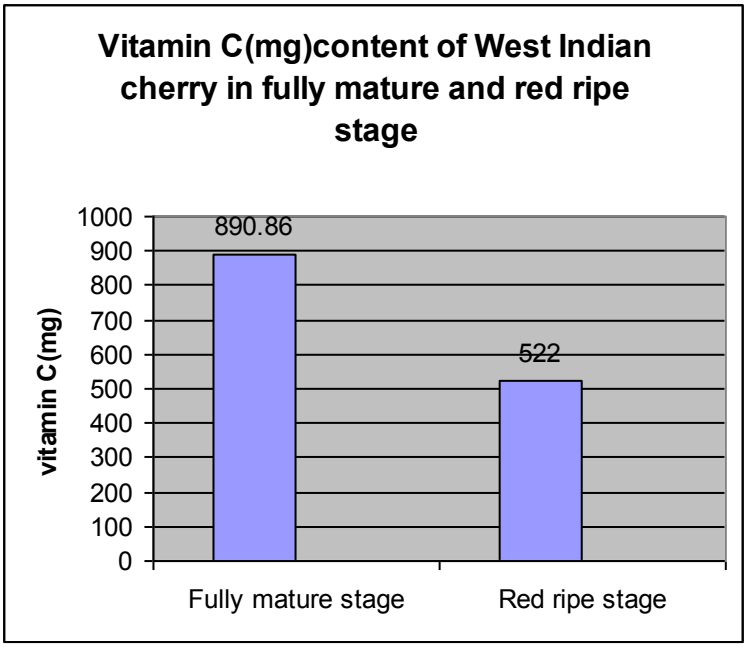


Fig.6 Chemical composition of red ripe West Indian cherry fruit


Vitamin C(mg)content of West Indian cherry in fully mature and red ripe stage
vitamin C(mg)
1000
900
800
700
600
500
400
300
200
100
0
890.86
522
Fully mature stage
Red ripe stage

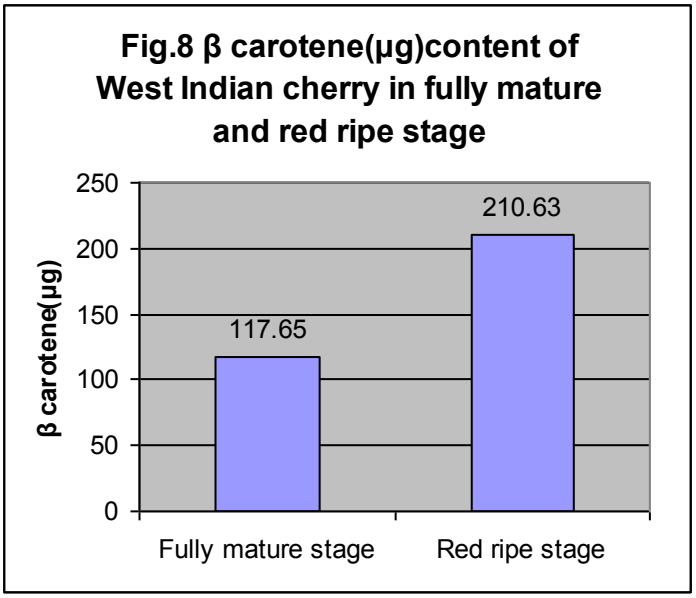


Fig.8 β carotene(µg)content of West Indian cherry in fully mature and red ripe stage
β carotene(µg)
250
200
150
100
50
0
210.63
117.65
Fully mature stage
Red ripe stage

4.3 Organoleptic evaluation

Appearance, colour, flavour, texture and taste of the developed products were evaluated, during the third month and during the sixth month of storage. Statistical analysis used for organoleptic studies was Kendall's Coefficient of Concordance. As the level of probability decreases the degree of agreement (w) increases.

4.3.1 Changes in the organoleptic qualities of West Indian cherry pickle during storage

The mean scores obtained for West Indian cherry pickle initially, during the third month and during the sixth month of storage are presented in Table 3 and the mean rank scores with statistical analysis in different storage periods are presented in Table 3(a).

As revealed in Table 3 and 3(a) appearance of pickle was high with a maximum initial score of 5 and stood steady with a score of 5 in the third month and then showed a decrease with a mean score of 4.8 by sixth month. The colour of the pickle had the highest mean score of 5 initially and during the third month. The mean score reduced to 4.9 during the 6^{th} month of storage.

When the flavour of sample was evaluated on various storage periods, it was found that the flavour of West Indian cherry pickle scored a maximum initial score of 5 and thereafter showed a gradual reduction of 4.8 in the third month and 4.7 in the sixth month of storage. The initial mean score for texture of the pickle was 4, which increased to 4.1 during the 3^{rd} month and to 4.3 during the 6^{th} month of storage.

Regarding the taste of the pickle maximum initial mean score of 5 was maintained till the third month and showed a mean score of 4.8 by the end of sixth month. Overall acceptability decreased from a mean rank score of 2.3 to 1.85

by the third month and there was no change in the mean rank score till the end of 6th month. The results are also shown in figure 9.

From the results it was clear that significant agreement was observed in all characters except in colour and flavour of pickle. The w values were found to be 0.20,0.23 and 0.20 for appearance, texture and taste respectively. Overall acceptability of pickle was maximum during the initial period and reduced to 1.85 in the third month and remained the same in the 6th month. W value was 0.18, which showed that there is significant agreement between judges regarding the overall acceptability of pickle during the storage periods. Pickles stored for different storage periods are shown in plate 2.

Table 3. Mean scores of quality attributes of West Indian cherry pickle during storage

Sl.no	Quality attribute	Mean scores		
		Initial	Third month	Sixth month
1	Appearance	5	5	4.8
2	Colour	5	5	4.9
3	Flavour	5	4.8	4.7
4	Texture	4	4.1	4.3
5	Taste	5	5	4.8
6	Overall acceptability	5	4.7	4.7

Table. 3(a) Mean rank scores of pickle in different storage periods

Sl.no	Parameters	Months of storage			W	Prob level of sig(%)
		Initial	3rd month	6th month		
1	Appearance	2.1	2.1	1.8	0.2	13.5
2	Colour	2.05	2.05	1.9	0.1	36.8
3	Flavour	2.15	2.00	1.85	0.1	36.8
4	Texture	1.8	1.95	2.25	0.23	9.7
5	Taste	2.1	2.1	1.8	0.2	13.5
6	Overall acceptability	2.3	1.85	1.85	0.18	16.5

W- Kendall's Coefficient of Concordance

4.3.2 Changes in the organoleptic qualities of West Indian cherry preserve during storage.

The initial mean scores of organoleptic qualities of West Indian cherry preserve and during the storage period of three and six months are presented in Table 4 and the mean rank scores of preserve in different storage periods are presented in Table 4(a).

The initial score for appearance of preserve decreased from 4 to 3.8 during the 3rd month and to 3.7 during the 6th month of storage.

The colour of the preserve scored the highest mean score of 5 during initial period and the score reduced to 4.6 during the third month and to 3.7 during the 6th month.

Flavour of the preserve increased from the mean score of 3.2 initially to 3.8, and 4 during the third month and sixth month respectively.

Texture of preserve increased from 2.7 initially to 3.5 and 4.2 during the third month and sixth month respectively.

Taste of preserve increased from 2.8 initially to 3.2 and 4 during the third and sixth month respectively. Overall acceptability of preserve increased gradually from 3.2 to 3.6 till 3rd month and again increased to 4.5 by the end of 6th month of storage. Overall acceptability of the preserve was found to increase from a mean rank score of 1.35 to 1.90 in 3rd month and to 2.75 in the 6th month.
The results are also presented in Figure.10

Significant agreement was noticed between the judges in all the sensory characters of the product except for appearance, which had a w value of only 0.14. The highest w values were found to be 0.84 for flavour followed by 0.83 for taste, 0.80 for texture and 0.79 for colour and the overall acceptability of preserve had a w value of 0.71 which showed that there is significant agreement between judges

regarding the overall acceptability of the preserve during the storage period. West Indian cherry preserve stored for different storage periods are presented in plate 3.

Table 4. Mean scores of quality attributes of West Indian cherry preserve during storage.

Sl.no	Quality attribute	Mean scores		
		Initial	3rd month	6th month
1	Appearance	4	3.8	3.7
2	Colour	5	4.6	3.7
3	Flavour	3.2	3.8	4.0
4	Texture	2.7	3.5	4.2
5	Taste	2.8	3.2	4.0
6	Overall acceptability	3.2	3.6	4.5

Table.4 (a) Mean rank scores of preserve in different storage periods

Sl.no	Parameters	Months of storage			W	Prob level of sig(%)
		Initial	3rdmonth	6th month		
1	Appearance	2.25	1.95	1.8	0.14	24.7
2	Colour	2.7	2.15	1.15	0.79	0.01
3	Flavour	1.1	2.30	2.6	0.84	0.01
4	Texture	1.15	2.1	2.75	0.80	0.01
5	Taste	1.35	1.75	2.9	0.83	0.01
6	Overall acceptability	1.35	1.90	2.75	0.71	0.1

W-Kendall's Coefficient of Concordance

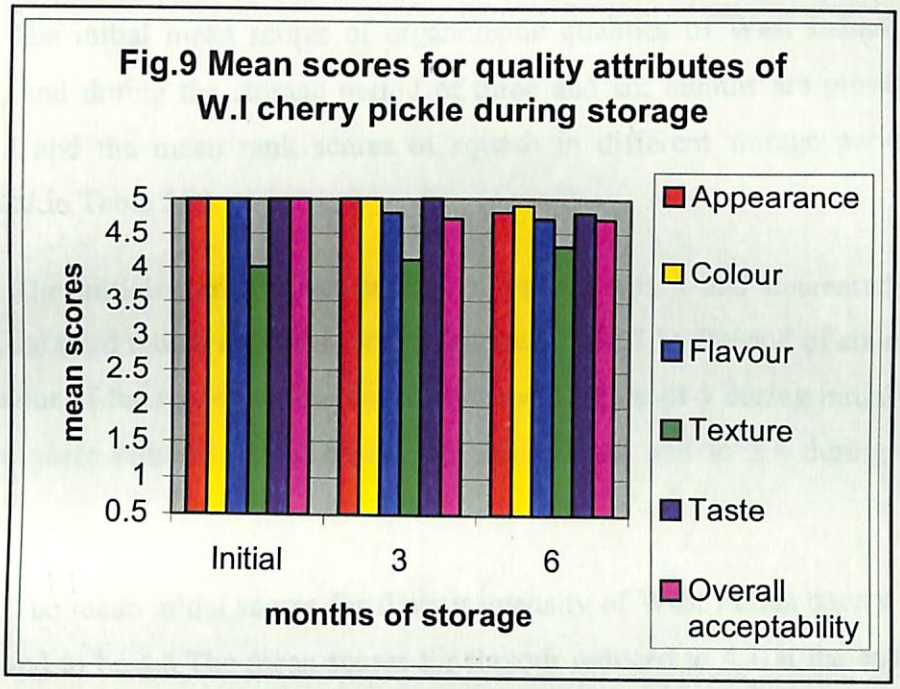


Fig.9 Mean scores for quality attributes of W.I cherry pickle during storage
mean scores
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Initial
3
6
months of storage
Appearance
Colour
Flavour
Texture
Taste
Overall acceptability

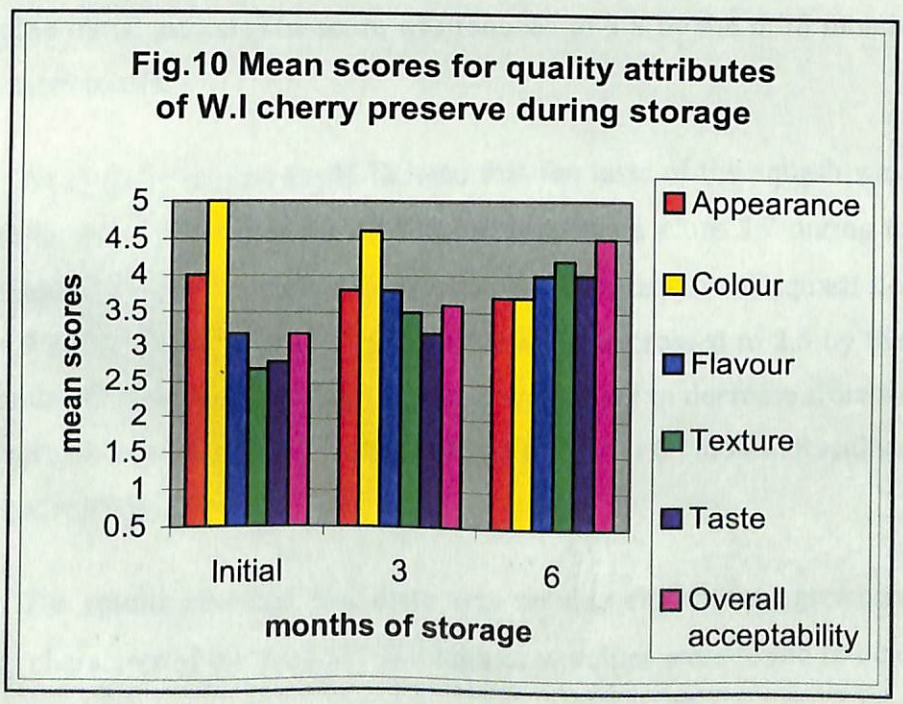


Fig.10 Mean scores for quality attributes of W.I cherry preserve during storage
mean scores
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Initial
3
6
months of storage
Appearance
Colour
Flavour
Texture
Taste
Overall acceptability

4.3.3 Changes in the organoleptic qualities of West Indian cherry squash during storage.

The initial mean scores of organoleptic qualities of West Indian cherry squash, and during the storage period of three and six months are presented in Table 5 and the mean rank scores of squash in different storage periods are presented in Table 5(a).

The initial score for appearance of squash was 5 and decreased to 3.8 during the third month and then further decreased to 2.7 by the end of six months. The colour of the squash scored the highest mean score of 5 during initial period and the score reduced to 3.1 during the third month and to 2.8 during the 6^{th} month.

The mean initial scores for flavour intensity of West Indian cherry squash was found to be 4.8.The mean scores for flavour reduced to 4.1 at the end of the third month and to 3.9 at the end of the sixth month.

Regarding the consistency of squash, highest score of 5 was obtained during the initial period .The score was reduced to 3.8 by the third month and to 3.6 by sixth month.

