OPTIMIZATION OF METHODS FOR JUICE EXTRACTION AND VALUE ADDITION OF PASSION FRUIT (*Passiflora edulis* Sims)

By

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(2014-12-120)

THESIS

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DECLARATION

I hereby declare that the thesis entitled "**OPTIMIZATION OF METHODS FOR JUICE EXTRACTION AND VALUE ADDITION OF PASSION FRUIT (*Passiflora edulis* Sims)**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that the thesis entitled **"OPTIMIZATION OF METHODS FOR JUICE EXTRACTION AND VALUE ADDITION OF PASSION FRUIT (*Passiflora edulis* Sims)"** is a record of research work done independently by Ms. Greeshma K. G. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Fruits are the choicest discovery of mankind which elevated the race to the civilization of the present century. Horticulture produces constitute a significant segment of the Indian agriculture and economy. India is in the second position after China in the world fruit production statistics. Many minor fruits are also contributing to the Indian fruit production. Passion fruit is one among the minor fruits which are considered to be less exploited and cultivated to a limited extend only.

The passion fruit (*Passiflora edulis* Sims.) from tropical America produces a fruit with unique flavour and aroma. It belongs to family Passifloraceae and there are two types, yellow (*Passiflora edulis f. flavicarpa*) and purple (*Passiflora edulis f. edulis*). Passion fruit is cultivated for both fresh consumption as well as for processing purpose. It is grown mostly in tropical and sub-tropical countries. In India, passion fruit is found growing wild in many parts of South India, Himachal Pradesh and North Eastern states including Nagaland, Manipur, Sikkim and Mizoram. In North Eastern states, its systematic cultivation is gaining importance in recent years (Nath *et al.*, 2009).

Passion fruit vine is a semi woody climber and perennial in nature. Fruit is ovoid or globose berry with a hard and thick shell of yellow or dark purple colour. Seeds are numerous, surrounded by yellow aromatic juicy or pulpy arils, with tart but pleasant flavour (Sharma *et al.*, 2009).

Passion fruits are fair to good sources of β-carotene (the precursor of vitamin A), ascorbic acid (vitamin C), riboflavin, niacin and have a high mineral content. Carotenes especially β-carotene which is linked most strongly to protection against cancer and the β-carotene content is very high in passion fruit (Nath *et al.*, 2009). Nowadays people are becoming more aware of the potential of this fruit and register an increased demand.

Passion fruit also excels most other fruit crops in the small quantity of pulp required to produce acceptable processed products. Aside from its unique flavour, the comparatively high acid content of passion fruit juice (2.4-5%, depending on the species) is its most distinctive characteristic and is important in processing and formulation of products containing the fruit. The juice of yellow type is more acidic and its recovery is comparatively less (25-30%) than the purple type (35-38%) (Rao *et al.*, 2014).

Owing to the poor shelf life of passion fruit, its use is limited to fresh consumption at the areas of production (Jena, 2013). The fruit pulp embedded with seeds together with its high viscosity pose difficulty for direct use as well as for processing. Different methods of pulp or juice extraction like enzymatic, mechanical and manual are reported in some fruits. The enzyme aided juice extraction has been advantageous in fruits which are difficult for juice extraction.

Passion fruit is achieving increasing importance as a source of juice in the world market. Because of its unique intense flavour and high acidity, it has been described as a natural concentrate. Because of this, passion fruit juice is generally diluted (1:6) when consumed as a nectar by itself or is used as a minor constituent when combined with other fruit juices. Passion fruit juice is highly palatable beverage when sweetened and diluted, and its flavour blends very well with other fruit juices. The purees or juices of orange, banana, papaya and guava have been successfully blended with passion fruit juice into tropical fruit drinks, punches, or syrups (Salunkhe and Kadam, 2013). Cashew apple juice blended with 25 percent lime juice was a highly acceptable drink (Remyamol, 2006). Similarly blending of passion fruit and cashew apple juices may be mutually beneficial by way of increasing the nutritional and sensory attributes. Passion fruit juice is a good choice for processing it into carbonated beverages with very distinctive and attractive flavour.

In extraction of juice from passion fruit, about two-third of the bulk is refuse, of which 90 percent is rind and about 10 percent is seeds. The rinds are high in

carbohydrates, low in ether extractable material, and moderate in crude protein. On a fresh weight basis, rind contains 1.78 percent pectin (Pruthi, 1963). For by-product making rind pulp can be utilized for the preparation of jam by blending of other fruit pulps like cashew apple pulp.

In India, limited study has been conducted on the post-harvest technology of passion fruit (Kishore *et al.*, 2010). Scientific interventions thus become the need of the hour to prevent the postharvest loss of this valuable natural resource. In this context the present study "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" was conducted with the objective of standardising technology for development of value added products utilising juice and rind of passion fruit.

Review of literature

2. REVIEW OF LITERATURE

Passion fruit (*Passiflora edulis* Sims.) belongs to family Passifloraceae, which is cultivated for both fresh consumption as well as for processing purpose. Passion fruit also excels most other fruit crops in small quantity of pulp required to produce acceptable processed products (Nath *et al.,* 2009).

Passion fruit is good source of β-carotene (the precursor of vitamin A) and ascorbic acid (vitamin C). Carotenes especially β-carotene which is linked most strongly to protection against cancer. In hilly district of Manipur, tender leaves of passion fruit are boiled and given to diabetic and cardiac patients. It is believed that the bitter principle of passion fruit leaves neutralize the blood sugar and relax muscles to control blood pressure (Nath *et al.,* 2009).

Genus has about 400 species out of which few are of economic importance. Within these species there are two distinct forms, the standard purple (*Passiflora edulis* Sims f. *edulis*) and the yellow (*Passiflora edulis* f. *flavicarpa*). Passion fruit is native to tropical America (Nath *et al.,* 2009).

Passion fruit has recently been considered as important raw material for pharmaceutical industry. Use of the glycoside passiflorine from *P. incarnata*, as a sedative or tranquilizer has opened up a new ray of hope in the medicinal sector. Italian chemists have extracted passiflorine from the air dried leaves of *P. edulis*. In Madeira, the juice of passion fruit is given as a digestive stimulant and treatment for gastric cancer (Nath *et al.,* 2009).

The passion fruits are woody perennial vines with alternate leathery, shiny-toothed, three-lobed leaves. The fruit is globose or oval with a hard shell. Fruits of both forms are roundish, about 4-6 cm diameter, with a brittle pericarp; the aril is yellowish in both forms. The purple passion fruit grows well in cooler climates. By contrast, yellow passion fruit is more often cultivated at lower altitudes or in warmer climates (Salunkhe and Kadam, 2013).

Under commercial cultivation, yellow type passion fruit (*Passiflora edulis* f. *flavicarpa*) is more popular and acceptable over purple type (*Passiflora edulis* Sims f. *edulis*) as it results in larger fruit size, greater yield, attractive fruit and juice colour and high acidity (Sandi *et al.*, 2004).

The species *Passiflora edulis* is having excellent medicinal properties like sedative, diuretic, antihelmintic, anti-diarrheal, stimulant and tonic. Also, in South Africa this is being used against the treatment of hypertension, menopausal symptoms, colic of infants *etc.* (Dhawan *et al.*, 2004).

Anesini and Perez (1993) reported that in West Indies, Mexico, Netherlands and South America, the roots are used as sedative and vermifuge. In Italy, the whole plant is used as an anti-spasmodic and sedative. In Mauritius, a combination of tincture and plant extract is used as a remedy for insomnia due to various nervous abnormalities, also roots are used as diuretic and a decoction of leaf as an emetic. The aerial parts of *Passiflora caerulea* are used as mild anti-microbial agents in catarrh (inflammation of a mucous membrane in humans or animals) and pneumonia diseases in Argentina.

2.1 PHYSICO-MORPHOLOGICAL PARAMETERS

Silva *et al.* (2008) reported 31.44 to 41.28% of pulp/juice yield in yellow passion fruits harvested at different seasons.

Commercial processing of yellow passion fruit yields 36% juice, 51% rinds and 11% seeds (Nath *et al.*, 2009). Passion fruit is round-shaped, peel colour changes from green to purple and yellow upon maturity; they contain numerous gelatinously surrounded seeds with yellow pulp responsible for an intense aroma and sweet-acid taste (Jimenez *et al.*, 2010).

The fruit shape of purple and yellow type passion fruit is round to ovoid and both types contain yellow to orange coloured pulpy juice exhibiting excellent flavour. A wide variability in morphological characters like fruit weight, rind

weight, pulp weight, seed weight and juice weight was observed in Pineapple Research Station, Vazhakulam, Kerala, after evaluating over fifty passion fruit accessions collected from different parts of Kerala and South India (Joy, 2010).

The average seed yield of ripened yellow passion fruit as reported by Oliveira *et al.* (2011) was 4.23%, Coelho *et al.,* (2011) reported 11.5% seed yield.

Patel *et al.* (2014) recorded the fruit weight of six passion fruit genotypes viz. *Passiflora edulis* (Megha Purple and Nagaland Purple), *P. edulis* f. *flavicarpa* (Kerala Yellow, RCPS-1 and Panama Yellow) and *P. alata* out of which, *Passiflora alata* recorded maximum weight (192.87 g) followed by RCPS-1 (133.75 g), whereas, the minimum weight 43.04 g and 41.02 g was recorded in Nagaland Purple and Megha Purple respectively, 90 days after flowering.

Patel *et al.* (2014) recorded juice percentage in six passion fruit genotypes viz. *Passiflora edulis* (Megha Purple and Nagaland Purple), *P. edulis* f. *flavicarpa* (Kerala Yellow, RCPS-1 and Panama Yellow) and *P. alata.* The maximum juice content (40.76%) was extracted from RCPS-1, followed by Panama Yellow (38.15%), Kerala Yellow (36.31%) and minimum in *P. alata* (22.35%), 90 days after flowering.