From the results, it could be seen that the taste of the squash was highly acceptable with an initial score of 5 and reduced to a score 3.7 during the third month and to 3.5 by the sixth month. Overall acceptability of squash decreased from 4.9 to 3.4 till the end of 3^{rd} month and again decreased to 2.5 by the end of six months. Overall acceptability of squash was found to decrease from the mean rank score of 3 to 1.8 in the 3^{rd} month and to 1.2 in the 6^{th} month. Results are also presented in Figure.11

The results revealed that there was notable significant agreement in all sensory characters of the product. The highest w values were found to be 0.97 for appearance followed by flavour (0.93), and taste (0.89). The w value obtained for

colour and consistency were 0.70 for each. Overall acceptability of squash had a w value 0f 0.93, which showed that there is significant agreement between, judges regarding the overall acceptability of the squash during storage periods. West Indian cherry squash stored for different storage periods are presented in plate 4.

Table 5. Mean values of quality attributes of West Indian cherry squash during storage

Sl.no	Quality attribute	Mean scores		
		Initial	3rd month	Sixth month
1	Appearance	5	3.8	2.7
2	Colour	5	3.1	2.8
3	Flavour	4.8	4.1	3.9
4	Consistency	5	3.8	3.6
5	Taste	5	3.7	3.5
6	Overall acceptability	4.9	3.4	2.5

Table.5 (a) Mean rank scores of Squash in different storage periods

Sl.no	Parameters	Months of storage			W	Prob level of sig(%)
		Initial	3rd month	6th month		
1	Appearance	3.00	1.95	1.05	0.97	0.01
2	Colour	2.75	1.75	1.5	0.70	0.1
3	Flavour	3.00	1.65	1.35	0.93	0.01
4	Consistency	2.8	1.7	1.5	0.70	0.1
5	Taste	3.00	1.6	1.4	0.89	0.01
6	Overall acceptability	3	1.8	1.2	0.93	0

W-Kendall's Coefficient of Concordance

4.3.4 Changes in organolpetic qualities of West Indian cherry sauce during storage

The mean scores of organoleptic qualities of West Indian cherry sauce in the initial period during the storage period of 3 and 6 months are presented in table 6 and the mean rank scores of sauce in different storage periods are presented in table 6(a).

Appearance of sauce obtained an initial mean score of 4.9 and decreased to 4.1 by the end of third month and again reduced to 3.8 by the end of sixth month. Colour of sauce obtained an initial score of 5 and it was 4.3 during the third month and to 4 during the sixth month of storage

Flavour of the sauce obtained a maximum initial score of 5, which reduced to 4.8 during third month and to 3.9 during sixth month of storage.

Regarding the consistency, highest score of 5 was obtained initially and decreased to 4.8 by the end of third month and then to 3.9 by the end of sixth month.

Taste of sauce obtained an initial score of 4.9 and 4 during third month and 3.2 during sixth month of storage. Overall acceptability of sauce decreased from 4.9 to 3.8 in the 3^{rd} month and decreased to 3.0 by the end of 6^{th} month. The mean rank scores of Overall acceptability of sauce decreased from 2.9 to 1.9 in the 3^{rd} month and to 1.2 in the 6^{th} month. Results are also presented in Figure.12.

Significant agreement was noted in all sensory characters of sauce. The highest w value was noted for flavour (0.97) followed by taste (0.92), consistency (0.83) and 0.79 was obtained for appearance and colour each. Over all acceptability of sauce had a w value of 0.85, which showed that there is significant agreement between the judges regarding the overall acceptability of the sauce during the storage periods. West Indian cherry sauce stored for different storage periods are presented in plate 5.

Table.6 Mean scores of quality attributes of West Indian cherry sauce during storage

Sl.no	Quality attribute	Mean scores		
		Initial	3rd month	6th month
1	Appearance	4.9	4.1	3.8
2	Colour	5.0	4.3	4.0
3	Flavour	5.0	4.8	3.9
4	Consistency	5.0	4.8	3.9
5	Taste	4.9	4.0	3.2
6	Overall acceptability	4.9	3.8	3.0

Table.6 (a) Mean rank scores of Sauce in different storage periods

Sl.no	Parameters	Months of storage			W	Problevel of sig(%)
		Initial	3rdmonth	6th month		
1	Appearance	2.85	1.75	1.4	0.79	0.01
2	Colour	2.85	1.8	1.35	0.79	0.01
3	Flavour	3.00	1.55	1.45	0.97	0.01
4	Consistency	2.9	1.75	1.35	0.83	0.01
5	Taste	2.95	1.95	1.1	0.92	0.01
6	Overall acceptability	2.9	1.9	1.2	0.85	0.0

W-Kendall's Coefficient of Concordance

Plate 2: West Indian cherry Pickle at different storage periods.

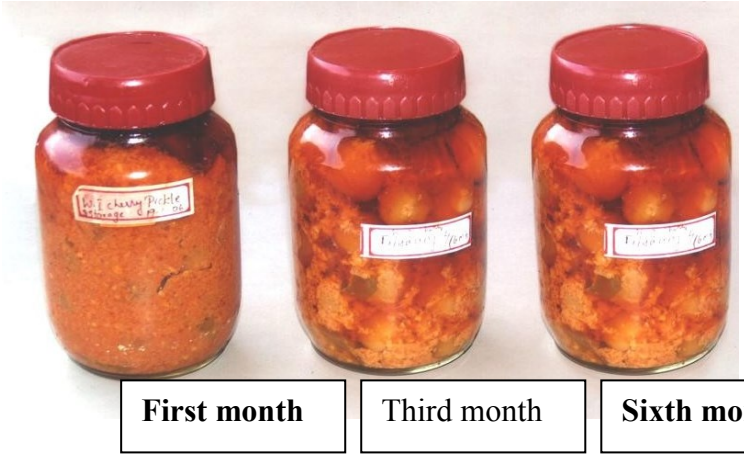
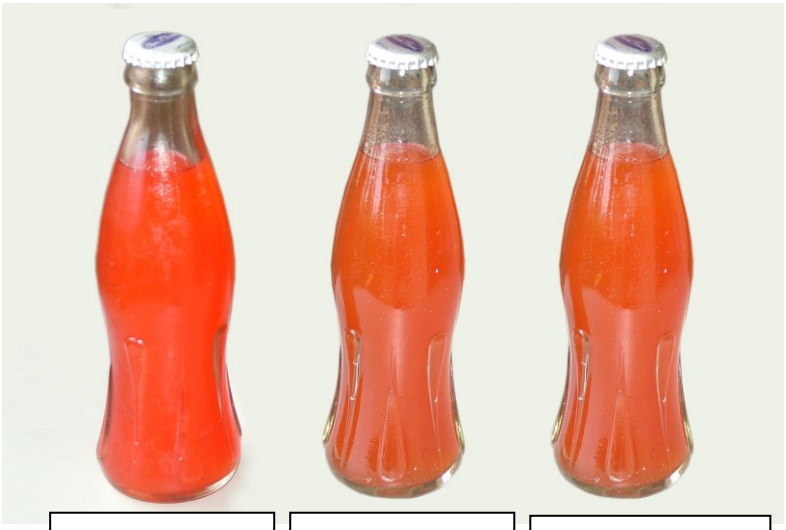


Plate 3 : West Indian cherry Preserve at different storage periods

Plate 4: Squash at different storage periods



First month	Third month	**Sixth month**

Plate 5 : Sauce at different storage periods

First month	Third month	**Sixth month**

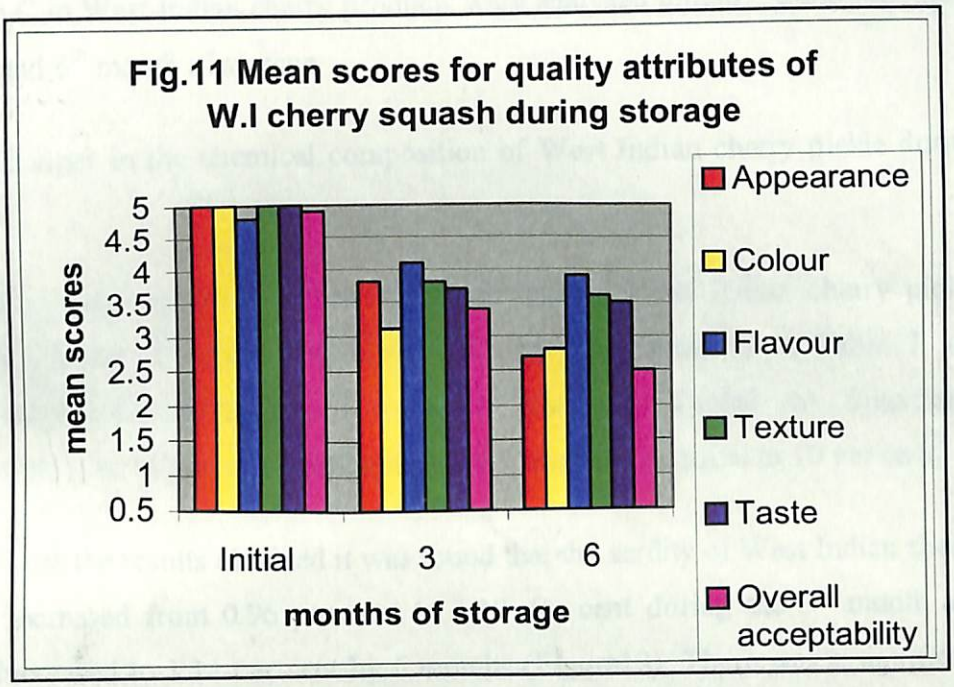


Fig.11 Mean scores for quality attributes of W.I cherry squash during storage
mean scores
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Initial
3
6
months of storage
Appearance
Colour
Flavour
Texture
Taste
Overall acceptability

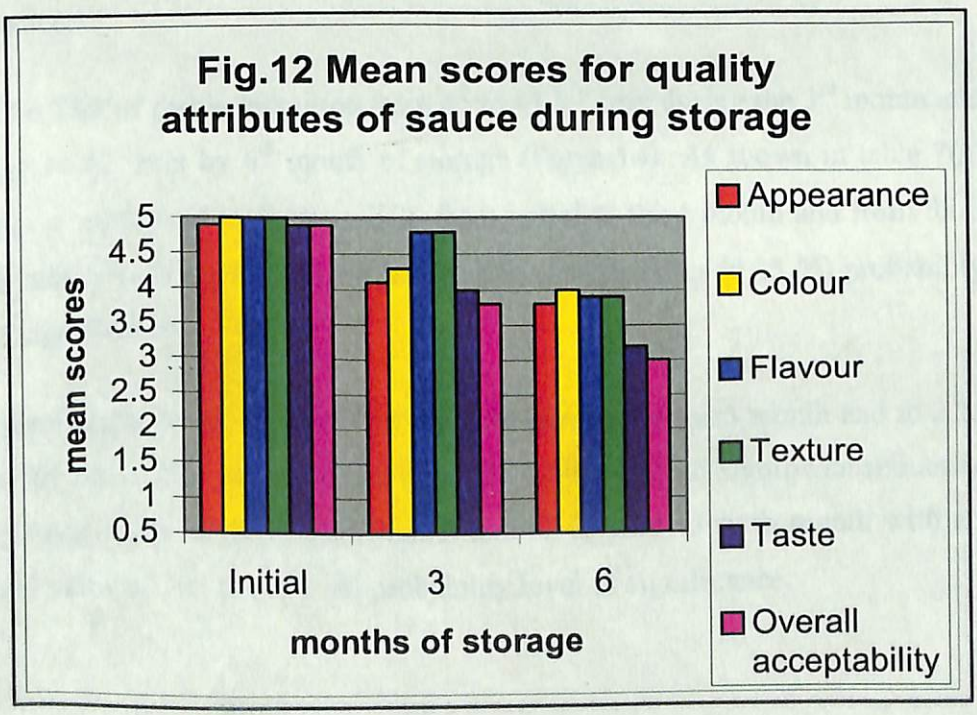


Fig.12 Mean scores for quality attributes of sauce during storage
mean scores
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
Initial
3
6
months of storage
Appearance
Colour
Flavour
Texture
Taste
Overall acceptability

4.4 Chemical composition of West Indian cherry products

Chemical composition such as acidity, TSS, total sugar, β-carotene and vitamin C in West Indian cherry products were analysed initially, during the third month and 6th month of storage.

4.4.1 Changes in the chemical composition of West Indian cherry pickle during storage.

The mean values of chemical constituents of West Indian cherry pickle initially, during 3rd and 6th months of storage are presented in Table 7 and statistical analysis using paired t test are shown in Table7 (a). Significant differences may be taken at a probability level less than or equal to 10 per cent.

From the results obtained it was found that the acidity of West Indian cherry pickle increased from 0.96 per cent to 1.12 per cent during the 3rd month and again increased to 1.14 per cent by 6 months (Figure13). There was a significant increase in acidity from initial to third month and from third month to sixth month with a t statistical value of 5.12, significant at (0.68%) probability level of significance.

The TSS of pickle increased from 41 to 41.2 ^{o} brix during the 3rd month and increased to 42^{o} brix by 6th month of storage (Figure14). As shown in table 7(a) there was a significant increase in TSS from initial to third month and from third to sixth month with a t statistical value of 6.7, significant at (0.25 %) probability level of significance.

Total sugar decreased from 2.39 to 2.35 percent by third month and to 2.23 per cent by the end of six months (Figure15). There was no significant reduction in total sugar from initial to third month and from third to sixth month with a t statistical value of 1.6, at (18.2 %) probability level of significance.

β-carotene decreased from 75.6µg to 53.6µg /100g during the third month and further decreased to 41.3µg/100g by 6 months (Figure16). There was significant reduction in β-carotene from initial to third month and from third to sixth months of storage with a t statistical value of 2.84, at (4.6%) probability level of significance.

The change in vitamin C content observed, was a reduction from the initial value of 511mg to 436mg/100g by the 3rd month and to 408mg/100g by 6th month of storage (Figure17). There was a significant reduction in vitamin C content from initial to third month and from third to sixth month of storage with a t statistical value of 117.07, at (0.0001%) probability level of significance.

Table 7. Chemical composition of West Indian cherry pickle during storage (per 100g).