2.2 NUTRITIONAL AND BIOCHEMICAL PARAMETERS

2.2.1 Total soluble solids

Silva *et al.* (2005) reported an increasing amount of TSS during maturation of passion fruits ranging from 10.2°Brix to 16.8°Brix whereas, Uchoa *et al.* (2008) reported 20.56°Brix of TSS in the matured passion fruit pulp.

The total soluble solids (TSS) of different passion fruit (*Passiflora* spp.) cultivars, *P. edulis* cultivar Purple, Frederick, Yellow, Pink, *P. edulis* f. *flavicarpa*, *P. maliformis* and *P. quadrangularis* was 17.2°Brix, 15.2°Brix, 16.0°Brix, 15.6°Brix, 15.2°Brix, 11.7°Brix and 10.7°Brix, respectively (Ramaiya *et al.,* 2012).

The total soluble solids (TSS) determined in six passion fruit genotypes at 90 days after flowering, ranged from 15°Brix to 19°Brix and the highest (19°Brix) was recorded in *Passiflora alata* followed by Panama Yellow (17.4°Brix), RCPS-1 (16.8°Brix), Kerala Yellow (16.4°Brix), Megha Purple (15.75°Brix) and lowest in Nagaland Purple (15°Brix) (Patel *et al.*, 2014).

2.2.2 Titratable acidity

Ramaiya *et al.* (2012) determined the titratable acidity in seven passion fruit (*Passiflora* spp.) cultivars: *P. edulis* cultivars Purple, Frederick, Yellow, Pink, *P. edulis* f. *flavicarpa*, *P. maliformis* and *P. quadrangularis*. The yellow type (*P. edulis* f. *flavicarpa*) recorded highest titratable acidity (3.03 ± 0.19%) whereas; the purple type (*P. edulis*) recorded second lowest titratable acidity (1.80 ± 0.10%) after *P. quadrangularis*.

The titratable acidity in six passion fruit genotypes at 90 days after flowering was determined, in which, Kerala Yellow recorded the highest acidity (4.50%), followed by RCPS-1 (4.35%), Panama Yellow (3.5%), Nagaland Purple (3.25%), Megha Purple (2.82%) and lowest (1.41%) in *Passiflora alata* (Patel *et al.*, 2014).

2.2.3 Sugars

The amount of total sugars was determined from fruit juice of seven passion fruit (*Passiflora* spp.) cultivars: *P. edulis* cultivars Purple, Frederick, Yellow, Pink, *P. edulis* f. *flavicarpa*, *P. maliformis* and *P. quadrangularis*. Purple and yellow types of *Passiflora edulis* resulted in higher concentration of total sugar, 142.85 ± 0.17 g/kg and 139.69 ± 0.12 g/kg respectively, compared to other cultivars (Ramaiya *et al.*, 2012).

The amount of total, reducing and non-reducing sugar content, in six passion fruit genotypes at 90 days after flowering was determined in which, total sugar was recorded highest in Nagaland Purple (18.1%), followed by Kerala Yellow (16.6%),

RCPS-1 (15.38%), Megha Purple (14.58%), *Passiflora alata* (13.75%) and the lowest (13.34%) in Panama Yellow. The reducing sugar was maximum (6.67%) in *P. alata*, followed by RCPS-1 (5.40%), Kerala Yellow (5.26%), Megha Purple (5.15%), Panama Yellow (5.00%) and minimum in Nagaland Purple (3.92%). Also, the non-reducing sugar recorded highest in Nagaland Purple (14.18%) followed by Kerala Yellow (11.34%), RCPS-1 (9.98%), Megha Purple (9.43%), Panama Yellow (8.34%) and the lowest (7.08%) was recorded in *Passiflora alata* (Patel *et al.,* 2014).

2.2.4 Ascorbic acid

Uchao *et al.* (2008) reported 11.76 mg/100g of ascorbic acid in yellow passion fruit. Ramaiya *et al.* (2012) determined the ascorbic acid content in fresh juice of different passion fruit (*Passiflora* spp.) cultivars: *P. edulis* cultivars Purple, Frederick, Yellow, Pink, *P. edulis* f. *flavicarpa*, *P. maliformis* and *P. quadrangularis*. The juice of purple type (*P. edulis*) recorded highest mean ascorbic acid content (0.32 ± 0.72 mg/100g) compared to other cultivars.

The ascorbic acid content in six passion fruit genotypes at 90 days after flowering was determined in which, Megha Purple recorded the highest vitamin-C (48.75 mg/100ml) followed by Nagaland purple (41.34 mg/100ml), RCPS-1 (31.5 mg/100ml), *Passiflora alata* (30.8 mg/100ml), Kerala Yellow (22.8 mg/100ml) and lowest (22.5 mg/100ml) in Panama Yellow (Patel *et al.,* 2014).

Yellow passion fruit grown under different cultivation systems, an organic and a conventional system were harvested and estimated for ascorbic acid (L-ascorbic acid and L-dehydroascorbic acid) content. The concentration of ascorbic acid present in organically cultivated fruits was higher than that of conventional system (Pertuzatti *et al.*, 2015).

2.2.5 Total carotenoids

The carotenoids are natural plant pigments responsible for yellow, orange and red colour of fruits and acting as important vitamin-A precursors. Kathiravan *et al.* (2013) reported a total carotenoid content of 1962.39 µg/100 ml in fresh yellow passion fruit juice (*Passiflora edulis*).

Yellow passion fruit grown under different cultivation systems, an organic and conventional system were harvested and estimated for total carotenoid content. The concentration of total carotenoids present in conventional system was twice that of fruits cultivated under organic system. The total carotenoid content in passion fruit ranges between 27,600 to 35,400 µg/100g. However the accumulation of carotenoids in passion fruit is variable according to the stage of maturity and systems of cultivation (Pertuzatti *et al.*, 2015).

2.3 HARVESTING AND HANDLING

The fruit is generally not picked, but left on the vine until it falls or full development of the flavour. Passion fruit takes about 72 days from flowering to maturity. In South Africa, fruits are subject to sunburn damage on the ground and for that reason, they picked from vines twice or thrice a week in summer time before they are fully ripe at light-purple stage. For juice processing, the fruit is allowed to attain a deep purple colour. In India and Israel, the fruits are always picked from the vine rather than being allowed to fall. It has been found that fallen fruits are lower in soluble solids, sugar content, acidity and ascorbic acid content. Fruits can be grouped into three categories based on the stages of maturity, colour and texture of fruit *i.e.* mature green, half ripe and full ripe stage (Nath *et al.,* 2009).

2.4 JUICE EXTRACTION METHODS

The juices with high cell wall polysaccharide compounds will cause problem during extraction and storage (Matta *et al.*, 2000).

Kotecha and Kadam (2002) studied the effect of different methods for extraction of pulp from tamarind fruits. Methods adopted were cold extraction, hot extraction and hot enzyme extraction. Hot enzymatic extraction in which 0.5 per cent biotropicase given after boiling and cooling the flesh with water at 1:3 proportion at 70°C for 10 minutes and incubated for 6 hours gave highest recovery.

The technology for banana juice based beverage was standardized by Mary (2005). Clear banana juice could be extracted using commercial pectinase enzyme at the rate of 5 ml per kg pulp and incubating for four hours at room temperature. Robusta juice was superior in terms of colour, flavour and overall acceptability compared to Poovan, Karpooravalli and Palayamkodan juices.

In order to develop and produce new fruit juice in market, enzymatic hydrolysis can be used to promote high yield, better viscosity and quality fruit juice (Qin *et al.*, 2005).According to Lee *et al.*, (2006) extraction of juice using the commercial pectinolytic enzymes and amylolytic enzyme will produce clearer fruit juice without cloudy appearance.

Ushikubo *et al.* (2007) showed the positive effect of enzymatic treatment for microfiltration of Umbu juice. Laorko *et al.* (2010) also applied an enzymatic treatment on apple juices before micro and ultrafiltration tests.

Anand *et al.* (2013) studied the effect of extraction techniques and clarifying treatments of kiwi juice. Clarifying treatments adopted were sedimentation, filtration, pectinase and filtration and kaolin and pectinase. The recovery of juice was higher when clarification of juice was carried out using the combination of kaolin (10 ml per L) and pectinase (500 mg per L) in kiwifruit juice.

The use of pectinolytic enzymes increases juice extraction yields by 35%. Apart from its consistency, which is higher, the chemical and physical properties of the enzyme- treated juice are similar to untreated juice. In Australia, passion fruit juice is extracted in several ways. In one method, the juice is expressed rotating rollers; in another, a modified apricot- pitting machine and plunger are used. In New

Zealand, the halved fruits are passed over a suction device which removes the pulp and seeds. A centrifugal separator consists essentially by Kinch has greatly improved the processing efficiency (Salunkhe and Kadam, 2013).

Arsad *et al.* (2015) studied the effect of different enzymatic treatment on sugar palm fruit juice processing. Sugar palm fruit purees were treated individually and in combination using two types of commercial enzymes like Novozymes cellulase and pectinex ultra SP-L at a concentration of 0.05 (w/w) and incubated at 45°C for 60 minutes. The enzyme treatment reduced the juice viscosity and ascorbic acid content, promoted juice clarification and increased juice yield, TSS and sugar content.

2.5 PROCESSING OF PASSION FRUIT

Carbonated beverages based on passion fruit juice have a very distinctive and attractive flavour (Rodriguez *et al.*, 1975). Carbonated passion fruit drink showed a pH of 3.2 (Khurdiya, 1994).

In extraction of juice from passion fruit, about two- thirds of the bulk is refuse, of which 90% is rind and about10% is seeds. On a fresh- weight basis, rind contains 1.78% pectin, which has good jelly properties (Pruthi, 1963).