Sl.no	Chemical composition	Mean values		
		Initial	3rd month	6th month
1	Acidity (%)	0.96	1.12	1.14
2	TSS (^{0} brix)	41	41.2	42
3	Total sugar(%)	2.39	2.35	2.23
4	β carotene (µg)	75.6	53.6	41.3
5	Vitamin C (mg)	511	436.7	408.39

Table (7a). Changes in chemical composition of pickle during storage

Sl.no	Parameters	Mean difference ± S.D		t stat	Prob level of sig(%)
		0-3 months	3-6 months		
1	Acidity (%)	0.16 ± 0.43	0.02 ± 0.03	5.12	0.68
2	TSS (^{0} brix)	0.23 ± 0.11	0.733± 0.057	6.7	0.25
3	Total sugar(%)	-0.04 ± 0.07	-0.12 ± 0.03	1.6	18.2
4	β-carotene(µg)	-22.03 ± 3.36	-12.26 ± 4.9	2.84	4.6
5	Vitamin C(mg)	-74.30 ± 0.65	-28.31 ± 0.24	117.07	0.0001

S.D-Standard deviation

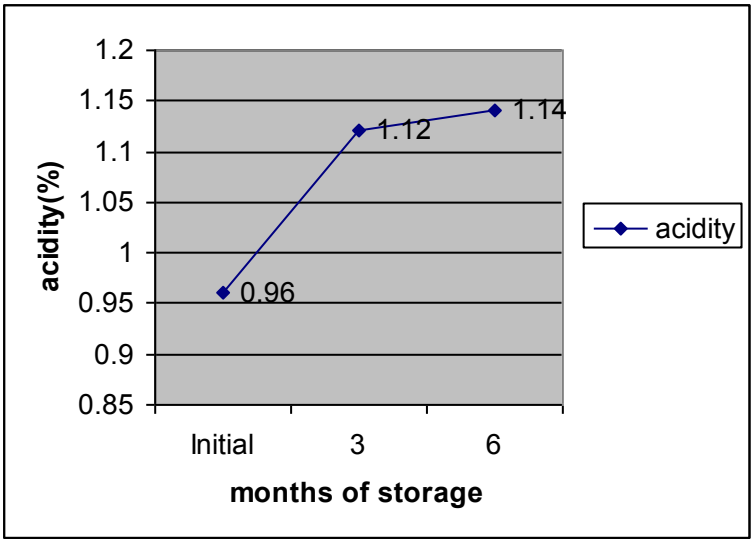


Fig.13 Acidity of West indian cherry pickle during storage

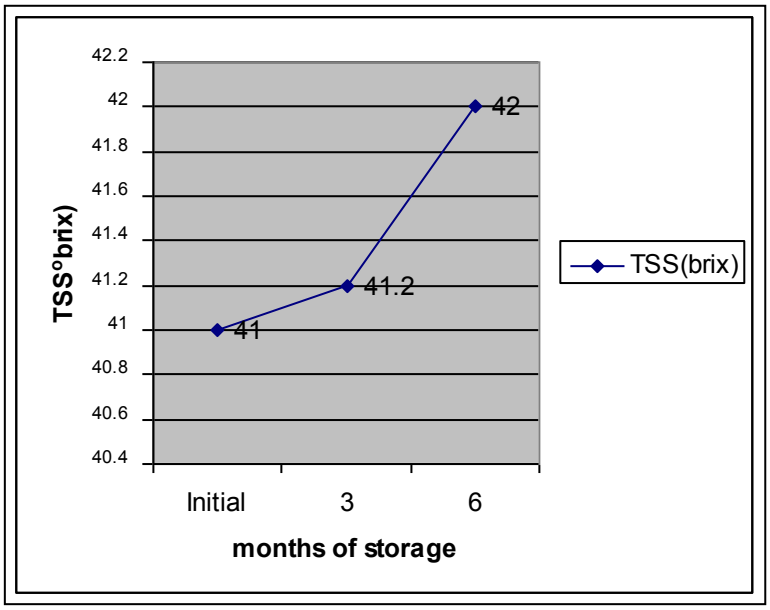


Fig.14 TSS content of West Indian cherry pickle during storage

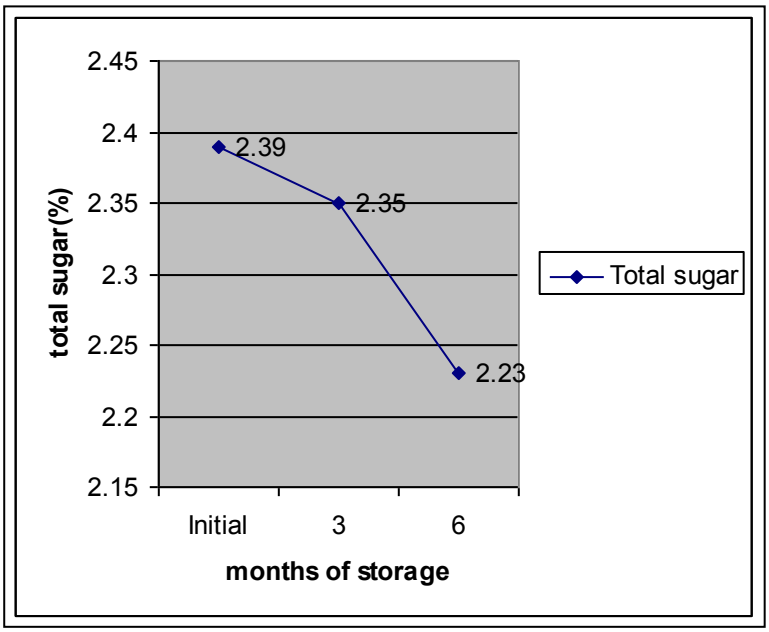


Fig.15 Total Sugar content of west indian cherry pickle during storage

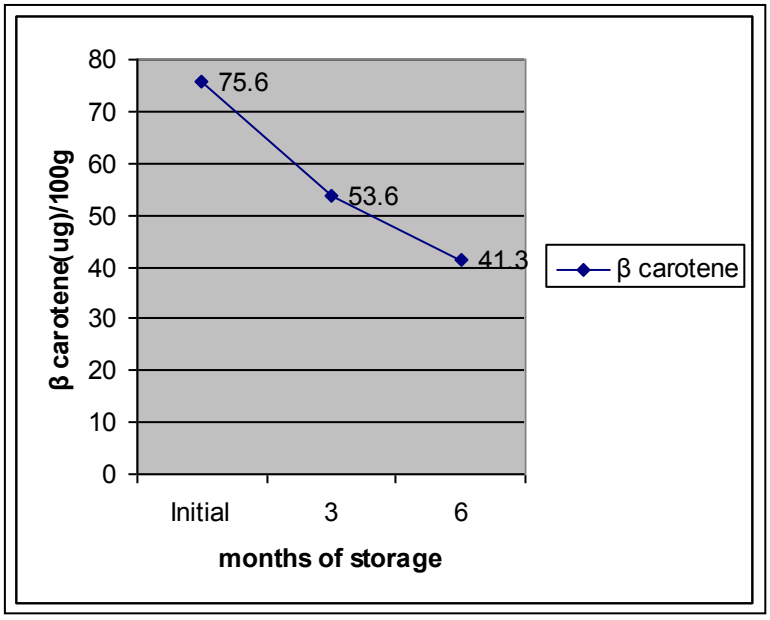


Fig.16 β -carotene content of West indian cherry pickle during storage

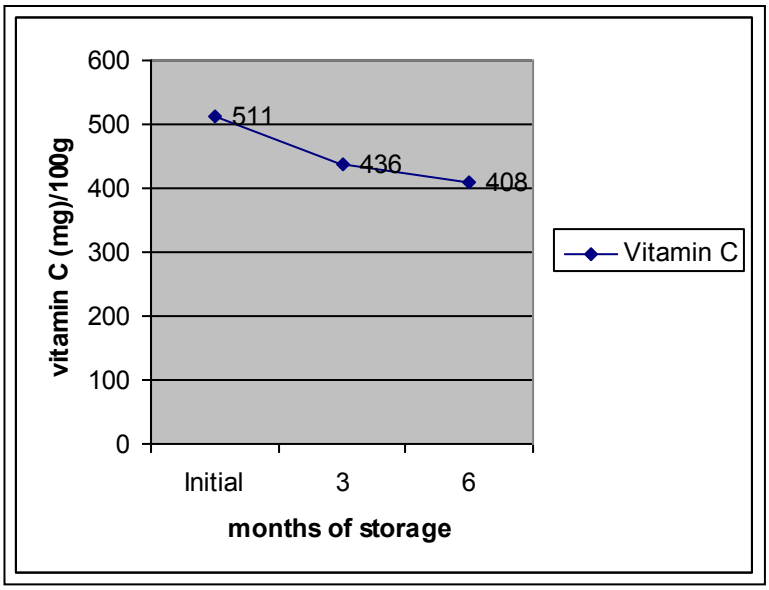


Fig.17 Vitamin C content of West Indian cherry pickle during storage

4.4.2. Changes in chemical composition of West Indian cherry preserve during storage.

The mean values of chemical constituents of West Indian cherry preserve initially and during the 3rd and 6th month of storage are presented in Table 8 and statistical analysis is revealed in Table 8(a).

There was a decrease in acidity from 0.37 to 0.21 percent by 3rd month and it further decreased to 0.06 per cent by 6 months of storage (Figure 18). There was no significant reduction in acidity from initial to 3rd month and from 3rd to 6th month of storage with a t statistical value of 1.96 at (12%) probability level of significance.

With regard to TSS there was an increase from the initial value of 68.3°brix to 69.1° brix by 3rd month and increased to 71.11 by 6th month of storage (Figure19). There was significant increase in TSS from initial to third month and from third to sixth month of storage with a t statistical value of 26.8, at (0.00001%) probability level of significance.

Total sugar increased from 59.1 per cent to 61.08 per cent by the 3rd month and to 62.48 per cent by 6th month (Figure20). There was no significant increase in total sugar from initial to 3rd month and from 3rd to 6th month of storage with a t statistical value of 0.73, at (50.5%) probability level of significance.

It was observed that β-carotene decreased from initial value of 57µg to 46µg by the 3rd month and to 24µg /100g by the 6th month of storage (Figure21). There was no significant difference in reduction from initial to third month and from third to sixth month of storage with a t statistical value of 0, at (100 %)probability level of significance.

It was noticed that the vitamin C level decreased drastically from the initial value of 422mg to 319mg by the 3rd month and to 162mg by the 6th month (Figure 22). There was a significant decrease in vitamin C content from initial to third month and from third to sixth month of storage with a t statistical value of 49.21, at (0.0001 %) probability level of significance.

Table 8. Chemical composition of West Indian cherry preserve during storage (per 100g)

Sl.no	Chemical composition	Mean values		
		Initial	Third month	Sixth month
1	Acidity (%)	0.37	0.21	0.06
2	TSS (^{0} brix)	68.3	69.1	71.11
3	Total sugar(%)	59.11	61.08	62.48
4	β carotene (µg)	57	46	24
5	Vitamin C (mg)	422	319	162

Table 8(a). Changes in chemical composition of Preserve during storage

Sl.no	Parameters	Mean difference ± S.D		t stat	Prob level of sig(%)
		0-3 months	3-6 months		
1	Acidity (%)	-0.16 ± 0.041	-0.15 ± 0.015	1.96	12
2	TSS (^{0} brix)	0.76 ± 0.057	2.03 ± 0.057	26.8	0.000011
3	Total sugar(%)	1.97 ± 1.21	1.39 ± 0.61	0.73	50.5
4	β carotene (µg)	-16.66 ± 7.76	-16.66 ± 4.5	0	100
5	VitaminC (mg)	-102.36± 1.55	-157.7± 1.179	49.21	0.0001

S.D – Standard deviation

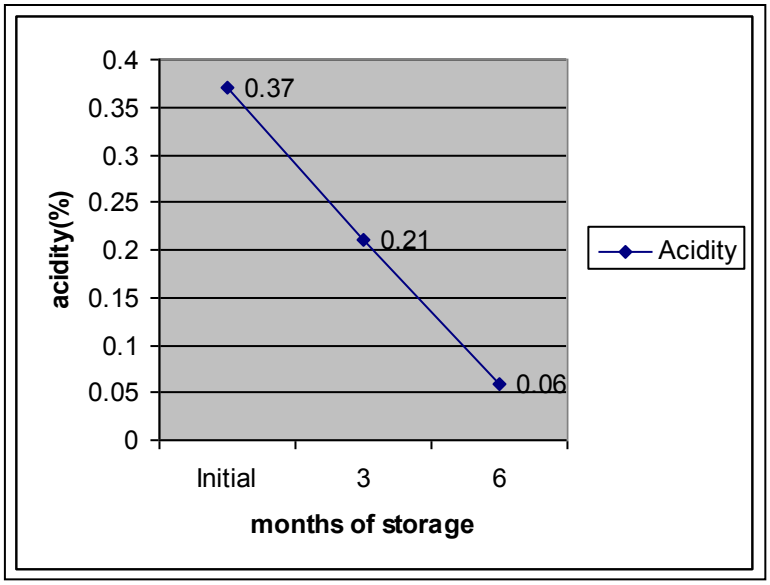


Fig.18 Acidity of West Indian cherry preserve during storage

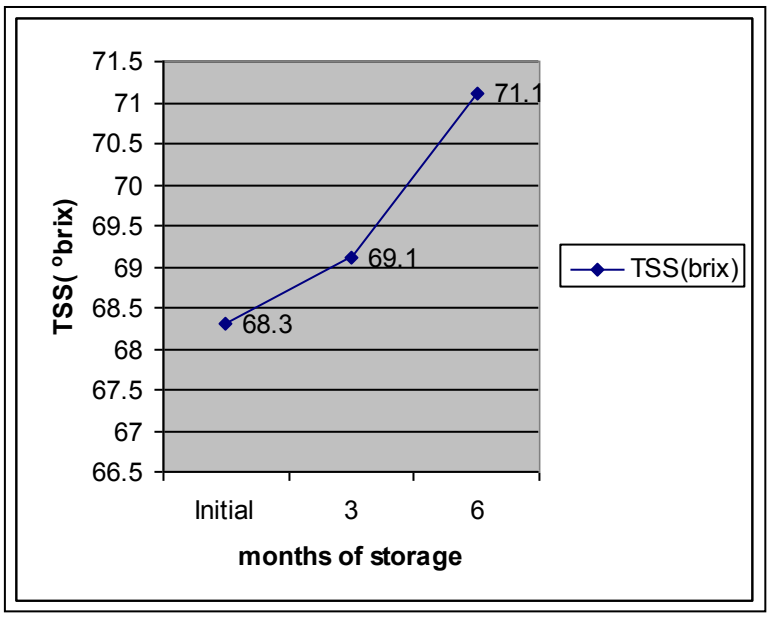


Fig.19 TSS of West Indian cherry preserve during storage

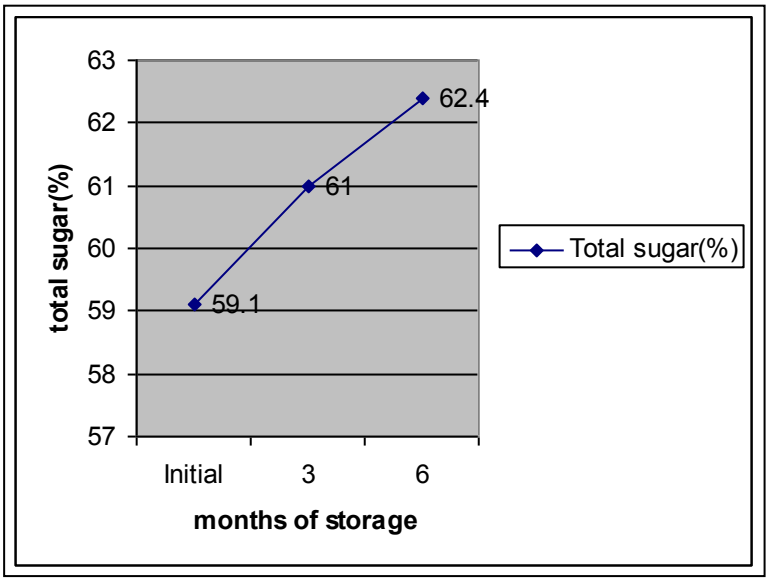


Fig.20 Total sugar content in West Indian cherry preserve during storage

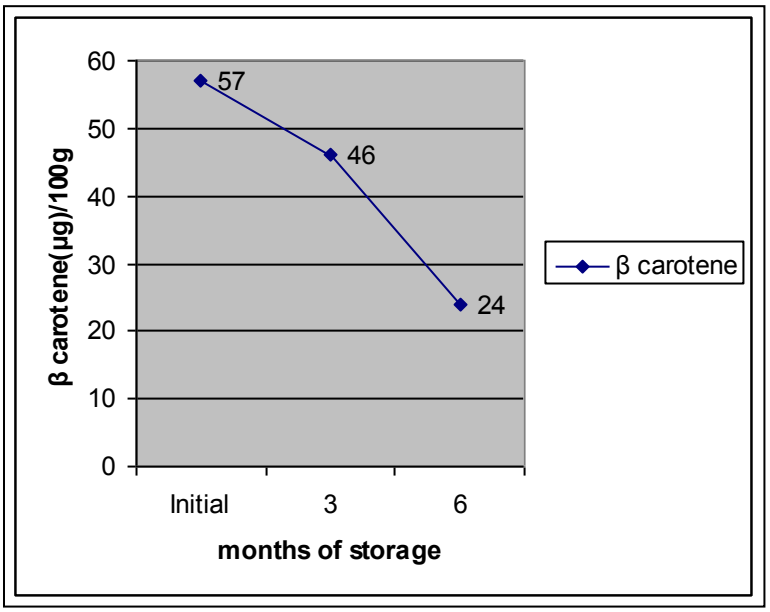


Fig.21 β-carotene in West Indian cherry preserve during storage

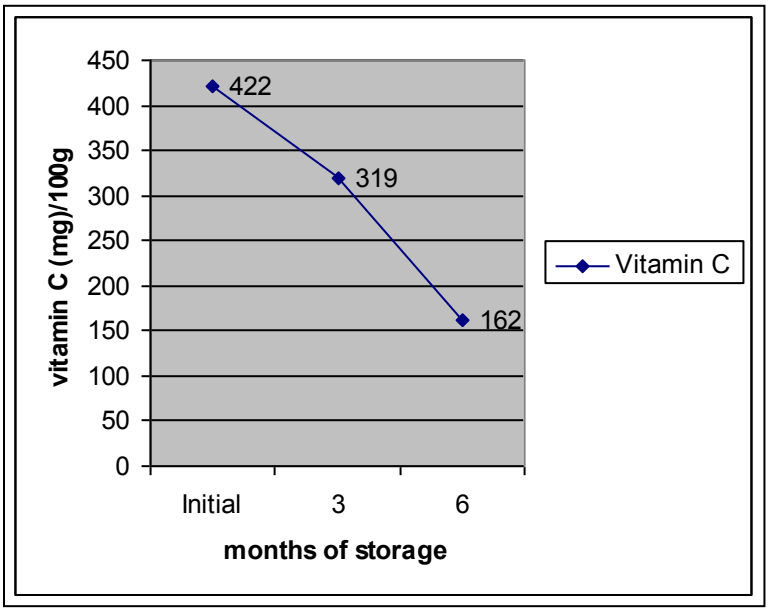


Fig.22 Vitamin C content in West Indian cherry preserve during storage

4.4.3 Changes in chemical composition of West Indian cherry squash during storage.

The mean values of chemical constituents of West Indian cherry squash initially and during the 3rd and 6th months of storage are presented in Table 9 and statistical analysis is given in Table 9(a).

The acidity decreased from 1.64 to 1.56 per cent during the 3rd month and to 1.36 percent by 6th month of storage (Figure 23). There was no significant decrease in acidity from initial to 3rd month and from 3rd to 6th month with a t statistical value of 0.56,at (60.47%) probability level of significance.

The results revealed that TSS in squash increased from the initial value of 45.1 to 45.8 by the third month and then decreased to 45.4 percent by 6th month of storage (Figure 24). There was a significant increase in TSS from initial to third month and a significant decrease from 3rd month to 6th month of storage with a t statistical value of 5.6,at (0.47 %) probability level of significance.

The total sugar in squash increased from 41.33 per cent to 42.24 per cent during the 3rd month and increased to 43.36 per cent by 6th month (Figure 25). There was no significant increase in total sugar from initial to third month and from third month to sixth month of storage with a t statistical value of 0.74, at (49.6 %) probability level of significance.

β-carotene content decreased from 88.5µg to 40.9µg/100g by the 3rd month of storage. It further decreased to 22.13µg/100g by the 6th month of storage (Figure 26). There was a significant decrease in β-carotene from initial to third month and from third to sixth month of storage with a t statistical value of 8.89, at (0.088 %) probability level of significance.

The Vitamin C content also decreased from 343mg to 311mg by third month and decreased to 288mg/100g by 6th month (Figure 27) and there found to be a significant reduction in Vitamin C content from initial to third month and

from third to sixth month of storage with a t statistic value of 5.99, at (0.38 %) probability level of significance.

Table 9. Chemical composition of West Indian cherry squash during storage(per 100g)

Sl.no	Chemical composition	Mean values		
		Initial	Third month	Sixth month
1	Acidity (%)	1.64	1.56	1.36
2	TSS (^{0} brix)	45.1	45.8	45.40
3	Total sugar (%)	41.33	42.24	43.36
4	β carotene (µg)	88.51	40.9	22.13
5	Vitamin C (mg)	343	311	288

Table9 (a) Changes in chemical composition of Squash during storage

Sl.no	Parameters	Mean difference ± S.D		t stat	Prob level of sig(%)
		0-3 months	3-6 months		
1	Acidity (%)	-0.076 ± 0.29	0.203±0.39	0.56	60.47
2	TSS (^{0} brix)	0.633 ± 0.25	-0.33± 0.15	5.6	0.47
3	Total sugar (%)	0.903± 0.947	1.42±0.75	0.746	49.6
4	β-carotene (µg)	-47.61± 5.54	-18.77±0.66	8.89	0.088
5	Vitamin C (mg)	-31.69 ± 1.22	-23.41±2.05	5.99	0.38

S.D-Standard deviation

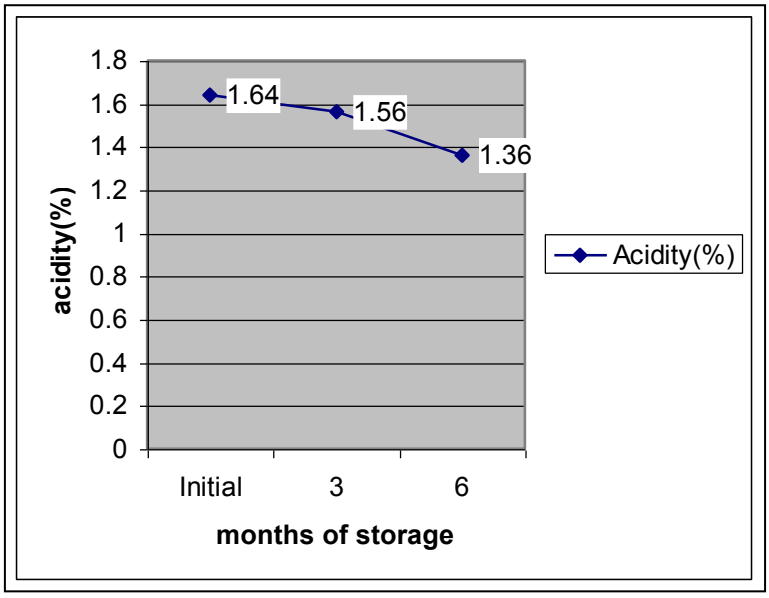


Fig.23 Acidity of West Indian cherry squash during storage

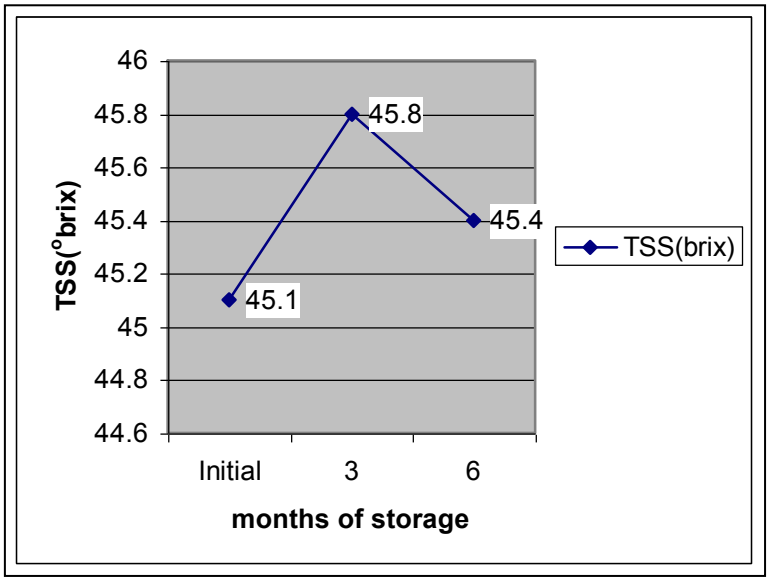


Fig.24 TSS content in West Indian cherry squash during storage

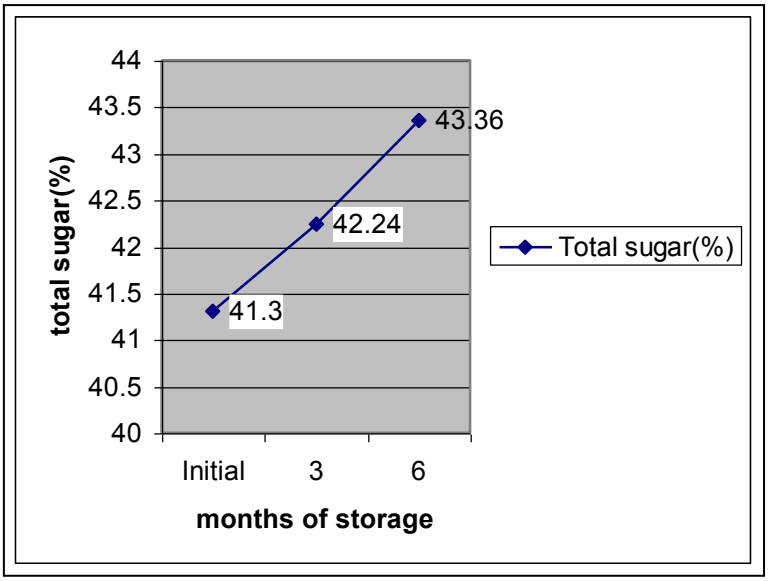


Fig.25 Total sugar content in West Indian cherry squash during storage

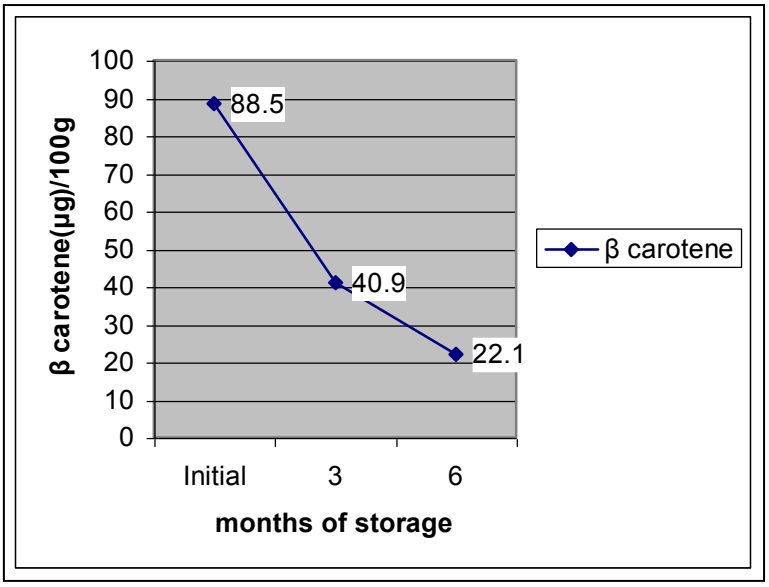


Fig.26 β-carotene content in West Indian cherry squash during storage

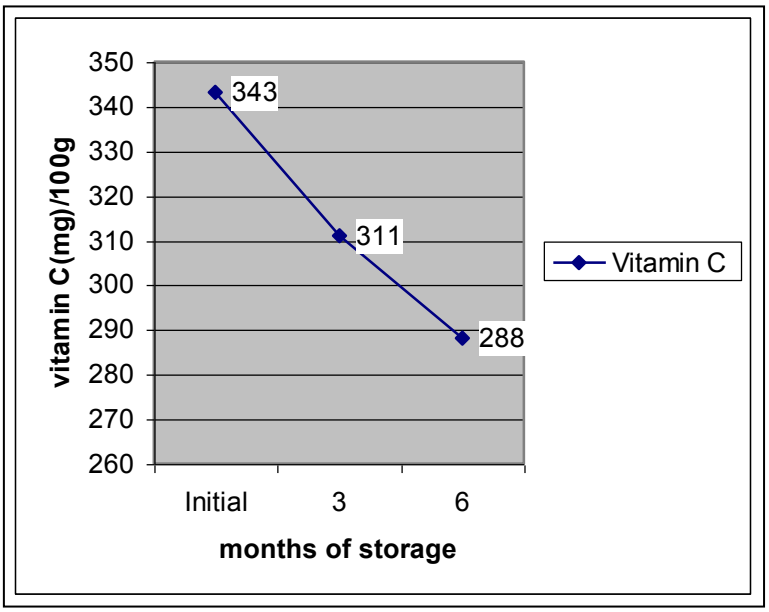


Fig.27 Vitamin C content of West Indian cherry squash during storage

4.4.4 Changes in chemical composition of West Indian cherry sauce during storage.

The mean values of chemical constituents of West Indian cherry sauce initially and during the 3rd and 6th months of storage are presented in Table 10 and statistical analysis in Table10 (a).