Chan (1980) reported that two characteristics of passion fruit exert an important influence on processing methods. First, the flavour is extremely sensitive to heat; and heat pasteurization inevitably leads to some loss of fresh fruit flavour. Second, the high starch content causes accumulation of gelatinous deposits on the heating surface of tubular and plate heat exchangers and a drop in efficiency of heat exchanger, with deterioration in juice flavour.

Pal (1995) developed RTS beverage, wine and jelly utilizing passion fruit and with blends of other fruits. Blending of fruit juices like lime and pineapple with passion fruit juice for better taste and quality was reported.

Passion fruit generally consumed as juice and its pleasant intensive aroma and flavour make it an attractive component for beverage and food industries (Vercelino-Alves *et al.*, 2001). As in the case of blending of fruit juices, blending of vegetable juices like carrot and beet root was also reported to be acceptable (Dhaliwal and Hira, 2001).

According to Jain and Khurdiya (2004) RTS beverage prepared by blending gooseberry and Pusa navrang grape juice in 20:80 proportions was found to be the best.

Standardisation of cashew apple RTS beverages by blending cashew apple juice with other fruit juices like orange, pineapple and lime. The beverage prepared by blending 75 percent cashew apple juice and 25 percent lime juice was found to be most acceptable (Remyamol, 2006).

Passion fruit juice and its concentrate are more popular in world market; the juice could be processed into squash, ready to serve beverages, nectars, syrups, etc. by mixing with other tropical fruit juices/pulps as it is having excellent blending property. In India, Mizoram, Manipur and Nagaland leads in the production of passion fruit processed products (Kulkarni and Vijayanand, 2009).

The rind residue contains about 5 to 6% protein and could be used as filler in poultry and livestock feed. In Brazil, pectin is extracted in purple form has a better quality than that in yellow. In Hawaii, the pectin is not extracted. Instead, the rinds are chopped, dried and combined with molasses as cattle or pig feed. They can also be converted into silage. Fresh rind contains 78.43-85.24% moisture, 2.04-2.84% crudeprotein, 1.64% sugars and 78.3 % ascorbic acid. The outer skin of the purple type contains 1.4 mg per 100 g of the anthocyanin pigment, pelargonidin 3-diglucoside. Rind also contains some tannin (Nath *et al.*, 2009).

Vaidya *et al.* (2009) prepared blended juices using cashew apple and water melon in the proportions of 75:25, 50:50 and 25:75 wherein all the blends were found to be highly acceptable.

Passion fruits are highly preferred in international market as they exhibit excellent sensory, nutritional and/or nutraceutical properties and also they can be successfully processed into value added soft drinks and juices (Jimenez *et al.*, 2010).

Jena (2013) standardised the technology for preparation of jam using passion fruit skin pulp and juice in different proportions. Processed passion fruit products are of two main types: those preserved by heat processing and those frozen and held in storage until consumed. Typical examples are frozen sherbet, canned passion fruit nectar and canned nectar combinations with citrus, pineapple and other juices. The purees or juices of orange, banana, papaya and guava have been successfully blended with passion fruit juice into tropical fruit drinks, punches or syrups. Passion fruit is achieving increasing importance as a source of juice in the world market. Because of its unique intense flavour and high acidity, it has been described as a natural concentrate. Passion fruit juice is a highly palatable beverage when sweetened and diluted (Salunkhe and Kadam, 2013).

Utilization of few highly nutritive fruits and vegetables is often limited because of high acidity, astringency, bitterness, etc. The core reason of blending different type of fruit juices is to enhance flavour, palatability, nutritive and medicinal value, to reduce astringency and polyphenols, etc. of the processed product. Cashew apple a nutritious fruit is being underutilized due to many reasons, but can be very well exploited for the preparation of healthy refreshing drinks. The astringent principle, polyphenols, makes it less palatable. Hence the palatability can be enhanced by blending with other fruit juices, thus resulting in enhanced consumption. Cashew apple, passion fruit, papaya, pineapple, lime and gooseberry and some spices can also be used for juice blending (Sobhana *et al.*, 2015). Passion fruit, a nutritious fruit with excellent blending property is being underutilized due to many drawbacks, but can be very well exploited for the preparation of healthy refreshing drinks

2.5.1 Changes in quality of passion fruit products during storage

2.5.1.1 *Total soluble solids*

An increase in TSS was observed in lime-aonla spiced beverage during 6 months of storage at different temperatures and glass containers. The increase was more in white bottles stored at ambient temperature as compared to low temperature and cool chamber storage (Deka *et al.*, 2004).

Singh *et al.* (2014) prepared nectar by blending pulp of aonla and mango with 50 per cent sugar + 50 per cent stevia + 15 per cent TSS and 0.25 per cent acidity and stored in glass bottles for 10 months at ambient temperature. No changes in total soluble solids (TSS) were observed up to five months during storage and thereafter it showed increasing trend from 9.2 per cent to 9.4 per cent.

The total soluble solids in RTS drink prepared by blending juices of passion fruit and cashew apple in different ratios such as 25:75, 50:50, 25:75 + ginger drops and 50:50 + ginger drops was 13.85°Brix, 14.50°Brix, 13.93°Brix and 14.92°Brix respectively (Sobhana *et al.*, 2015).

Touati *et al.* (2015) observed a significant increase in total soluble solids (TSS) in heat processed grape, orange and pear nectars during 28 days of storage at 4, 25 and 37°C temperature. This rate of increase advances with increase in storage time and temperature.

2.5.1.2 *Titratable acidity*

Three types of squash (Method-A, Method-B and Method-C) prepared from ripe ou-tenga (*Dillenia indica*) fruits showed decreasing trend in titratable acidity from 0.65 to 0.49% in Method-A, 0.72 to 0.55% in Method-C but abrupt increase in Method-B from 0.51 to 0.77% during 60 days of storage in glass bottles (Saikia and Saikia, 2002).

Deka *et al.* (2004) reported decreasing trend in acidity of lime-aonla spiced beverage during 6 months of storage at different temperatures and glass containers. The decrease was less in amber coloured bottles stored at low temperature as compared to cool chamber and ambient temperature.

Ladaniya *et al.* (2004) reported that, the sweetened, filtered and pasteurized 'Nagpur' Mandarin orange juice stored in crown corked glass bottles under ambient and refrigerated conditions, showed slight decrease in titratable acidity up to 45 days and then recovered to initial values after 90 and 180 days, irrespective of storage conditions.

The acidity variation between 0.87 to 3.03% in cashew apple juice after blending with other fruit juices was reported by Remyamol (2006). The titratable acidity in RTS drink prepared by blending juices of passion fruit and cashew apple in different ratios such as 25:75, 50:50, 25:75 + ginger drops and 50:50 + ginger drops was 0.35%, 0.61%, 0.41% and 0.66% respectively (Sobhana *et al.*, 2015).

2.5.1.3 *Sugars*

Sandi *et al.* (2004) reported that the concentration of reducing sugar was increased in passion fruit juice pasteurized at both lower (75°C/60 sec) and higher (85°C/27 sec) temperatures irrespective of storage condition and this increase was maximum in juices pasteurized at lower temperatures and stored under refrigeration.

The amount of total sugars in RTS drink prepared by blending juices of passion fruit and cashew apple (50:50) along with the addition of ginger drops was 14.92% (Sobhana *et al.*, 2015).

Fang *et al.* (1986) reported that the concentration of organic acids are rich in passion fruit juice, which results in higher conversion of non-reducing sugars (sucrose) to reducing sugars when stored under ambient condition as compared to refrigeration, as long as the juice has been pasteurized correctly.

A gradual increase in reducing and total sugars was noticed in lime-aonla spiced beverage during storage at different temperatures and glass containers. The increasing rate of reducing sugar was more than double at the end of 6 months of storage (Deka *et al.*, 2004).

2.5.1.4 *Ascorbic acid*

A significant decrease in ascorbic acid content was observed in canned mango juice at both initial as well as after 12 months of storage when compared to fresh mango pulp (Doreyappagowda and Ramanjaneya, 1995).

Kabasakalis *et al.* (2000) reported that, loss in ascorbic acid content was observed from commercial fruit juices like, orange, grape fruit, lemon, cocktail-A (orange, peach, grapefruit, pineapple, apple, mango, kiwi) and cocktail-B (orange, apple, apricot). The loss was in the range of 29% to 41% when juices were stored in closed containers at room temperature for a period of 4 months.

The retention of ascorbic acid in processed products during storage depends on preparation methods, processing time, temperature, salt and sugar concentration, pH, oxygen availability, activity of enzymes and metal catalysts. A percentage loss of 42%, 37% and 31% of ascorbic acid content in drumstick (*Moringa oleifera*) was observed after canning at 110°C for 32 min, 115°C for 27 min and 121°C for 20 min respectively (Wijayawardana and Bamunuarachchi, 2002).

Deka *et al.*, (2004) observed a continuous decrease in ascorbic acid content with increase in storage period in lime-aonla spiced beverage during storage at different temperatures and glass containers. Minimum loss was noticed in beverage stored in amber coloured bottles at low temperature as compared to cool chamber and ambient temperature.

The ascorbic content of sweetened 'Nagpur' Mandarin orange juice decreased from 21.84 mg/100g (initial) to 17.68 mg/100g after pasteurization, also,

this decreasing trend continued throughout the storage period up to 180 days, irrespective of storage conditions (Ladaniya *et al.*, 2004).

The ascorbic acid content in RTS drink prepared by blending juices of passion fruit and cashew apple in different ratios such as 25:75, 50:50, 25:75 + ginger drops and 50:50 + ginger drops was 80.26 mg/100 g, 79.73 mg/100 g, 76.39 mg/100 g and 79.29 mg/100 g respectively (Sobhana *et al.*, 2015).