Initial acidity of sauce increased from 1.63 to 1.71per cent by the end of third month and showed a gradual increase upto 1.73 per cent by the end of sixth month of storage (Figure 28). Acidity of sauce showed a significant increase from initial to third month and from third to sixth month of storage with a t statistical value of 2.3, at (8.08 %) probability level of significance.

TSS of the sauce increased from 36º brix to the 36.3 ºbrix by the end of the third month and again increased to 37ºbrix by the end of sixth month of storage (Figure 29). There was a significant increase in TSS from initial to third month and from third to sixth month of storage with t statistical value of 5, at (0.74%) probability level of significance.

Total sugar of West Indian cherry sauce decreased from 29.2 per cent to 28.6 per cent by the end of third month and further decreased to 27.9 per cent by the end of sixth month of storage (Figure 30). There was no significant reduction in Total sugar from initial to third month and from third to sixth month of storage with t statistical value of 0.18, at (86 %) probability level of significance.

β-carotene content decreased from 58.85µg to 48.51µg by the end of third month and decreased to 41.62µg by the end of sixth month (Figure31). There was a significant decrease in β-carotene from initial to third month and from third to sixth month of storage with a t statistical value of 12.4, at (0.02 %) probability level of significance

Vitamin C content of the sauce decreased from 322mg to 284mg by the end of third month of storage and further decreased to 214 mg by the 6th month of

storage (Figure 32). There was a significant reduction from initial to third month and from third to sixth month in vitamin C content of sauce during storage with a t statistical value of 25.7, at (0.0001%) probability level of significance.

Table.10 Chemical composition of West Indian cherry Sauce during storage(per 100g)

Sl.no	Chemical composition	Mean values		
		Initial	Third month	Sixth month
1	Acidity (%)	1.63	1.71	1.73
2	TSS (^{0} bx)	36	36.3	37
3	Total sugar (%)	29.2	28.6	27.9
4	β carotene (µg)	58.85	48.51	41.62
5	Vitamin C (mg)	322	284	214

Table.10 (a) Changes in chemical composition of Sauce during storage

Sl.no	Parameters	Mean difference± S.D		t stat	Prob level of sig(%)
		0-3 months	3-6 months		
1	Acidity (%)	0.08± 0.043	0.02 ± 0.01	2.32	8.08
2	TSS (^{0} bx)	0.36 ± 0.057	0.7 ± 0.1	5.00	0.74
3	Total sugar(%)	- 0.6 ± 1.3	-0.7 ± 0.85	0.185	86
4	β carotene (µg)	- 24.47 ± 1.39	-14.46 ± 0.62	12.42	0.024
5	Vitamin C(mg)	- 38 ± 2.01	-70.53 ± 1.0	25.77	0.0001

SD - Standard deviation

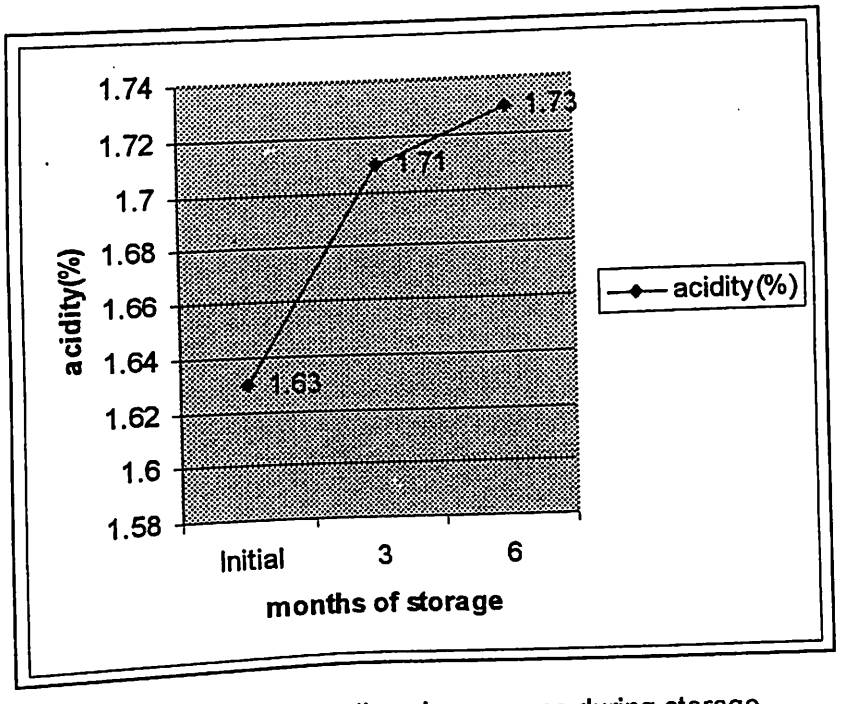


Fig.28 Acidity of West Indian cherry sauce during storage

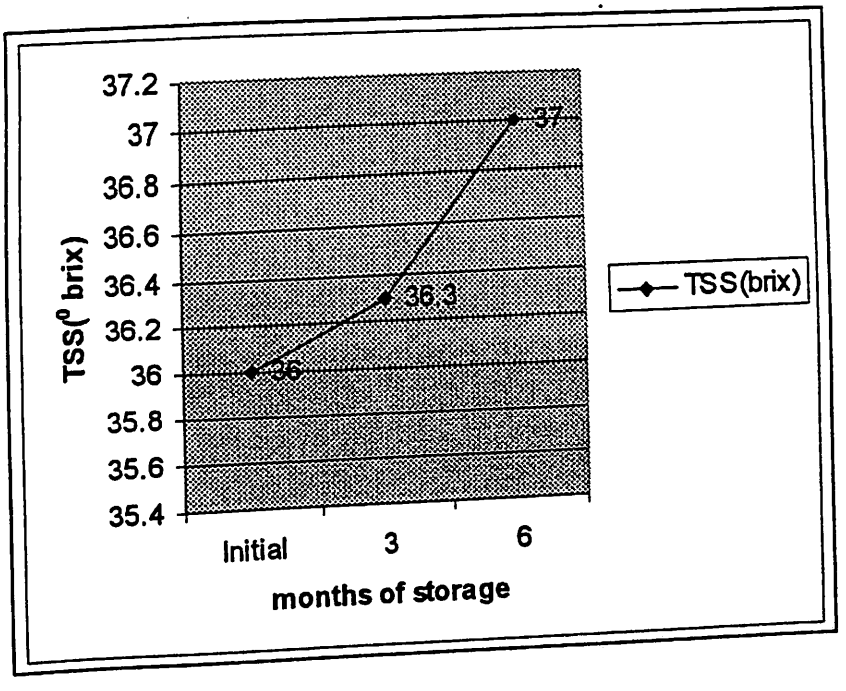


Fig.28 TSS content of West Indian cherry sauce during storage

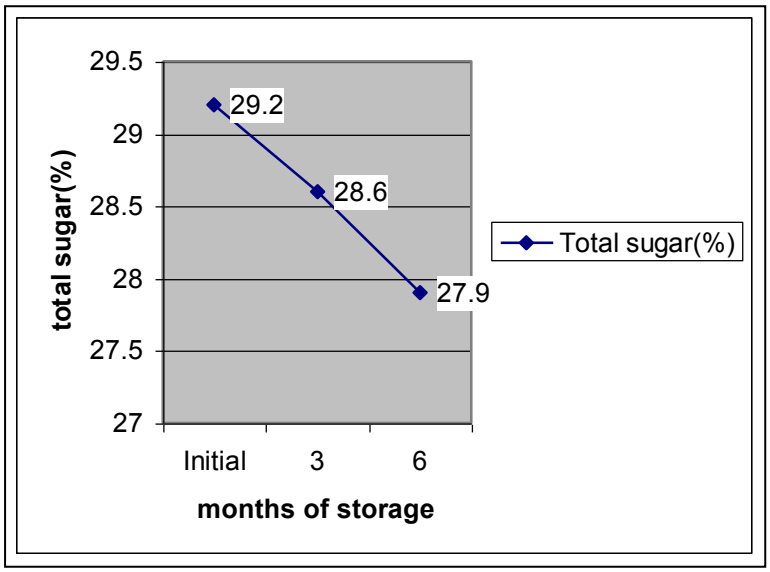


Fig.30 Total sugar content in West Indian cherry sauce during storage

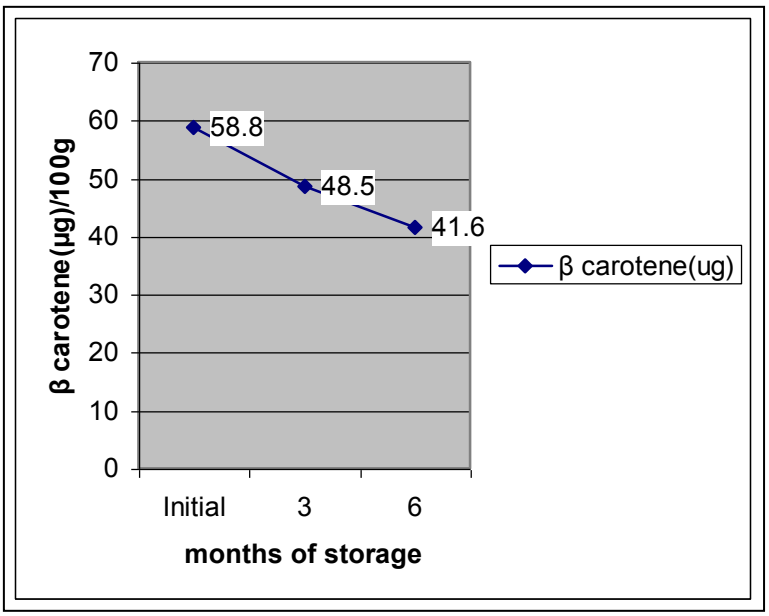


Fig.31 β-carotene content in West Indian cherry sauce during storage

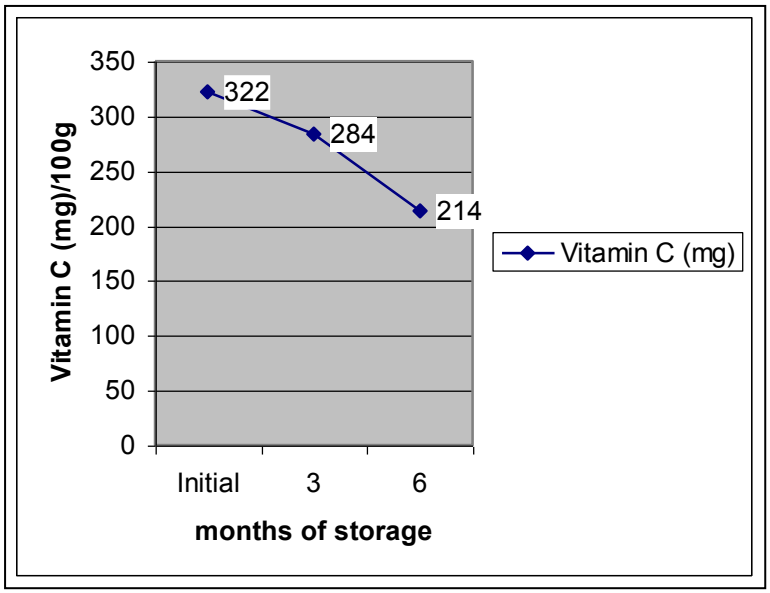


Fig.32 Vitamin C content of West Indian cherry sauce during storage

4.5 Confirmation of West Indian cherry products with FPO standards.

Fruit product order has specified certain standards for fruit products. (Siddappa, 1967). Specifications are indicated for squash, sauce, pickle and preserve. The products developed were tested for confirming to FPO standards.

The products prepared in the study were compared with FPO requirements for preserve, pickle, squash and sauce in general and the data is presented in Table 11 and Table 12. Table.11 reveals the confirmation of West Indian cherry pickle and preserve with FPO standards.

On analysis, the preserve prepared from West Indian cherry showed a TSS of 68 per cent and fruit portion 57 per cent as against 68 per cent and 55 per cent of FPO value. It also contained the FPO specified limits of preservative (Sodium benzoate-200ppm).

The pickle developed from West Indian cherry was prepared using gingelly oil and it contained Sodium benzoate in the prescribed limit of 250ppm.

Table12 reveals the confirmation of West Indian cherry squash and sauce with FPO standards.

As revealed in Table 12, for West Indian cherry squash, the TSS was found to be 45 per cent as against 40 per cent specified by FPO and 25 per cent of fruit juice in the final products. Preservative (Sodium benzoate) added in squash also confirmed to FPO specifications.

With regard to sauce, FPO prescribes a minimum percentage of total soluble solids weight (w/w) as not less than 15 per cent. The sauces should contain 15-30 per cent sugar according to the kind of sauce made from fruits and vegetables. The sauce prepared from West Indian cherry contains 36 per cent in the final product. FPO specified preservative Sodium benzoate (750ppm) was

also added to the product. Acidity in sauce as specified by FPO was not less than 1.2 per cent and in the prepared West Indian cherry sauce it was 1.63 per cent.

Table11. Confirmation of West Indian cherry –Preserve and Pickle with FPO standards.

	West Indian cherry preserve			**West Indian cherry pickle**	
Particulars	% of TSS inthe final product	% of fruit portion in the final product	Amount of preservative added(ppm)	Preparation with oil	Amount of preservative added(ppm)
FPO specified value	68%	55%	200	Any edible oil like gingelly oil	250
Analysed value	68%	57%	200	Gingelly oil	250

Table 12. Confirmation of West Indian cherry- squash and sauce with FPO standards

	West Indian cherry squash			West Indian cherry sauce		
Particulars	% of TSS in the final product	% of fruit juice in the final product	Amount of Sodium benzoate added(ppm)	% of TSS in the final product	%Acidity in the final product	Amount of preservative added(ppm)
FPO value	⩽40%	⩽25%	600ppm	⩽15%w/w	⩽1.2%	750
Analysed value	45%	25%	600ppm	36%	1.63%	750

4.6 Microbial studies

Table 13 presents the results of microbial analysis of West Indian cherry products during storage and Table 13(a) presents the results of statistical analysis.

The microbial examination of pickle, preserve, sauce and squash prepared from West Indian cherry, failed to show the presence of microorganisms during the initial period. In case of pickle and squash, there was complete absence of microorganisms even after 6 months of storage.

In preserve the bacterial count was $1.43x10^{-6}$/g by 3rd month, which increased to $3.7x10^{-6}$/g by 6th month of storage. There was no fungal growth during the 3rd month, but by 6th month, the fungal count was $5.5x10^{-3}$/g. Similarly there was no yeast growth by the 3rd month, but by 6th month the yeast count was $3.3x10^{-3}$/g. In sauce the bacterial count was $1.43x10^{-6}$/g by 3rd month, which increased to $4.1x10^{-6}$/g by the end of 6th month of storage. There was no fungal count during the initial and during the 3rd month but there was a fungal count of $3.6x10^{-3}$/g in the 6th month. No yeast count was observed in sauce through out the storage period. In case of sauce and preserve there was a significant increase in bacterial count between 0-3 months and 3-6 months of storage.

Table. 13 Microbial count of West Indian cherry products during storage

Fruit product	Microbial count during storage								
	Bacteria			Fungi			Yeast		
	Initial	3 months	6 months	Initial	3m	6m	Initial	3m	6m
Pickle	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Preserve	Nil	$1.43x10^{-6}$/g bacteria	$3.7x10^{-6}$/g bacteria	Nil	Nil	$5.5x10^{-3}$/g fungi	Nil	Nil	$3.3x10^{-3}$/g yeast
Squash	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sauce	Nil	$1.43x10^{-6}$/g bacteria	$4.1x10^{-6}$/g bacteria	Nil	Nil	$3.6x10^{-3}$/g fungi	Nil	Nil	Nil

Table.13 (a) Mean increase of bacterial count in Sauce and Preserve during storage

Product	Mean increase ± S.D		t stat	Prob level of sig(%)
	0-3 months	3-6 months		
Sauce	1.43 ± 0.41	4.1 ± 0.1	9.007	1.2
Preserve	1.43 ± 0.251	3.7 ± 3.05	9.007	1.2

S.D-Standard deviation

4.7 Benefit cost ratio of the developed products:

Yield and Benefit cost ratio (BC) of products prepared from West Indian cherry were worked out and is given in Table 14.The cost was worked out based on the prices of various commodities needed for the preparation of the product. The final product was computed by taking into consideration the quantity of West Indian cherry fruits and other ingredients required to prepare a definite quantity of the product. The market price of similar popularly available fruit products like lemon pickle, amla preserve, pine apple squash and tomato sauce were compared with the West Indian cherry products, since West Indian cherry products are not available in the market for comparison and benefit cost ratio was calculated.

The highest yield was observed in squash (1500g). This is followed by both pickle and preserve (1250g) and the least yield for sauce (700g).

The cost was highest for preserve (Rs.49.32/kg) followed by pickle (Rs.34.30/kg), squash (33.48/kg) and the cheapest product was sauce (18.40/kg). Benefit cost ratio was found to be highest for sauce (6.79) and 3.2 for pickle followed by 2.12 for squash. BC ratio was low for preserve (1.02).

Table.14 Yield and BC ratio of products

Sl. no	Product	Yield/kg of West Indian cherry (kg)	Cost/kg of product (Rs. ps)	Market price of products/Kg (Rs.ps)	BC ratio
1.	Pickle	1.25	34.30	109.76 (lemon)	3.2
2.	Preserve	1.25	49.32	50.30 (amla)	1.02
3.	Squash	1.5	33.48	70.97 (pineapple)	2.12
4.	Sauce	0.70	18.40	124.93 (tomato)	6.79

Discussion

DISCUSSION

Discussion of the study entitled "Value addition and quality evaluation of West Indian cherry" are presented under the following headings.

5.1 Physical characteristics of West Indian cherry fruits
5.2 Chemical constituents of West Indian cherry fruits
5.3 Organoleptic changes
5.4 Chemical composition of the products
5.5 Confirmation of the products with FPO standards.
5.6 Microbiological count
5.7 Benefit cost analysis

5.1 Physical characteristics of West Indian cherry fruits:

The colour of fully mature West Indian cherry fruit was green with pink tint and it was of full red colour in red ripe stage. Morton (1987) reported that the fruits borne singly or in 2's or 3's in the leaf axils, are oblate to round, cherry like but more or less obviously 3-lobed; 1.25-2.5cm wide bright red, with thin, glossy skin and orange coloured, very juicy, acid to sub acid.

The firmness of the fully mature fruit was found to be 3.8 pressure in kg/cm^2 and reduced to 1.6 pressure in kg/cm^2 in ripe fruits. The number of fruits per 100g in fully mature stage was noted as 21 and in red ripe stage it was 16 since the fruit weight increased upon ripening from 4.76g in fully mature stage to 6.25g in red ripe stage.

Fruit pulp ratio of the fruit was 60 per cent in red ripe stage and in mature stage it was 40 per cent. Bharati *et al.* (1994a) observed that the fruit pulp ratio of West Indian cherry was found to be 1.90g/fruit for raw fruit and that of 2.20g/fruit for red ripe fruit. In the present study the fruit pulp ratio was found to be higher in red ripe stage (3.75g/fruit) than the reported value.

Weight of the fruit after harvest in fully mature stage was 4.76grams and upon ripening the fruits under room temperature, the weight was reduced to 3.3grams.This loss of weight in fruits upon ripening under room temperature may be due to respiration loss.

Bharati *et al***.** (1994a) observed that the physical characteristics of West Indian cherry fruits were higher for ripe fruits in terms of weight, volume, specific gravity, length, girth, and pulp/seed ratio than for raw fruits. The present study reveals the superior physical characters of red coloured fruits in fruit weight, pulp recovery and colour of the fruits over the other. The above observations are in accordance with the study of Muthukrishnan and Palaniswamy (1972) who reported the same physical characters in West Indian cherry in red ripe stage.

5.2 Chemical constituents of West Indian cherry

The fully mature fruit has moisture content of 83.7 per cent and for red ripe fruit it was 87.13 per cent and the increase in moisture content was not significant. The fibre content was found to be 1.13grams in mature stage and 0.55grams in red ripe stage. Calcium in fully mature and red ripe fruits were found to be 12.04mg/100g and 11.73mg/100g and the phosphorus content of fully mature fruit was 21.56mg and that of red ripe fruit was 20.53mg/100g.There was no significant variation in calcium and phosphorus contents between fully mature and red ripe stage. Iron content of fully mature fruit (1.036mg) was significantly reduced to 0.396mg in red ripe stage. There was no significant variation in potassium content in both stages. They are in line with the values reported by Asenjo (1980) and Morton (1987) in West Indian cherry fruits.

Fully mature West Indian cherry contains 117.65µg/100grams of β-carotene, which increased significantly upon ripening to 210.63µg/100grams. Same trend of carotene was reported by Munsell (1950) in West Indian cherry fruits. Regarding the chemical composition, the ascorbic acid constituted the major vitamin in this fruits in both the types recording 890.86mg/100grams in

fully mature stage and 522mg/100grams in red ripe stage. There was significant reduction in vitamin C upon ripening. Loss of ascorbic acid during ripening process could be due to oxidation of this vitamin as it is a reducing agent. (Bharati *et al*., 1994a).

Acidity of the fruit decreased during ripening from 1.8 per cent to 1.23 per cent. But this decrease in acidity during ripening was not significant. Bharati *et al*. (1994a) also observed a similar decrease in acidity during ripening in West Indian cherry. This decrease can be attributed to conversion of acid to sugars resulting in increased total sugar and sugar to acid ratio.

The reducing sugar increased from 4.41 to 5.04 per cent, and total sugar from 4.34 to 5.71 per cent during ripening. There was an increase in trend in reducing and total sugars in West Indian cherry. Similar decreasing trend in ascorbic acid and increasing trend in sugars during ripening was reported in mango by Sahni and Khurdiya (1989).

Total soluble solids increased from 5.43^{o}brix to 7.4^{o}brix during ripening. The values for TSS in fully mature and red ripe stage were low compared to the results of Muthukrishnan and Palaniswamy (1972) who found TSS of red ripe fruit as 8.7^{o} brix and 7^{o}brix in West Indian cherry fruit.

5.3 Organoleptic qualities of West Indian cherry products during storage

5.3.1 Changes in the organoleptic qualities of West Indian cherry pickle during storage:

The organoleptic qualities were found to change during storage. The organoleptic qualities of West Indian cherry pickle were assessed till the end of 6 months, details of which are discussed below.

Appearance and colour are the most important factors, which added aesthetic values to the products. Poor products of deteriorated colour are not accepted by the consumers.

In the present study, the appearance and colour of the product remained with a highest score of 5 till the 3rd month and showed a slight fall in the score to 4.8 in the case of appearance and to 4.9 in the case of colour by the end of 6 months. Bhasin and Bhatia (1981) reported that best pickles were obtained at early maturity of fruits in order to get good colour and appearance. Chavan *et al.* (2005) also reported best appearance of carrot pickle at 3 months of storage.

There was a decrease in trend in the flavour of the pickle from (5 to 4.7) at the same time texture was improved from 4 to 4.3 at the end of storage period. These changes could be due to the increase in acid content with the advancement of storage period. The change in flavour and texture may be varied according to the rough material. Verma *et al*. (1986) reported that pickles prepared from medium acidity mangoes were poor in flavour. Joy (2003) observed a decrease in the scores for flavour and texture in bilimbi pickle by the end of storage period. Chavan *et al*. (2005) reported that in carrot pickle texture was improved by the 3rd month of storage.

With reference to taste, there was no change till the end of 3rd month and then a slight fall in the score from 5 to 4.8 by the end of six months, was observed which was found to be significant. Joy (2003) also observed a decline in taste score from 5 to 3.7 during storage in bilimbi pickle.

The overall acceptability of the product decreased with the advancement of storage period and there was a significant difference between the initial and third month of storage.

5.3.2 Changes in the organoleptic qualities of West Indian cherry preserve during storage:

Organoleptic qualities of West Indian cherry preserve were found to change considerably with respect to different quality attributes. Colour change is the major factor that usually occurs in the processed products, which affect the appearance. Appearance of preserve scored 4 during initial and showed a decline in score upto 3.7 by the end of storage period. Tripathi *et al.* (1988) and Saima (2002) observed a decline in the colour and appearance of amla preserve during different intervals of storage period.

The colour of preserve showed a good initial score of 5 which reduced to 4.6 by 3rd month and further reduced to a score of 3.7 by the end of six months. Darkening and fermentation are the major problems associated with the storage of amla preserve. Tripathi *et al.* (1988) examined various commercial darkened samples of amla preserve and revealed that darkening in amla preserve starts from surface of the fruit and penetrates gradually inside towards the stone during storage. Similar darkening was observed in West Indian cherry preserve also by the end of 6 months of storage.

There was an upward trend in the scores from 3.2 to 3.8 and again to 4 in case of flavour and also a simultaneous improvement in the taste score from 2.8 to 3.2 by the 3rd month and again increased to 4 with regard to taste. Texture of preserve also had higher scores with storage period from 2.7 to 3.5 and again to 4.2 by six months of storage. An increase in score for flavour and taste was also reported in amla preserve with the progress of storage period. (Saima, 2002).

An increase in the mean scores for colour, taste and flavour with the advance of the storage period was observed in amla preserve by Tripathi *et al.* (1988). Their study showed that the per cent of acceptability for taste, colour, and flavour of stored preserve increased with the advance of the storage period up to 45th day and did not change upto 135th day, but the acceptability of texture was found to increase to a maximum by the 90th day which then reduced.

According to Singh *et al.* (1999) the preserve should preferably be stored for at least 60 days before consumption. The improved acceptability of the preserve with the advance of the storage period can be attributed to the increased penetration of sugar into the fruit tissues from the syrup and the improvement of texture. Alzomora *et al.* (1993) reported that lower pH and penetration of sugar into the fruit chunks improved the sensory quality by establishing sugar acid ratio with the storage.

In the present study also the overall acceptability of West Indian cherry preserve increased significantly from initial to sixth month of storage.

5.3.3 Changes in the organoleptic qualities of West Indian cherry squash during storage:

In the present study, a gradual decrease was observed in the appearance and colour of squash during storage. The decrease in appearance was from score of 5 to 2.7 and colour from 5 to 2.8 at the end of storage period. This change may be due to deterioration of pigments in West Indian cherry fruit. Wasker and Khurdiya (1987) reported similar trends in the degradation of anthocyanins in phalsa juice. They noted that the squash prepared from phalsa beverages was acceptable upto 180days as there was maximum retention of anthocyanins in phalsa beverages kept in cool store. The accelerated rate of decomposition of anthocyanins at higher temperature may be due to hydrolysis of the protective 3-glycosidic linkage to give unstable anthocyanins.Colour and appearance of West Indian cherry may be an indication of the presence of anthocyanins which can be degraded in the course of processing and storage.

Hema (1997) stated that decrease in colour value of jamun squash might be due to colour bleaching by light rays that had passed through the colourless glass containers. Similar decrease in colour of rose apple squash was also observed by Joy (2003).

Flavour of the squash decreased from 4.8 to 3.9 at the end of the storage period. According to Shukla *et al.* (1991) browning reaction is a major reason for the impairment of flavour in fruit products. This might be the case in the present study also. Taste of squash declined from 5 to 3.5. The squash showed a decreasing trend in score from 5 to 3.6 with respect to consistency. The possible reason for decrease in these values could be the loss of volatile aromatic substances during storage. 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 overall acceptability continuously decreased from 4.9 to 2.5 by 6^{th} month. The squash was found to be highly acceptable during the initial period and then gradually decreased in acceptability. Parvathi *et al.* (1998) also stated that squash developed using West Indian cherry was delicious but the keeping quality was low compared to other squashes stored under ambient conditions. Temperature plays an important role in inducing certain biochemical changes in the product and discolourisation (browning) and thus, masking the original flavours and colour of the product.

5.3.4 Changes in the organoleptic qualities of West Indian cherry sauce during storage:

The West Indian cherry sauce prepared was evaluated for various quality attributes such as appearance, colour, flavour, taste, texture and overall acceptability with storage period.

The appearance of the sauce decreased from 4.9 to 4.1 by 3^{rd} month and to 3.8 by 6^{th} month and that of colour from 5 to 4.3 and then to 4. Similar decrease in appearance and colour were noted in strawberry sauce during storage of 90 days (Kumar and Manimegalai, 2001) and in tomato ketchup (Kurian, 1990).

Appearance of sauce during storage was affected by the black neck formation. The air trapped in the bottle during capping caused the darkening of sauce at neck portion. (Narkviroj and Ranganna, 1976).

The flavour of sauce decreased from 5 to 3.9 and consistency of sauce decreased from 5 to 3.9 and that of taste decreased from 4.9 to 3.2 during the end of storage. The reduction in flavour, consistency and taste was found to be significant. Similar decrease in values of flavour, consistency and taste were observed in strawberry sauce (Kumar and Manimegalai,2001).