2.5.1.5 *Total carotenoids*

A significant decrease in total carotenoid content was observed in canned mango juice at both initial and after 12 months of storage as compared to fresh mango pulp (Doreyappagowda and Ramanjaneya, 1995).

Majumdar *et al.* (2012) reported that, a significant loss in total carotenoid (β-Carotene) content from 1270 µg/100ml to 520 µg/100ml was observed in sterilized ashgourd-mint leaves juice during 8 months of storage at ambient condition, which accounted a total loss of 59.1% of β-Carotene. But under refrigerated condition the loss of β-carotene was only 20%.

The total carotenoid content remains stable without any significant differences between the homogenized and pasteurized juice of yellow mombin (*Spondias mombin* L.) (deCarvalho, 2013).

The total carotenoid content in orange nectar stored at 4, 25 and 37°C temperature for 28 days decreased significantly from 26.19 mg *β*CE/100 mL to 24.50, 22.05 and 18.73 *β*CE/100 mL respectively with increase in storage period (Touati *et al.*, 2015).

2.5.2 Sensory quality of beverages

A decreasing trend was observed in sensory scores with respect to colour, consistency, flavour and overall acceptability of canned mango juice after 12

months of storage when compared with initial scores (Doreyappagowda and Ramanjaneya, 1995).

Juice was prepared by blending cashew apple and sweet orange juice in different proportions and subjected to organoleptic evaluation, in which the ratio 60:40 was found to be more acceptable in terms of flavour, taste and overall acceptability (Inyang and Abah, 1997).

The pasteurized, chemically preserved and control juice of purple passion fruit stored at -18°C, 4-8°C and 23°C were subjected to sensory evaluation using 7-point hedonic scale at monthly intervals for 3 months. The scores for off-flavour and after taste was recorded highest in pasteurized juice compared to chemical preservation and control indicating that pasteurization has adverse effects on flavour profile (Namutebi, 1998).

The sensory scores of lime-aonla spiced beverage showed decreasing trend gradually right from initial day to the next 6 months during storage, irrespective of storage conditions and storage containers (Deka *et al.*, 2004).

The organoleptic scores for body, taste, colour and aroma of sweetened 'Nagpur' Mandarin orange juice decreased with increase in storage period irrespective of storage conditions, while score for bitterness increased. However, scores for overall acceptability topped in refrigerated juice compared to ambient temperature (Ladaniya *et al.*, 2004).

The aseptically processed ash gourd-mint leaves juice was organoleptically evaluated during 8 months of storage period. The scores for taste, flavour and overall acceptability were not statistically significant compared to initial value except the score for colour. Mean values for colour, taste, aroma and overall acceptability ranged from 6.8 to 7.5, 7.2 to 7.5, 7.1 to 7.4 and 7.2 to 7.5 respectively indicating good acceptability of the product during storage (Majumdar *et al.*, 2012).

Cashew apple juice when blended with equal quantity of passion fruit juice with and without the addition of ginger drops, showed better acceptability in terms of flavour, taste, sweetness, appearance and colour in both samples (Sobhana *et al.*, 2015).

2.5.3 Microbial quality of products

Fang *et al.* (1986) reported that pasteurization of passion fruit juice at 75°C for 40 sec is sufficient to ensure the microbiological quality in both ambient and refrigerated storage conditions.

Acidity in processed passion fruit juice inhibited the growth and multiplication of pathogenic microorganisms hence, the presence of pathogenic *Escherichia coli*, *Streptococcus* or *Staphylococcus* was nil, but might contain non-pathogenic fungi, yeasts or lactic acid bacteria (Tchango-Tchango *et al.*, 1994).

Ladaniya *et al.* (2004) reported that, bacteria and yeast counts were negligible in sweetened 'Nagpur' Mandarin orange juice throughout the storage period irrespective of storage conditions. However, up to 45 days, no fungal population was detected in both refrigerated and ambient storage conditions, but detected after 180 days.

The yellow passion fruit juice after pasteurization at three different levels (85°C/27 sec, 80°C/41 sec, 75°C/60 sec) was initially subjected to microbial analysis before storage. The treatment 75°C/60 sec itself showed complete inhibition of microbial population, also the juice stored under refrigeration remained microbiologically safe throughout the storage period (Sandi *et al.*, 2004).

The aseptically processed ashgourd-mint leaves juice was investigated for microbial quality during 8 months of storage. The presence of coliform, spores, yeast and mould was nil throughout the storage period, also, total plate count (TPC) was nil up to 6 months of storage but TPC was 12 cfu/ml after 8 months of storage (Majumdar *et al.*, 2012).

Materials and methods

3. MATERIALS AND METHODS

The investigation on "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" was carried out with accessions of passion fruit collected from different parts of Kerala. These accessions were compared with Kaveri, the only one variety of passion fruit released in India. The study was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara, Thrissur during 2014-2017.

The study was conducted under following experiments:

1. Selection of passion fruit accessions for postharvest quality attributes
2. Technology for passion fruit juice extraction
3. Product development
4. Storage studies

To support the foregoing aspects of the investigation, physico-chemical attributes of different accessions were analysed and organoleptic evaluation of products were conducted. The results were analysed statistically.

3.1 SELECTION OF ACCESSIONS FOR POSTHARVEST QUALITY ATTRIBUTES

3.1.1 Collection of passion fruits

Passion fruit accessions (yellow and purple) collected from different localities of Kerala and Kaveri, a popular purple fruited type released by the Central Horticultural Experiment Station (CHES), Chettali (substation of the Indian Institute of Horticulture Research (IIHR), Bengaluru) were used for the study (Table 1). Thus 11 accessions were included in the study.

Table 1. Passion fruit accessions included in the study

Passion fruit	Type	Location
Accession 1	Yellow	Orange and vegetable farm, Nelliyampathi
Accession 2	Yellow	Pineapple Research Station (PRS), Vazhakulam
Accession 3	Yellow	Nadathara, Thrissur
Accession 4	Yellow	Athirampuzha, Kottayam
Accession 5	Yellow	Panamaram, Wayanad
Accession 6	Purple	Pineapple Research Station (PRS), Vazhakulam
Accession 7	Purple	Orange and vegetable farm, Nelliyampathi
Accession 8	Purple	Sulthanbatheri, Wayanad
Accession 9	Purple	Nelluvai, Pattambi, Palakkad
Accession 10	Purple	Karunagapally, Kollam
Kaveri	Purple	Central Horticultural Experiment Station (CHES), Chettalli, Karnataka

Physico-chemical and nutritive parameters of these accessions were evaluated and comparisons were made.

Plate 1. Passion fruit yellow accessions

*Nelliyampathi

*Vazhakulam

*Nadathara (Thrissur)

*Athurampuzha (Kottayam)

*Panamaram (Wayanad)

*Place of passion fruit collection

Plate 2. Passion fruit purple accessions

*Vazhakulam

*Nelliyampathi

*Sulthanbatheri

*Pattambi

*Karunagapalli (Kollam)

Kaveri- *Chettalli (Karnataka)

*Place of passion fruit collection

3.1.1.1 *Observations*

Observations on physicochemical and nutritive parameters were taken as detailed below.

3.1.1.1.1 *Physical parameters*

The following physical parameters were taken for twelve fruits separately from each accessions.

3.1.1.1.1.1 *Fruit weight*

The fruit weight was taken using weighing balance, average worked out and expressed in gram.

3.1.1.1.1.2 *Juice recovery percentage*

Juice was extracted from fruits manually, average worked out and expressed in percentage.

3.1.1.1.1.3 *Rind content*

Weight of rind of fruit was taken using an electronic balance, its proportion to the total weight of the fruit was calculated and expressed in percentage.

3.1.1.1.1.4 *Seed content*

Seed weight was taken using an electronic balance, average worked out and expressed in percentage.

3.1.1.1.2 *Nutritive and biochemical parameters*

3.1.1.1.2.1 *Total soluble solids (TSS)*

TSS was measured directly using a digital refractometer and expressed in degree brix (^{0} Brix).

3.1.1.1.2.2 *Titratable acidity*

The titratable acidity was estimated by titrating a known weight/volume of the sample against 0.1N NaOH solution using phenolphthalein as an indicator for all the samples. The acidity was calculated and expressed as per cent citric acid (AOAC, 1998).

3.1.1.1.2.3 *Total sugars*

A known weight of filtered juice sample was first neutralised with 1N NAOH by using phenolphthalein as an indicator and transferred to a 250 ml volumetric flask. About 100ml of distilled water was added followed by 2ml pre standardised 45 per cent neutral lead acetate for clarification. Excess lead acetate was neutralized by addition of 2ml pre standardised 22 per cent potassium oxalate solution. The clarified solution was made up to the mark with distilled water. This was filtered through Whatman's No.1 filter paper. In the clarified filtrate, the reducing sugars were determined by titrating against standard Fehling's solution using methylene blue as an indicator (Ranganna, 1997).

50 ml of the filtrate used in the estimation of reducing sugars was taken into a 100ml volumetric flask and 5 ml of concentrated HCl was added for hydrolyzing the sample. Then the hydrolysed solution was neutralized with 20 per cent NaOH by using one or two drops of phenolphthalein. Diluted HCl was added till it became colourless. Finally, the volume was made upto 100ml and it was titrated against standard Fehlings solution using methylene blue as an indicator (Ranganna, 1997). The total sugars were calculated as given below.

$$\text{Total sugars (\%)} = \frac{\text{Fehling's factor} \times 250 \times \text{dilution}}{\text{Titre value} \times 50 \times \text{weight of sample}} \times 100$$

3.1.1.1.2.4 *Ascorbic acid*

Ascorbic acid was determined by titrating a known weight of sample with 2, 6-dichlorophenol indophenol dye, using metaphosphoric acid as stabilizing agent (AOAC, 1998).

A known weight of juice of each accession was taken in 100ml volumetric flask, followed by adding 3 per cent metaphosphoric acid to make up the volume. From this, 10 ml of aliquot was titrated against 2, 6-dichlorophenol indophenol dye. The dye factor was calculated by titrating standard ascorbic acid solution against dye and ascorbic acid content of sample was expressed as:

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value x dye factor x volume made up x 100}}{\text{Weight of sample x aliquot of sample}}$$

3.1.1.1.2.5 *Total carotenoids*

A known weight of juice sample was taken in a separating funnel. Then 10-15ml of petroleum ether and water containing 5 per cent anhydrous sodium sulphate were added. Extraction of acetone phase was repeated with small volume of petroleum ether until no more colour was extracted. A small amount of anhydrous sodium sulphate was added to absorb the excess water and volume was made up with eluent (3% acetone in petroleum ether). The colour was measured at 452 nm using eluent as blank in spectrophotometer. Results were expressed as µg/100g of material (Ranganna, 1997).

$$\text{Total carotenoids (µg/100g)} = \frac{\text{3.857 x optical density x volume made up}}{\text{Weight of the sample}} \text{ x 100}$$

3.1.2 Selection of accessions

Physico-chemical and nutritive parameters of the eleven accessions were evaluated and comparisons were made. The experiment was conducted in a

Completely Randomized Design (CRD). One best accession each from yellow and purple passion fruit was selected for further studies and compared with the released variety Kaveri. Thus three accessions were selected for further evaluations.

3.2 TECHNOLOGY FOR JUICE EXTRACTION

The three types selected were subjected to following methods of juice extraction.

3.2.1 Addition of enzymes

3.2.1.1 *Standardisation of quantity of enzyme*

Pectinase and cellulase and their mixture at equal quantities were added to the fresh pulp at 1, 3 and 5ml per L and incubated at 50° C for 60 minutes at 200 rpm in a shaker cum incubator. Juice was taken by straining without any addition of pressure. Best treatments were selected based on the percentage recovery of juice. The details of enzymes used for juice extraction is given in Appendix I. Thus under 3.2.1.1 experiment there were 9 treatments replicated thrice for each category (best accessions of yellow, purple passion fruits and also for Kaveri variety).

3.2.1.2 *Standardisation of incubation time and temperature*

The freshly extracted passion fruit pulp was added with selected enzyme at specified concentration (best treatment evolved in experiment 3.2.1.1) and incubated at 45, 60 and 90 minutes at incubation temperature of 40°C and 50° C. Based on the recovery percentage and quality of juice, the best method were selected.

Thus under 3.2.1.2 experiment there were 6 treatments replicated thrice for each category.

Plate 3. Enzymatic method of juice extraction

Before enzyme addition

Pectinase Cellulase

Inside the incubator- cum- shaker

After enzymatic juice extraction

3.2.2 Mechanical extraction

Juice was taken in a juice extractor from 1kg passion fruit pulp. After filtration weight of the juice was recorded. Based on this recovery percentage of juice was calculated.

3.2.3 Conventional method

Juice was taken from 1kg passion fruit pulp by squeezing through a muslin cloth and weight of juice was recorded. Based on this recovery percentage of juice was calculated.

The experiment was conducted in a Completely Randomized Design (CRD) with three replications in each treatment.

3.2.4 Identification of best method of juice extraction

The best enzyme treatment was identified first and the same was compared with mechanical and conventional methods based on the juice recovery and quality.

3.2.5 Observations

The juice recovery, quality of juice and organoleptic characters of the juice was recorded as detailed below.

3.2.5.1 *Percentage recovery of juice*

Juice was extracted from 1 kg of pulp by different methods (enzymatic, mechanical and manual methods). Juice obtained by each method was weighed using an electronic balance. Based on the values, percentage recovery of juice was worked out.

3.2.5.2 *Nutritive and biochemical parameters*

3.2.5.2.1 *Total soluble solids (TSS)*

TSS were estimated as in 3.1.1.1.2.1

3.2.5.2.2 *Titratable acidity*

Titratable acidity was estimated as in 3.1.1.1.2.2

3.2.5.2.3 *Total sugars*

Total sugars were estimated as in 3.1.1.1.2.3

3.2.5.2.4 *Ascorbic acid*

Ascorbic acid was estimated as in 3.1.1.1.2.4

3.2.5.2.5 *Total carotenoids*

Total carotenoids were estimated as in 3.1.1.1.2.5

3.2.5.3 *Organoleptic evaluation*

Quality of passion fruit juice was judged by a semi trained panel for appearance, colour, flavour, texture, odour, taste and after taste based on a 9 point hedonic scale rating (Amerine *et al.*, 1965). A score of 5.5 and above was considered acceptable. The score card for assessing is given in Appendix II.

3.3 PRODUCT DEVELOPMENT

3.3.1 Sweetened juice

The juice was extracted using the best method identified in experiment 3.2.4, from three category of passion fruits and used for the preparation of sweetened juice. The sweetened juice was prepared by blending passion fruit juice with cashew apple juice. The passion fruit sweetened juice and cashew apple sweetened juice alone were also prepared for comparison.

3.3.1.1 *Treatments*

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Sweetened juice was prepared using standard procedures. TSS and percentage of juice was maintained as per FSSAI specifications. The blended sweetened juices were compared with that made from cashew apple and passion fruit juice alone.

3.3.2 RTS beverage

The juice was extracted using the best method identified in experiment 3.2.4, from three category of passion fruits and used for the preparation of RTS beverage. The blended RTS beverage was prepared by blending passion fruit juice with cashew apple juice. The passion fruit RTS beverage and cashew apple RTS beverage alone were also prepared for comparison. Treatments are same as 3.3.1.1.

RTS beverage was prepared using standard procedures. TSS and percentage of juice was maintained as per FSSAI specifications. The blended RTS beverages were compared with that made from cashew apple and passion fruit juice alone.

3.3.3 Carbonated drink

The juice was extracted using the best method identified in experiment 3.2.4, from three category of passion fruits were used for the preparation of carbonated drink. For the preparation of carbonated drink 40 ml of fruit syrup was used in each treatment. The blended syrup was prepared by blending

passion fruit juice with cashew apple juice. The passion fruit syrup and cashew apple syrup alone were also prepared for comparison. Treatments are same as 3.3.1.1.

Carbonated drinks were prepared using standard procedures. TSS and percentage of juice was maintained as per FSSAI specifications. Carbonated drinks were prepared by mixing 40 ml of syrup with 160 ml of carbonated water containing 4.5 volumes of carbon dioxide at 100 psi pressure (pounds per square inch). The blended carbonated drinks were compared with that made from cashew apple and passion fruit juice alone.

3.3.4 Jam

Rind of each category of passion fruit was made into pulp and was used for the preparation of jam. The rind was washed in clean water thoroughly and steam blanched for five minutes. After cooling and removal of soft white portion of the skin, pulp was made in a blender. Jam was prepared by mixing cashew apple pulp with the rind pulp of passion fruit in 3:1, 1:1 and 1:3 ratios and compared with the jam prepared from cashew apple alone. Required quantity of sugar and citric acid were added to the pulp mixture and cooked. Jam was heated till the required consistency was attained. FSSAI specifications for jam were maintained for preparations.

3.3.4.1 *Treatments*

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

T4- Cashew apple pulp alone

The experiment was conducted in a Completely Randomized Design (CRD) with three replications in each treatment.

3.3.5 Observations

3.3.5.1 *Organoleptic evaluation*

Organoleptic evaluation of products were conducted as in 3.2.5.3

3.3.5.2 *Nutritive and biochemical parameters*

3.3.5.2.1 *Total soluble solids (TSS)*

TSS were estimated as in 3.1.1.1.2.1

3.3.5.2.2 *Titratable acidity*

Titratable acidity was estimated as in 3.1.1.1.2.2

3.3.5.2.3 *Ascorbic acid*

Ascorbic acid was estimated as in 3.1.1.1.2.4

3.3.5.2.4 *Total carotenoids*

Total carotenoids were estimated as in 3.1.1.1.2.5

The best treatment in each product was identified based on the above observations.

3.4 STORAGE STUDIES

RTS beverage and jam prepared with best treatment was stored for three months in glass bottles under ambient conditions. The changes in quality of RTS beverages and jam were evaluated based on organoleptic evaluation, biochemical parameters and microbiological analysis during storage at monthly intervals.

3.4.1 Organoleptic evaluation

Organoleptic evaluation of products were conducted as in 3.2.5.3

3.4.2 Nutritive and biochemical parameters

3.4.2.1 *Total Soluble Solids (TSS)*

TSS were estimated as in 3.1.1.1.2.1

3.4.2.2 *Titratable acidity*

Titratable acidity was estimated as in 3.1.1.1.2.2

3.4.2.3 *Ascorbic acid*

Ascorbic acid was estimated as in 3.1.1.1.2.4

3.4.2.4 *Total carotenoids*

Total carotenoids were estimated as in 3.1.1.1.2.5

3.4.3 Microbiological analysis

The estimation of microbial population present in the samples was carried out by serial dilution plate count method as described by Agarwal and Hasija (1986). Ten gram sample was added to 90 ml distilled water and shaken well to form a suspension. From this suspension, 1 ml was transferred to a test tube containing 9 ml distilled water. This gave a dilution of 10^{-2}. Later 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were prepared from these serial dilutions.

The products were subjected to microbiological analysis initially and also at specific intervals during their storage. The samples were analysed for the population of bacteria, fungi and mould in standard plate count Nutrient Agar (NA), Martin Rose Bengal Agar (MRBA) and Sabouraud Dextrose Agar (SDA) media, respectively and the results were expressed in cfu/g of sample.