The overall acceptability of the sauce showed a significant agreement between judges during storage months and the overall acceptability of the product decreased as the storage period advanced. The overall acceptability was found to be highly acceptable during initial and later decreased as the storage period increased. This reduction in overall acceptability of the sauce is reasonable because of the reduction in sensory qualities with advancement in storage period.

5.4 Chemical composition of the products.

5.4.1 Changes in chemical constituents in West Indian cherry pickle during storage:

Variations noted in the various chemical constituents of West Indian cherry pickle during different storage periods are discussed below.

An increase in acidity was observed from 0.96 per cent to 1.12 per cent in the 3rd month and further increased to 1.14 per cent by the 6th month of storage. This finding is line with the findings of an increase in acidity in West Indian cherry pickle by Bharati *et al.* (1994a) and in carrot pickle by Chavan *et al.* (2005).

Pertaining to TSS in West Indian cherry pickle, significant increase was recorded as storage period advanced. The value increased from 41^{o}brix in the initial period to 42^{o}brix by the 6th month. A similar increase in TSS was also noted in bilimbi pickle reported by Joy (2003). Total sugar decreased from 2.39 per cent to 2.35 per cent by 3rd month and further decreased to 2.23 per cent with the increase in storage period.

In the present study, there was a decrease in β-carotene content from 75.6µg/100g to 41.3µg/100g and the loss of β-carotene in fresh pickle was found to be about 36 per cent from that of the fruit and percentage loss of β-carotene during storage was about 46 per cent by 6th month when compared to the initial product. Thus the β-carotene retention in pickle by the end of storage period was about 55 per cent compared to the initial product. Similar retention of 31.71 per cent of β-carotene was observed in carrot pickle by Chavan *et al.* (2005).

Vitamin C content of the pickle reduced significantly with storage period. In fresh pickle vitamin C was 511mg, which showed 57 per cent retention when compared to fresh fruits. During the 3rd month of storage vitamin C content reduced significantly, but about 85 per cent of the vitamin C from the initial period was retained and vitamin C further reduced by 6th month and again showed about 80 per cent retention from the initial period. Tripathi *et al.* (1988) and Saima (2002) also reported a decrease in the ascorbic acid content of amla products during storage. This loss can be attributed to oxidation due to light and storage temperature. Chavan *et al.* (2005) reported that the reduction in ascorbic acid of carrot pickle was 31.25 per cent. Thus West Indian cherry pickle is a processed product, which can retain a higher percentage of vitamin C even after a storage period of 6months (408.49mg/100g).

5.4.2 Changes in chemical constituents in West Indian cherry preserve during storage:

Changes in chemical constituents of West Indian cherry preserve were analysed over a period of 6 months and the results revealed that acidity of the preserve decreased from 0.37 per cent to 0.06 per cent during storage. This finding on acidity changes in preserve during storage is similar to the results reported by Tripathi *et al.* (1988) in amla preserve and Joy (2003) in lovi lovi preserve.

An increase in TSS of West Indian cherry preserve was found from 68.3°brix to 71.1°brix. Similar increase in TSS during storage was reported in amla preserve by Singh *et al.* (1999) and in lovi lovi preserve by Joy (2003).

In the present study, there was an increase in total sugar from 59.1 per cent to 62.48 per cent during storage, but this increase was not significant, 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) and similar increase in total sugar in preserves during storage was noted by Kalra (1988) and Saima (2002).

There was a significant reduction in the β-carotene content of preserve during storage from 57μg to 24 μg/100g. This decrease could be due to the preparation and storage of products at higher temperature. Similar decrease in β- carotene content was observed in cashew apple candy and tutti fruiti by Suman (2006).

A significant reduction in vitamin C content of the preserve during storage was observed from 422mg/100g to 162mg/100g in the present study. Tripathi *et al***.** (1988) also observed a reduction in vitamin C during storage of amla preserve. In the present study 47 per cent of vitamin C was retained in the initial preserve when compared to the fresh fruits. The retention of vitamin C in the final processed product depends on the method of preparation, blanching and pricking of the fruits, which is necessary to render the preserve soft and to facilitate uniform absorption of sugar. But most of the vitamin C is lost during blanching. During the 3rd month 75 per cent of the vitamin C was retained and during 6th month 38 per cent of the vitamin C was retained when compared to the initial product even though there was a reduction in this vitamin in storage.

The lower vitamin C content of preserve stored under ambient conditions in the present study could be attributed to the higher loss of vitamin C at higher

temperature. Salunkhe *et al.* (1991) stated that the ascorbic acid content of stored fruit generally decreased rapidly at higher storage temperature.

5.4.3 Changes in chemical constituents of West Indian cherry squash during storage:

The acidity of squash decreased during storage from 1.64 per cent to 1.56 per cent during the third month and from 1.56 per cent to 1.36 per cent during the 6th month of storage. Similar results were observed by Muthukrishnan and Palaniswamy (1972) in West Indian cherry squash. Similarly they noticed a decreasing trend in acidity of pine apple and lime squashes, but in contrast there was an increase in acidity of squash prepared from rose apple by Joy (2003). Kannan and Thirumaran (2004) also observed a decrease in acidity during storage of jamun squash. This decrease might be due to chemical interactions between organic acids and anthocyanins.

The TSS of squash showed an upward trend in the value from initial to third month from 45.1^{o}brix to 45.8^{o}brix and then it slightly decreased to 45.4^{o}brix by the end of 6th month. This result was similar to the findings noted by Muthukrishnan and Palaniswamy (1972) in West Indian cherry squash who also observed an increase in TSS and then a reduction during storage. Jain *et al.* (1986) found that there was no appreciable change in TSS value during storage of phalsa, kaphal and litchi squashes. The decrease in TSS could be attributed to settling down of some soluble colloidal solids, incipient fermentation and other chemical reactions of sugars in presence of acid during storage (Khurdiya and Anand, 1980).

An increase in total sugar content from 41.33 to 43.36 per cent in West Indian cherry squash was observed at the end of storage period. The result obtained in this study with regard to this particular parameter is in conformity with the findings of Hema (1997) in jamun squash and Joy (2003) in rose apple

squash. This increase in the total sugar content might be due to the conversion of some amount of acids to sugars (Babsky *et al.,* 1986).

The β-carotene content was significantly reduced from 88.51µg to 40.9 µg in the 3rd month and further reduced to 22.13 µg during 6th month of storage. In West Indian cherry squash it retained about 42 per cent of β-carotene when compared to fresh fruits. In the third month 46 per cent and in the 6th month 25 per cent of β-carotene was retained when compared to the initial product. It was found that β-carotene was better retained in the jackfruit RTS samples stored in green colour bottles followed by colourless bottles. Similar decrease in β-carotene content of mango RTS beverages during storage was observed by Beerh *et al*. (1989)

The loss of β-carotene may be due to oxidative or non-oxidative changes (cis-trans isomerisation, epoxide formation, or thermal degradation) and such changes will alter the colour of the product and lower the flavour and nutritive value of the product (Land, 1962 and Eskin, 1979).

There was a significant reduction in vitamin C content of squash during storage from 343 mg to 311mg by the 3rd month and reduced to 288 mg /100mg in the 6th month. Since vitamin C is a strong antioxidant, it oxidizes itself resulting in rapid reduction of vitamin C during storage. Kalra *et al.* (1991b) reported that during storage, vitamin C content decreased by 50 per cent in all market drinks except guava, in which the vitamin C retention was better. In the present study on West Indian cherry squash, it retained about 66 per cent of vitamin C when compared to fresh fruits. In the 3rd month, 91 per cent and in the 6th month 84 per cent of vitamin C was retained when compared to the initial product.

5.4.4 Changes in chemical constituents of West Indian cherry sauce during storage:

A general increase in the acidity from 1.63 to 1.73 percent was observed during storage of sauce for 6 months. The titratable acidity of the apple pomace

sauce changed from 1.20 to 1.27 percent after storing for 6 months at room temperature (Joshi *et al*., 1996). Similar results were reported by Kumar and Manimegalai (2001) in straw berry sauce also.

The TSS of West Indian cherry sauce increased gradually from 36^{o} to 37^{o}brix. Similar trend was found in the TSS of apple pomace and in straw berry sauce by Joshi *et al. (*1996) and Kumar and Manimegalai (2001) respectively.

The total sugar content of sauce decreased from 29.2 per cent to 27.9 per cent but this was not a significant reduction. Ranote *et al.* (1993) also reported a decline in total sugar content of kinnow products stored at room temperature.

The β-carotene content of West Indian cherry sauce decreased significantly from 58.85µg to 48.51µg by the 3rd month and to 41.62µg during the 6th month of storage period. The retention of β-carotene was found to be only 28 per cent in the initial product compared to fresh West Indian cherry (210.63µg). There was a retention of 20 per cent of β-carotene during 6th month when compared to the initial product. Thus β-carotene in West Indian cherry sauce was very low and further decreased with storage. Similar decrease in β-carotene content was observed by Kurian (1990) in tomato ketchup during storage.

Vitamin C content of the sauce decreased significantly from 322mg to 214mg by 6th month of storage. The retention of vitamin C in freshly prepared sauce from that of the fruit was about 62 per cent and the retention of vitamin C after 3 months and 6 months of storage period was found to be 88 per cent and 66 per cent respectively when compared with the initial value of this vitamin in the sauce. The reduction in ascorbic acid can be substantiated by oxidation of ascorbic acid to dehydroascorbic acid, which is further degraded to products with no vitamin C activity (Sherkut and Luh, 1976). The decline in vitamin C values was in accordance with the findings reported by Kumar and Manimegalai (2001) in straw berry sauce.

Bharati *et al.* (1994a) reported that West Indian cherry ketchup retained 174mg of vitamin C after 18 months of storage. In the present study, vitamin C was found to be 214mg after 6 months of storage. So West Indian cherry sauce can also be considered as a processed product, which can retain high vitamin C even after 6 months of storage.

5.5 Confirmation of the products with FPO standards:

The present study with West Indian cherry products satisfied the FPO requirements for similar products. Similar FPO confirmations were reported by several workers for different minor fruit products (Sheeja, 1994., Majeed,1995., Pal,1995., Hema,1997 and Joy,2003).

5.6 Microbial count

The shelf life of any product is dependant on the absence of harmful microorganisms. The microbial growth or microbial damage of a product is dependant upon certain factors both chemical and physical, which are favourable for their growth. (Frazier and Westhoff, 1974).

No microbial activity was observed upto 6 months of storage, which confirmed the successful storage behaviour and shelf life of West Indian cherry pickle. Addition of preservative to the product may be useful for the successful storage behaviour. The results are in accordance with the findings of Joy (2003) who had reported similar findings in bilimbi pickle during storage period.

The microbial count of preserve from West Indian cherry was analysed before and after storage. The preserve recorded zero microbial count initially. After 3months of storage the sample contained $1.43x10^{-6}$/g bacterial flora and by 6 months of storage the sample contained $3.7x10^{-6}$/g bacterial flora. There was no fungal and yeast growth upto 3 months but after that it showed a fungal growth of $5.5x10^{-3}$/g and yeast $3.3x10^{-3}$/g. No microbial growth was observed in amla preserve by Saima (2002). Sethi and Anand (1984) studied the market samples of

amla preserve and found that the yeast count ranged from $2.4x10^{-6}$/g to $3x10^{-6}$/g and bacterial count as $4x10^{-6}$/g to $6x10^{-6}$/g.

The microbial examination of the squash failed to show the presence of microorganisms even at the end of 6 months. The added preservative in squash may help to increase the shelf life. This is a positive indication for the safe use of West Indian cherry squash over six months under ambient storage. Similar results were observed in jamun squash studied by Hema (1997) and in rose apple squash by Joy (2003).

The microbial load of the stored sauce samples were analysed and recorded zero microbial count initially. After 3 months of storage, the samples contained $1.43x10^{-6}$/g bacterial flora and by six months $4.1x10^{-6}$/g bacterial flora. There was no fungal growth upto 3 months of storage but observed fungal growth by the end of storage period. Similar findings were reported in straw berry sauce by Kumar and Manimegalai (2001).

5.7 Benefit cost analysis

Among the selected four West Indian cherry products all the products viz pickle, preserve, squash and sauce were found to obtain BC ratio above one and could be recommended for popularization. West Indian cherry sauce had the maximum BC ratio (6.79) and the preserve had the least BC ratio (1.02). Cost of production of West Indian cherry sauce was only Rs.18.40/kg followed by squash Rs.33.48/kg. Maximum yield of the product was also for squash 1.5kg/kg of the fruit.

The results of the study revealed that all the products prepared with West Indian cherry had a BC ratio above one, which indicated their suitability for commercialization. But it was seen that in West Indian cherry sauce with maximum BC ratio of 6.9, the overall acceptability of the sauce significantly reduced with storage period. Vitamin C retention of the product was 62 per cent initially compared with the fruits in red ripe stage. Vitamin C retention was 88 per

cent and 66 per cent in sauce stored for 3 months and 6 months respectively when compared with the initial product. So this can be considered as a processed product with high vitamin C but from 3rd month onwards there was bacterial contamination in West Indian cherry sauce. Bacterial contamination can also be a factor affecting the sensory qualities of the product on storage. By providing better storage conditions and packaging materials we can control this bacterial growth and there by improve the overall acceptability of this product.

The product with next high BC ratio (3.2) was West Indian cherry pickle. The overall acceptability of the product showed a decrease from the 3rd month of storage but after that there was not much change in the acceptability. Pickle stored for 6 months retained a high level of Vitamin C (408.39mg) and there was no microbial growth in pickle during storage.

BC ratio for squash was 2.12 but here also the overall acceptability of the products decreased considerably with storage time. West Indian cherry squash was found to retain 66 per cent of vitamin C initially when compared with fresh red ripe fruits and retained 91 per cent and 84 per cent of vitamin C by the 3rd month and 6th month respectively when compared with the initial product. There was no microbial growth in squash during storage of 3 months and 6 months respectively when compared with the initial product.

The lowest BC ratio was for preserve (1.02). Here the overall acceptability of the preserve increased significantly with storage time. Vitamin C retention was 47 per cent in the initial product when compared to the fully mature fruits and retained 75 per cent and 38 per cent vitamin C during storage of 3 months and 6 months respectively when compared with the initial product.

In general the overall acceptability was found to be affected mainly in the products with red ripe fruits of West Indian cherry. This may be due to the pigments containing phenolic groups in the red ripe fruits causing changes in the sensory qualities of the products during storage. A detailed study of the phenolic

pigments in ripe fruits will give useful information for modifying the processing techniques and thereby overall acceptability of the products can be improved during storage. Usually the retention of vitamin C in processed fruit products are very low, whereas in West Indian cherry products the retention of vitamin C was found to be fairly high even after processing and storage. Thus, this study highlighted the significance of processed West Indian cherry products as a solution for the increased consumer demand for nutritious and economical fruit products.