3.4.3.1 *Estimation of bacterial population*

Bacterial population was estimated using 10^{-5} dilution on nutrient agar medium. One ml of 10^{-5} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of the melted and cooled Nutrient Agar (NA) media

was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petridishes were kept as replicate for each sample. The petriplates were incubated at room temperature for 48 hours. The colonies developed were counted and expressed as cfu/g of sample.

3.4.3.2 *Estimation of fungal population*

Fungal population was estimated using 10^{-3} dilution on Martin Rose Bengal Agar medium. One ml of 10^{-3} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of the melted and cooled Martin Rose Bengal Agar (MRBA) media was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petridishes were kept as replicate for each sample. The petriplates were incubated at room temperature for 4 to 5 days. The colonies developed were counted and expressed as cfu/g of the sample.

3.4.3.3 *Estimation of yeast population*

Yeast population was estimated using 10^{-3} dilution on Sabouraud's Dextrose Agar media. One ml of 10^{-3} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of the melted and cooled Sabouraud's Dextrose Agar (SDA) was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petridishes were kept as replicate for each sample. The petriplates were incubated at room temperature for 4 to 5 days. The colonies developed were counted and expressed as cfu/g of the sample.

3.5 TABULATION AND STATISTICAL ANALYSIS

The data obtained were analysed statistically using analysis of variance (ANOVA) technique. The critical difference value at five per cent level was used for making comparison among different treatments. The scores of sensory evaluation were analysed by Kendall's coefficient of concordance and the mean sensory scores were taken to differentiate the methods.

Results

4. RESULTS

The results obtained in the present study entitled "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" are presented in this chapter under following sections.

1. Selection of passion fruit accessions for postharvest quality attributes
2. Technology for passion fruit juice extraction
3. Product development
4. Storage studies

4.1 SELECTION OF ACCESSIONS FOR POSTHARVEST QUALITY ATTRIBUTES

The passion fruit accessions (yellow and purple) collected from different localities of Kerala and Kaveri were analysed for physical, nutritive and biochemical characters. Wide variation in the characters were observed among the different accessions (Table 1).

4.1.1 Physical parameters

4.1.1.1 *Fruit weight (grams)*

There was significant difference in fruit weight of yellow and purple accessions (Table1). In yellow accessions, Acc.1 had the highest mean fruit weight (98.27 g) and the lowest (60.85 g) was recorded for Acc.3. Among purple accessions Acc.9 (104.50 g) exhibited the maximum fruit weight and minimum was observed for Kaveri (71.90 g).

4.1.1.2 *Juice recovery (per cent)*

Significant difference was observed in percentage juice recovery of yellow and purple accessions (Table 1). Mean percentage juice recovery was highest for Acc.1 (35.38%) followed by Acc.5 (29.09%) and lowest was for Acc.3 (23.70%)

in yellow accessions. In purple accessions juice recovery was highest for Acc.7 (36.79 %) followed by Acc.10 (33.44%). Lowest mean percentage juice recovery was for Kaveri (24.04 %).

4.1.1.3 *Rind content (per cent)*

There was significant difference in rind content among accessions of yellow and purple types (Table 1). The maximum rind content of 59.38% was observed for Acc.4 and a minimum rind content of 46.05% was recorded for Acc.1 in yellow types. In purple types, Kaveri (55.67%) recorded the highest rind content and the least rind content was for Acc.7 (46.55%).

4.1.1.4 *Seed content (per cent)*

Seed content did not differ significantly among the yellow fruited accessions (Table 1). However the maximum seed content of 15.05% was recorded for Acc.3. Significant difference was noticed in seed content of purple accessions. The maximum seed content was observed in Kaveri (16.48%) while the least seed content was in Acc.8 (9.16%) among the purple accessions.

4.1.2 Nutritive and biochemical attributes

The data recorded on nutritive and biochemical attributes of yellow and purple accessions are presented in Table 2.

4.1.2.1 *Total soluble solids (TSS) (^{0} Brix)*

The total soluble solids varied significantly among the different yellow passion fruit accessions (Table 2). The maximum TSS of 19.43^0 Brix was observed for Acc.1 and the minimum of 16.97^0 Brix was recorded for Acc.3. In purple types, Acc.7 (19.20^0 Brix) recorded the maximum TSS and Acc.6 (17.50^0 Brix) recorded the least. The variety Kaveri recorded a TSS of 19^0 Brix which was on par with Acc.7.

Table 1. Physical attributes of passion fruit accessions

Accessions		Fruit weight (g)	Juice recovery (%)	Rind (%)	Seed (%)
Yellow accessions (*Passiflora edulis* Sims f. *flavicarpa*)	**Acc. 1**	98.27(9.91)	35.38(5.95)	46.05(6.79)	12.20 (2.62)
	Acc. 2	67.85(8.24)	26.62(5.16)	56.31(7.50)	14.19 (3.74)
	Acc. 3	60.85(7.79)	23.70(4.87)	57.11(7.56)	15.05 (3.89)
	Acc. 4	62.41(7.89)	27.09(5.21)	59.38 (7.71)	11.49 (3.61)
	Acc. 5	79.26(8.90)	29.09(5.39)	57.97(7.61)	9.32 (3.24)
	CD(0.05)	0.54	0.08	0.17	NS
Purple accessions (*Passiflora edulis* Sims f. *edulis)*	**Acc. 6**	76.93(8.77)	28.90(5.38)	53.32(7.30)	11.53(3.39)
	Acc. 7	92.93(9.64)	36.79(6.07)	46.55(6.82)	12.38(3.52)
	Acc. 8	89.00(9.43)	30.08(5.49)	54.95(7.41)	9.16(3.03)
	Acc. 9	104.50(10.22)	31.34(5.59)	53.64(7.32)	10.81(3.29)
	Acc. 10	100.20(10.01)	33.44(5.78)	52.35(7.23)	9.81(3.13)
	Kaveri	71.90(8.48)	24.04(4.90)	55.67(7.46)	16.48(4.06)
	CD(0.05)	0.03	0.03	0.17	0.06

NS-Non Significant

*Values in brackets are square root transformed values

4.1.2.2 *Titratable acidity (per cent)*

There was significant difference with respect to acidity among yellow accessions (Table 2). The maximum titratable acidity was observed in Acc.3 (3.46%) while titratable acidity did not differ significantly among the other four accessions.

In purple type, titratable acidity did not differ significantly among accessions except in Acc.10 which recorded the lowest acidity of 2.51%.

4.1.2.3 *Total sugars (per cent)*

The total sugars varied significantly among the different yellow and purple passion fruit accessions (Table 2). Total sugar was highest in Acc.2 (10.09%) and the lowest was in Acc.4 (8.65%) in yellow type. In purple accessions, the total sugar content ranged between 5.93 and 11.56 %. Maximum was recorded for Acc.7 (11.56 %) and minimum was for Acc.9 (5.93%).

4.1.2.4 *Ascorbic acid (mg $100g^{-1}$)*

There was significant difference in ascorbic acid content among the yellow fruited accessions (Table 2). The maximum ascorbic acid content was observed in Acc.1 (25.94 mg $100g^{-1}$) of yellow type and the minimum content was observed in Acc.2 (19.20 mg $100g^{-1}$).

The ascorbic acid content ranged between 22.55 to 32.51 mg $100g^{-1}$ in purple accessions. The Acc.7 (32.51 mg $100g^{-1}$) and Kaveri (32.05 mg $100g^{-1}$) recorded the high ascorbic acid content. The Acc.6 (22.55 mg $100g^{-1}$) recorded the minimum ascorbic acid content.

4.1.2.5 *Total carotenoids (mg $100g^{-1}$)*

Both yellow and purple fruited accessions exhibited significant difference with respect to total carotenoid content. In yellow type, Acc.1 (2.81 mg $100g^{-1}$) showed the highest total carotenoid content and lowest (1.27 mg $100g^{-1}$) was in Acc.2. Among the accessions of purple types, maximum total carotenoid content

Table 2. Nutritional and biochemical attributes of passion fruit accessions

Accessions		TSS (°Brix)	Titratable acidity (%)	Total sugar (%)	Ascorbic acid (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)
Yellow accessions (*Passiflora edulis* Sims f. *flavicarpa*)	**Acc. 1**	19.43	3.08	9.42	25.94	2.81
	Acc. 2	17.47	3.07	10.09	19.20	1.27
	Acc. 3	16.97	3.46	9.10	21.25	1.76
	Acc. 4	18.53	3.11	8.65	20.50	2.32
	Acc. 5	18.43	3.09	8.89	22.71	1.40
	CD(0.05)	0.21	0.20	0.11	0.01	0.02
Purple accessions (*Passiflora edulis* Sims f. *edulis*)	**Acc. 6**	17.50	3.08	7.26	22.55	2.41
	Acc. 7	19.20	3.13	11.56	32.51	2.10
	Acc. 8	18.27	2.85	9.23	26.84	1.13
	Acc. 9	18.67	2.93	5.93	30.67	1.79
	Acc. 10	18.50	2.51	8.56	24.12	1.49
	Kaveri	19.00	3.15	10.84	32.05	1.91
	CD(0.05)	0.32	NS	0.08	1.11	0.07

NS- Non Significant

was observed in Acc.6 (2.41 mg $100g^{-1}$) and the minimum in Acc.8 (1.13 mg $100g^{-1}$).

4.1.3 Selection of accessions

Based on the physico-chemical attributes of the different accessions, one best accession each from yellow and purple types was selected for further studies of juice extraction and for preparation of different products. Among yellow fruited type, Accession 1 which recorded highest fruit weight, juice recovery, total soluble solids, ascorbic acid content, total carotenoids and low rind content was selected as best accession. Whereas, accession 7 with highest juice recovery, total soluble solids, ascorbic acid content, total sugar and low rind content was selected as best in purple accessions. The variety Kaveri was also used for further studies.

4.2 TECHNOLOGY FOR JUICE EXTRACTION

The results of the experiment on different methods of juice extraction *viz.*, addition of enzyme, mechanical extraction and conventional method are presented here under.

4.2.1 Addition of enzymes

4.2.1.1 *Standardisation of quantity of enzyme*

The percentage recovery of juice from different accessions of passion fruits (Acc.1, Acc.7 and Kaveri) by the addition of enzymes at different quantities are given in the Table 3. The percentage recovery of juice was significantly influenced by the treatments. The treatment T3 (pectinase 5 ml per litre incubated at 50° C for 60 minutes at 200 rpm), which recorded 73.52% in Acc.1 (yellow type) and 73% juice recovery in Acc.7 (purple type) was selected as the best method for extracting juice by enzymatic method in both the types (plate 3). The lowest juice recovery for T4 (58.31% and 55.95% in Acc.1 and Acc.7 respectively). The superiority of T3 (pectinase 5 ml per litre incubated at 50° C for 60 minutes at 200 rpm) in

Table 3. Juice recovery in response to varying quantity of enzymes

	Treatments	Recovery of juice (%)
Acc.1 (yellow)	T1	63.53^{c} (7.97)
	T2	65.96^{b} (8.12)
	T3	73.52^{a}(8.57)
	T4	58.31^{h} (7.64)
	T5	60.21^{f} (7.76)
	T6	61.55^{e} (7.85)
	T7	59.18^{g} (7.69)
	T8	61.65^{e} (7.85)
	T9	62.48^{d} (7.90)
	CD (0.05)	0.02
Acc.7 (purple)	T1	61.96^{c} (7.87)
	T2	64.64^{b} (8.04)
	T3	73.00^{a} (8.54)
	T4	55.95^{i} (7.48)
	T5	57.22^{g} (7.56)
	T6	58.16^{e} (7.63)
	T7	56.56^{h} (7.52)
	T8	57.44^{f} (7.58)
	T9	60.07^{d} (7.75)
	CD (0.05)	0.01
Kaveri	T1	60.84^{c} (7.80)
	T2	62.61^{b} (7.91)
	T3	71.01^{a} (8.43)
	T4	53.45^{h} (7.31)
	T5	56.53^{f} (7.52)
	T6	57.69^{e} (7.59)
	T7	54.46^{g} (7.38)
	T8	57.51^{e} (7.58)
	T9	59.63^{d} (7.72)
	CD (0.05)	0.03

*Values in brackets are square root transformed values

T1- Pectinase 1ml per L
T2- Pectinase 3ml per L
T3- Pectinase 5ml per L
T4- Cellulase 1ml per L
T5- Cellulase 3ml per L
T6- Cellulase 5ml per L
T7- Pectinase and cellulase mixture at equal quantities (1ml per L)
T8- Pectinase and cellulase mixture at equal quantities (3ml per L)
T9- Pectinase and cellulase mixture at equal quantities (5ml per L)

Incubation condition: 50° C for 60 minutes at 200 rpm

extracting more juice was also evident in Kaveri. An amount of 71.01% juice was obtained when T3 was applied in the pulp of this variety. The least juice recovery was with T4.

4.2.1.2 *Standardisation of incubation time and temperature*

The percentage recovery of juice from three accessions of passion fruits by the addition of pectinase enzyme 5 ml per L at different incubation time (45, 60 and 90 minutes) and temperature (40° C and 50° C) are given in the Table 4. The treatments differed significantly with respect to juice recovery in Acc.1 (yellow) and Acc.7 (purple) as well as in Kaveri. T6 (74.91%, 74.20% and 72.74% in Acc.1 and Acc.7 and variety Kaveri respectively) was found to be the best for getting maximum juice recovery. Hence T6 (pectinase 5 ml per litre incubated at 50° C for 90 minutes at 200 rpm) was selected as the best treatment for enzymatic juice extraction (plate 5).

4.2.2 Identification of best method of juice extraction

The percentage recovery of juice in the best enzyme treatment T6 (pectinase 5 ml per litre incubated at 50° C for 90 minutes at 200 rpm), was compared against the conventional and mechanical juice extraction (Table 5) to select the ideal method. The percentage recovery of juice was significantly different among treatments with respect to all the types studied. T1 was found to be the best for getting more juice in all the cases. The lowest percentage recovery of juice was recorded for T3 (mechanical juice extraction). Hence T1 was selected as the best treatment for extraction of juice. The juice recovery recorded was 74.91% in Acc.1 (yellow type), 74.20% in Acc.7 (purple type) and 72.74% in Kaveri when the best enzyme treatment was applied. This was 27-29% more compared to mechanical extraction.

The biochemical characters of the juice were analysed for the categories of fruits under study (Table 6). The TSS, acidity and total sugars were highest in T1 (19.56^0 Brix, 3.12% and 9.51% respectively) for Acc.1 (yellow type). The other treatments T2 and T3 had comparatively low TSS, acidity and total sugars.

Table 4. Juice recovery in response to pectinase (5 ml per litre) treatment at different incubation time and temperature

	Treatments	Recovery of juice (%)
Acc.1 (yellow)	T1	67.06
	T2	69.84
	T3	71.17
	T4	69.19
	T5	73.52
	T6	74.91
	CD (0.05)	0.77
Acc.7 (purple)	T1	66.88
	T2	69.07
	T3	71.18
	T4	69.21
	T5	73.00
	T6	74.20
	CD (0.05)	0.75
Kaveri	T1	65.26
	T2	67.63
	T3	69.32
	T4	68.01
	T5	71.01
	T6	72.74
	CD (0.05)	0.98

Incubation condition: at 200 rpm

T1- Pectinase 5ml per L incubated at 40° C for 45 minutes

T2- Pectinase 5ml per L incubated at 40° C for 60 minutes

T3- Pectinase 5ml per L incubated at 40° C for 90 minutes

T4- Pectinase 5ml per L incubated at 50° C for 45 minutes

T5- Pectinase 5ml per L incubated at 50° C for 60 minutes

T6- Pectinase 5ml per L incubated at 50° C for 90 minutes

Plate 4. Standardisation of quantity of enzyme

Best treatment:

T3- Pectinase 5ml per L incubated at 50° C for 60 minutes at 200 rpm

(for Acc. 1 (yellow), Acc. 7 (purple) and Kaveri)

T3- Acc. 1 (yellow) T3- Acc. 7 (purple) T3- Kaveri

Plate 5. Standardisation of incubation time and temperature

Best treatment:

T6- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

(for Acc. 1 (yellow), Acc. 7 (purple) and Kaveri)

T6- Acc. 1 (yellow) T6- Acc. 7 (purple) T6- Kaveri

Table 5. Effect of extraction method on recovery of juice

Treatments	Acc.1 (yellow)	Acc.7 (purple)	Kaveri
	Recovery of juice (%)	Recovery of juice (%)	Recovery of juice (%)
T1	74.91(8.66)	74.20(8.61)	72.74(8.53)
T2	71.97(8.48)	69.29(8.32)	68.45(8.27)
T3	46.85(6.84)	44.69(6.69)	45.03(6.71)
CD (0.05)	0.13	0.08	0.15

*Values in brackets are square root transformed values

T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Ascorbic acid content recorded was 25.95 mg $100g^{-1}$ (T2 and T3) which was the highest and T1 (23.13 mg $100g^{-1}$) recorded the lowest. Total carotenoid was also high in T2 and T3 (2.81 and 2.82 mg $100g^{-1}$ respectively). T1 (2.67 mg $100g^{-1}$) recorded the lowest total carotenoid content.

In Acc.7 (purple type), T1 recorded the highest TSS, acidity and total sugars (19.83^0 Brix, 3.24% and 11.61% respectively) (Table 6). Ascorbic acid content was more in T2 (32.54 mg $100g^{-1}$) compared to other treatments (30.04 mg $100g^{-1}$ in T1 and 32.51 mg $100g^{-1}$ in T3). Maximum total carotenoid content was observed in T2 (2.12 mg $100g^{-1}$) and T1 (1.86 mg $100g^{-1}$) recorded the lowest total carotenoid content.

In Kaveri (Table 6), the treatment T1 recorded the highest TSS, acidity and total sugars (19.7^0 Brix, 3.23% and 10.95% respectively). The highest ascorbic acid content recorded was in T3 (32.08 mg $100g^{-1}$). T1 (30.44 mg $100g^{-1}$) recorded the lowest ascorbic acid content. Total carotenoid content was high in T2 (1.94 mg $100g^{-1}$).

The sensory attributes of juice extracted by enzyme treatment, manual and mechanical method was assessed using Kendalls co-efficient of concordance (Table 7). There was no significant difference among treatments with respect to sensory attributes in all the accessions studied.