Summary

SUMMARY

The present study entitled "Value addition and quality evaluation of West Indian cherry" was undertaken to investigate the nutritive value of West Indian cherry fruits and to find out its suitability for development of various processed products. The investigation also aimed to study the organoleptic, nutritional and shelf life qualities of the developed products. In the present study, the products prepared were West Indian cherry pickle, preserve, squash and sauce.

Physical examination of the fully mature West Indian cherry fruits revealed that the colour of fully mature fruits were green with pink tint with a firmness of 3.8 pressure in kg/cm^2 and number of fruits per 100g was 21 and it has fruit pulp ratio of 40 per cent and the mean weight of fruit was 4.76g.

Physical examination of the ripe fruits revealed that it was of full red colour with a firmness of 1.6 pressure in kg/cm^2. Number of fruits per 100g was 16, and the fruit pulp ratio was 60 per cent. The mean weight of fruit was 6.25g.The present study revealed the superior physical characters of red coloured fruits in fruit weight, pulp recovery and colour of the fruits over the other. But upon ripening the fruits under room temperature, average fruit weight reduced to 3.3grams.

Chemical constituents of the fruits in both fully mature and red ripe stage revealed that, fully mature fruit is superior to red ripe fruit in case of fibre (1.13g), Vitamin C (890.86mg), acidity (1.8%), iron (1.036mg), calcium (12.04mg) and phosphorus (21.56mg), where as the red ripe fruit is high in β-carotene (210.63µg), moisture (87.13%), total sugar (5.71%), TSS (7.4ºbx) and reducing sugar (5.04%).

In the present study, appearance, colour and taste of the pickle remained as such with a highest score of 5 till the 3rd month and showed a slight fall in the score to 4.8, 4.9 and 4.8 respectively by the end of 6months. Flavour of the pickle

did not differ significantly where as texture of the pickle improved with a score from 4 to 4.3 by the end of storage period. The overall acceptability of the pickle decreased significantly between the initial and third month of storage and then did not vary much till the 6th month.

The initial score for appearance and colour of the preserve decreased from 4 and 5 to 3.7 by six months of storage. The overall acceptability of preserve was improved significantly from an initial score of 3.2 to 4.5 by 6th month of storage and this was mainly contributed by the high scores for flavour, texture and taste of the preserve during storage.

Sensory qualities such as appearance, colour, consistency and taste of the squash decreased from the maximum score of 5 to 2.7, 2.8, 3.6 and 3.5 respectively by the end of the storage period. The overall acceptability of the squash gradually decreased from 4.9 to 2.5, which showed that the squash was highly acceptable during the initial period and due to changes in qualities such as appearance, colour, consistency and taste, the overall acceptability was decreased after storage.

The colour, flavour and consistency of the sauce showed a highest score of 5 during the initial period and then decreased to 4, 3.9, and 3.9 respectively by the end of six months. There was also a gradual decline in the acceptability of appearance and taste also. Hence the overall acceptability of West Indian cherry sauce was found to be highly acceptable during the initial period and later decreased as the storage period increased.

In West Indian cherry pickle a gradual increase in acidity from 0.96 per cent to 1.14 per cent and TSS from 41^{o}brix to 42^{o}brix was observed by the 6th month of storage. A gradual decrease in total sugar was observed from 2.39 to 2.23 percent by the end of storage period. A significant decrease in β-carotene (75.6µg/100g) and vitamin C (511mg/100g) to 41.3µg and 408.39mg/100g by the end of six months was also observed. The loss of β-carotene in fresh pickle was

found to be 36 per cent from that of the fruit and percentage loss of β-carotene during storage was 46 per cent by the 6th month when compared to the initial product. Even though a significant loss of vitamin C was also observed, fresh pickle showed 57 per cent retention when compared to fruits and 80 per cent vitamin C retention was found in pickle stored for 6 months when compared to the initial product.

In West Indian cherry preserve, there was an increase in TSS and total sugar and a decrease in acidity during storage. A significant reduction in β carotene and vitamin C was also observed during the storage of preserve. Even then, there observed 38 per cent vitamin C retention in preserve stored for 6 months (162mg/100g) when compared to the initial product (422mg/100g).

In West Indian cherry squash, there was an increase in TSS and total sugar but a decrease in acidity was noted. About 42 per cent of β-carotene was retained in the squash when compared to fresh fruits. In the 3rd month 46 per cent and in the 6th month 25 per cent of β-carotene was retained in the squash when compared to the initial product. With regard to vitamin C, squash retained about 66 per cent of vitamin C when compared to fresh fruits. In the 3rd month 91 per cent and in the 6th month 84 per cent retention of vitamin C was observed in the squash when compared to the initial product.

In West Indian cherry sauce an increase in acidity and TSS and a decrease in total sugar was noted with storage period. The retention of β-carotene was only 28 per cent in the sauce when compared to the fruits but about 20 per cent of this β-carotene was found to be retained in the sauce after six months of storage. About 66 per cent of vitamin C retention (214mg/100g) was observed in sauce stored for six months when compared to the initial product (322mg/100g).

There was no microbial growth in pickle and squash during storage but microbial contamination in sauce was observed from 3rd month onwards which could also affect the sensory qualities of the products on storage. Though there

was microbial contamination of the preserve after three months, the sensory qualities of the product was not affected even by six months of storage.

All the products were in confirmation with FPO specification for similar products. The BC ratio for four West Indian cherry products viz pickle, preserve, squash and sauce were found to be above one and could be recommended for popularistaion. West Indian cherry sauce had the maximum BC ratio (6.79) and the preserve had the least BC ratio (1.02).

Even though West Indian cherry products showed high acceptability initially, the products mainly with red ripe fruits showed a decrease in overall acceptability with storage. This may be due to the high concentration of pigments containing phenolic groups in the fruits. Overall acceptability of the products on storage can be improved by modifying the processing techniques, which will minimize the activity of these phenolic compounds and also with maximum vitamin C retention.

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* Originals not seen

Appendices

APPENDIX - I

Score card for Organoleptic Evaluation of the West Indian Cherry

Product : Pickle

Tested by :
Signature :
Date :
Age :
Designation :

Quality Attribute	Word description	Score	Assigned score
Appearance	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Colour	Very acceptable	5	
	Acceptable	4	
	Slightly acceptable	3	
	Neither acceptable nor unacceptable	2	
	Unacceptable	1	
Flavour	Very acceptable	5	
	Pleasant	4	
	Neither pleasant nor unpleasant	3	
	Unpleasant	2	
	Not at all pleasant	1	
Texture	Very acceptable	5	
	Acceptable	4	
	Slightly acceptable	3	
	Neither acceptable nor unacceptable	2	
	Unacceptable	1	
Taste	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Overall acceptability	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	

Score card for Organoleptic Evaluation of West Indian Cherry

Product : Sauce

Date :

Tested by :
Signature :
Age :
Designation :

Quality Attribute	Word description	Score	Assigned score
Appearance	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Consistency	Correct	5	
	Thin	4	
	Thick	3	
	Too thin	2	
	Too thick	1	
Colour	Very acceptable	5	
	Acceptable	4	
	Slightly acceptable	3	
	Neither acceptable nor unacceptable	2	
	Unacceptable	1	
Flavour	Very pleasant	5	
	Pleasant	4	
	Neither pleasant nor unpleasant	3	
	Unpleasant	2	
	Not at all pleasant	1	
Taste	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Overall acceptability	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	

Score card for Organoleptic Evaluation of West Indian Cherry

Product : Squash

Date :

Tested by :
Signature :
Age :
Designation :

Quality Attribute	Word description	Score	Assigned score
Appearance	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Consistency	Correct	5	
	Thin	4	
	Thick	3	
	Too thin	2	
	Too thick	1	
Colour	Very acceptable	5	
	Acceptable	4	
	Slightly acceptable	3	
	Neither acceptable nor unacceptable	2	
	Unacceptable	1	
Flavour	Very acceptable	5	
	Pleasant	4	
	Neither pleasant nor unpleasant	3	
	Unpleasant	2	
	Not at all pleasant	1	
Taste	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	
Overall acceptability	Excellent	5	
	Good	4	
	Satisfactory	3	
	Mediocre	2	
	Poor	1	

Score card for Organoleptic evaluation of the West Indian Cherry

Product : Preserve

Tested by :
Signature :
Date :
Age :
Designation :

Quality Attribute	Word description	Score	Assigned score
Appearance	Excellent Good Satisfactory Mediocre Poor	5 4 3 2 1	
Colour	Very acceptable Acceptable Slightly acceptable Neither acceptable nor unacceptable Unacceptable	5 4 3 2 1	
Flavour	Very acceptable Pleasant Neither pleasant nor unpleasant Unpleasant Not at all pleasant	5 4 3 2 1	
Texture	Moderately hard Hard Very hard Hard & shrunken Stony shrunken	5 4 3 2 1	
Taste	Excellent Good Satisfactory Mediocre Poor	5 4 3 2 1	
Overall acceptability	Excellent Good Satisfactory Mediocre Poor	5 4 3 2 1	

APPENDIX 2

Quantity for the preparation of products

1. Squash

Fruit juice - 750g

Sugar - 1500g

Citric acid - 5 g

Sodium benzoate- 600ppm

1. Sugar syrup was prepared
2. Citric acid was added into the syrup.
2. Added the juice into the strained and cooled syrup
3. Sodium benzoate was added and poured into sterilized glass bottles.

2. Sauce

Fruit pulp - 810g
Sugar - 180g
Chilli powder - 7g
Salt - 12.75g
Garlic - 0.67g
Pepper - 0.1g
Cardamom - 2
Cloves - 3
Cinnamom - 2-3 pieces

The fruits were washed and pulped by using a mixer and the pulp was passed through a hand pulper to filter the debris. Sugar and salt are mixed to the fruit pulp and cooked on medium flame with spices tried in muslin bag. Cooking was continued till the final TSS reached 37^{o} brix and cooled at room temperature and sodium benzoate was added at the rate of 750mg/kg of the final product.

3.Pickle

West Indian cherry	- 700g
Gingelly oil	- 150ml
Ginger paste	- 30g
Garlic paste	- 30g
Green chilli	- 1/4kg
Salt	- 150g
Chilli powder	- 150g
Fenugreek powder	- 15g
Mustard powder	- 10g
Asafoetida powder	- a pinch
Vinegar	- 75ml

Heat oil, add chopped green chillies, then add ginger and garlic paste and after getting some brown colour, add chilli powder and salt, while adding chilli powder and salt, keep in a low flame and then add some vinegar and then add fenugreek powder, asafoetida powder and mustard powder and then stir it well and then add the fruits and mix thoroughly and add vinegar again and also oil.

4.**Preserve**

Fruits	- 580g
Sugar	- 780g
Citric acid	- 2g

Fully mature West Indian cherry fruits were selected and put in tap water and then pricked with stainless steel fork. The fruits were kept in 10% lime solution for 1 hr. The fruits were subjected to blanching for 1-2 mints. Sugar of half the weight of the fruits was taken and were kept in alternate layers and then left for 24hrs. In the following day the sugar dissolved (38^{o}bx). The fruits were taken out from syrup, more sugar was added (60^{o}bx) and boiled, citric acid was added at boiling point. The syrup was strained through muslin cloth and the fruits were kept in hot syrup for 24 hrs. On the 3rd day again the fruits were taken out from the syrup and boiled till the sugar percent reached 68^{o}bx.Sodium benzoate was added at the rate of 200mg/kg of the final product. Left the fruits in the syrup

for 3-4 days. Finally the strength of the syrup was raised to 70^{o}bx. Then the fruits were kept in hot syrup. Preserve was ready for use within 15-20 days.

VALUE ADDITION AND QUALITY EVALUATION OF WEST INDIAN CHERRY(*Malpighia punicifolia* L.*)*

By

POKKANDATH JYOTHI

ABSTRACT OF THE THESIS

submitted in partial fulfillment of the requirement for the degree of

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ABSTRACT

The present study entitled "Value addition and quality evaluation of West Indian cherry" was an investigation on the nutritive values of West Indian cherry fruits, product development such as pickle, preserve, squash and sauce and evaluation of organoleptic, nutritional and shelf life qualities of the developed products.

Physical examination of the fruit in both the maturity stages revealed that the red ripe fruits were superior in fruit weight (6.25g), pulp recovery (60%) and colour of the fruits over the fully mature fruits. But upon ripening the fruits under room temperature, the average fruit weight reduced to 3.3g in red ripe stage. Chemical constituents in the fruit in both stages revealed that fully mature fruit is superior to red ripe fruit in case of fibre, vitamin C, acidity, and minerals like calcium, iron and phosphorus where as red ripe fruit is rich in β-carotene when compared to fully mature fruits. Moisture, total sugar, TSS and reducing sugar were also found to be high in red ripe fruits.

Regarding the organoleptic qualities of the products during storage, the overall acceptability of the pickle decreased significantly between the initial and 3rd month of storage and then did not vary much till the 6th month. The acceptability of West Indian cherry preserve improved with storage period with high scores for flavour, texture and taste.

The acceptability of West Indian cherry squash was very high initially, but due to changes in qualities such as appearance, colour, consistency and taste in storage the overall acceptability was decreased. The overall acceptability of West Indian cherry sauce was also found to be highly acceptable during the initial period and later decreased as the storage period increased.

The major chemical constituents analysed in the products developed from the West Indian cherry were TSS, acidity, total sugar, β-carotene and vitamin C. During the storage period of six months TSS was found to increase and β-carotene and vitamin C were found to decrease in all the products by the end of six months. Acidity showed an increasing trend in pickle and sauce and a decreasing trend in preserve and squash during storage. The total sugar showed a decline in pickle and sauce and an increase in preserve and squash in storage.

No microbial count was observed in pickle and squash through out the storage study but sauce and preserve showed microbial contamination from 3rd month onwards. All the products developed in the present study confirmed with FPO specifications. All the products showed a BC ratio of above one and among the products sauce showed the highest BC ratio followed by pickle, squash and preserve.

The results of the above study revealed that compared to other processed products West Indian cherry products have better retention of vitamin C. The maximum retention of vitamin C was found in squash (288mg/100g) among the products prepared from red ripe fruits and with fully mature fruits pickle retained maximum of Vitamin C (408.39mg/100g). Usually the retention of Vitamin C in processed fruit products is very low where as in West Indian cherry products the retention of the Vitamin C was found to be fairly high even after processing and storage.

The study highlighted the significance of processed West Indian cherry products as a solution for the increased consumer demand for nutritious, delicately flavoured and economical fruit products.