4.3 PRODUCT DEVELOPMENT

4.3.1 Sweetened juice

The mean sensory score values for sweetened juice prepared through different treatments of three category of passion fruits are given in Table 8. The best treatment was identified using Kendall's co-efficient of concordance. Total mean sensory score was found to be maximum for T1 in three categories. Based on the mean sensory scores, it was judged that T1 (sweetened juice prepared by

Table 6. Effect of method of extraction on quality of juice

	Treatments	TSS (°Brix)	Titratable acidity (%)	Total sugar (%)	Ascorbic acid (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)
Acc.1 (yellow)	T1	19.56	3.12	9.51	23.13	2.67
	T2	19.42	3.08	9.42	25.95	2.81
	T3	19.42	3.08	9.43	25.95	2.82
	CD (0.05)	0.08	0.03	0.05	0.23	0.02
Acc.7 (purple)	T1	19.83	3.24	11.61	30.04	1.86
	T2	19.22	3.15	11.51	32.54	2.12
	T3	19.23	3.16	11.52	32.51	2.08
	CD (0.05)	0.07	0.02	0.02	0.03	0.01
Kaveri	T1	19.70	3.23	10.95	30.44	1.76
	T2	19.04	3.15	10.83	32.03	1.94
	T3	19.01	3.16	10.86	32.08	1.91
	CD (0.05)	0.34	0.05	0.07	0.88	0.12

T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Table 7a. Effect of method of extraction on sensory attributes of juice (Acc.1- yellow)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8.4	8.1	7.5	7.1	8.1	8.1	7.6	54.9
T2	8.0	8.2	7.5	7.2	8.1	8.1	7.8	54.9
T3	8.0	8.1	7.5	7.1	8.1	8.1	7.5	54.4
Kendall's W (a)	0.26	0.03	0.00	0.04	0.00	0.00	0.08	

a- Kendall's coefficient of concordance

T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Table 7b. Effect of method of extraction on sensory attributes of juice (Acc.7- purple)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.9	7.9	7.7	7.6	8.1	7.8	7.4	54.4
T2	7.6	8.0	7.7	7.6	8.2	7.8	7.4	54.3
T3	7.5	7.7	7.5	7.5	8.1	7.5	6.9	52.7
Kendall's W (a)	0.18	0.08	0.10	0.01	0.03	0.05	0.08	

a- Kendall's coefficient of concordance

T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm
T2- Conventional method (manual juice extraction)
T3- Mechanical juice extraction

Table 7c. Effect of method of extraction on sensory attributes of juice (Kaveri)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8	7.9	7.6	7.6	8.1	7.8	7.7	54.7
T2	7.6	8.0	7.6	7.6	8.1	7.8	7.7	54.4
T3	7.4	7.6	7.3	7.4	8.1	7.1	7.5	52.4
Kendall's W (a)	0.20	0.17	0.08	0.01	0.00	0.16	0.16	

a- Kendall's coefficient of concordance

T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm
T2- Conventional method (manual juice extraction)
T3- Mechanical juice extraction

blending of passion fruit juice and cashew apple juice in 3:1 ratio) was the best treatment for Acc.1 (yellow type), Acc.7 (purple type) and Kaveri for the preparation of sweetened juice.

The product from treatments were also subjected to quality analysis for TSS, titratable acidity, ascorbic acid and total carotenoid content (Table 9). The quality attributes of sweetened juice differed significantly with respect to treatments. The quality attributes *viz*. TSS and titratable acidity showed no specific difference in response to blending done for preparations of sweetened juice. Sweetened juice from different treatments ranged between 10 and 10.1^0 Brix. The titratable acidity ranged from 0.97 to 1.03%. The ascorbic acid recorded variation among the treatments and sweetened juice prepared with cashew apple juice alone (T4) was found to contain 86.09 mg $100g^{-1}$ ascorbic acid content. The total carotenoid content varied between 0.37 and 0.84 mg $100g^{-1}$.

4.3.2 RTS beverage

The effect of different treatments on quality of RTS beverage was analysed based on the sensory score values for appearance, colour, flavour, consistency, taste, odour, after taste and overall acceptability. The values are presented in the table 10.

In the case of RTS beverages from Acc.1 (yellow), Acc.7 (purple) and Kaveri passion fruit, the maximum mean sensory score for appearance, flavour, consistency, taste, odour, after taste and overall acceptability were recorded for T1 except for the colour, for which T5 got the maximum mean sensory score. Thus T1 (RTS beverage prepared by blending of passion fruit juice and cashew apple juice in 3:1 ratio) was selected as the best treatment for preparation of RTS beverage from the passion fruit and subjected to storage studies.

The RTS beverage prepared with treatments were also subjected to quality analysis for TSS, titratable acidity, ascorbic acid and total carotenoid content (Table

Table 8a. Sensory attributes of sweetened juice (Acc.1 - yellow)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.7	8.4	6.2	7.2	8.1	6.5	6.5	50.6
T2	7.6	6.8	7.2	6.5	7.9	7.5	6.5	50
T3	7.0	6.5	6.6	6.5	8.0	7.5	6.5	48.6
T4	6.0	6.6	6.6	6.0	6.5	6.5	6.0	44.2
T5	8.0	8.4	5.6	7.1	8.0	6.0	5.5	48.6
Kendall's W (a)	0.70	0.83	0.83	0.59	0.47	0.72	0.55	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 8b. Sensory attributes of sweetened juice (Acc.7 - purple)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.5	7.4	7.7	7.3	7.2	7.8	7.7	52.6
T2	6.8	6.0	6.1	5.4	6.7	7.3	5.6	43.9
T3	6.1	6.2	6.0	6.1	6.6	6.7	6.5	44.2
T4	6.3	7.1	6.0	6.2	6.3	6.1	6.1	44.1
T5	7.1	7.5	6.8	7.1	6.9	7.0	6.8	49.2
Kendall's W (a)	0.42	0.52	0.46	0.50	0.15	0.21	0.44	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 8c. Sensory attributes of sweetened juice (Kaveri)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.5	7.5	7.7	7.4	7.3	7.9	7.8	53.1
T2	6.8	6.2	6.2	5.5	6.8	7.3	5.8	44.6
T3	6.2	6.1	6.1	6.2	6.8	6.6	6.7	44.7
T4	6.2	7.1	6.0	6.2	6.5	6.1	6.1	44.2
T5	7.1	7.5	7.0	7.2	7.0	7.2	6.9	49.9
Kendall's W (a)	0.36	0.53	0.40	0.49	0.18	0.24	0.46	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Plate 6. Sweetened juice

Acc. 1 (yellow)

Acc. 7 (purple)

Kaveri

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Table 9. Quality attributes of sweetened juice preparations

Treatments		TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)
Acc.1 (yellow)	**T1**	10.0	1.03	15.62	0.84
	T2	10.0	1.01	16.44	0.82
	T3	10.1	1.01	20.88	0.80
	T4	10.1	0.97	86.09	0.37
	T5	10.0	1.03	15.91	0.80
	CD (0.05)	0.08	0.03	4.0	0.05
Acc.7 (purple)	**T1**	10.0	1.00	17.93	0.74
	T2	10.1	1.00	19.01	0.72
	T3	10.0	0.98	23.00	0.70
	T4	10.1	0.97	86.09	0.37
	T5	10.0	1.01	19.47	0.44
	CD (0.05)	0.02	0.03	5.09	0.02
Kaveri	**T1**	10.0	1.01	17.82	0.73
	T2	10.0	0.99	19.99	0.73
	T3	10.0	0.98	22.16	0.71
	T4	10.1	0.97	86.09	0.37
	T5	10.0	1.02	19.05	0.70
	CD (0.05)	0.02	0.03	4.39	0. 12

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Table 10a. Sensory attributes of RTS beverage (Acc.1 - yellow)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.4	7.2	7.7	7.2	7.2	7.6	7.5	51.8
T2	6.4	5.5	5.1	4.0	5.0	5.5	4.7	36.2
T3	5.7	5.6	5.7	5.6	5.3	5.5	5.4	38.8
T4	6.3	7.1	6.0	6.0	6.1	5.7	5.9	43.1
T5	7.1	7.5	6.7	7.1	6.4	6.6	6.7	48.1
Kendall's W (a)	0.71	0.85	0.88	0.91	0.83	0.69	0.84	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 10b. Sensory attributes of RTS beverage (Acc.7 - purple)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8.0	7.2	7.5	7.4	7.3	7.7	7.4	52.5
T2	6.8	6.2	5.6	5.5	6.0	6.5	5.8	42.4
T3	5.9	5.3	5.0	4.0	4.4	4.8	4.8	34.2
T4	6.7	7.2	6.3	6.2	6.5	6.2	5.7	44.8
T5	7.5	7.3	7.0	7.0	6.6	6.8	6.3	48.5
Kendall's W (a)	0.68	0.68	0.78	0.87	0.70	0.67	0.75	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 10c. Sensory attributes of RTS beverage (Kaveri)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	7.9	7.3	7.6	7.3	7.2	7.6	7.1	52
T2	6.7	6.3	5.7	5.5	6.1	6.5	5.5	42.3
T3	6.0	4.9	4.8	4.2	4.6	4.7	4.8	34
T4	7.0	7.3	6.3	6.4	6.5	6.6	5.7	45.8
T5	7.6	7.3	6.9	6.9	6.6	7.0	6.3	48.6
Kendall's W (a)	0.66	0.66	0.76	0.82	0.67	0.65	0.52	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Plate 7. RTS beverage

Acc. 1 (yellow)

Acc. 7 (purple)

Kaveri

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

11). The quality attributes of RTS beverage differed significantly with respect to treatments. The quality attributes *viz.* TSS and titratable acidity showed no specific difference in response to blending done for preparations of RTS beverage. The total soluble solids of different RTS beverage treatments ranged from 10 to 10.4^0 Brix, whereas the titratable acidity varied between 0.31 and 0.36%. The total carotenoid content of RTS beverage ranged from 0.21 to 0.53 mg $100g^{-1}$. The ascorbic acid recorded variation among the treatments and RTS beverage prepared with cashew apple juice alone (T4) was found to contain 80.04 mg $100g^{-1}$ ascorbic acid content.

4.3.3 Carbonated drink

The mean sensory score values for carbonated drink prepared through different treatments in the three category of passion fruits are given in Table 12. The best treatment was identified using Kendall's co-efficient of concordance.

In Acc.1 (yellow passion fruit), carbonated drink prepared using T1 obtained the highest mean sensory score for appearance and colour. Considering flavour, consistency, taste, odour and after taste the highest score was for carbonated drink in T2. The maximum mean sensory score for overall acceptability was recorded for carbonated drink under T2. The score was least for carbonated drink in T4. Thus T2 (carbonated drink prepared by blending of passion fruit juice and cashew apple juice in 1:1 ratio) was selected as the best treatment for preparation of carbonated drink in Acc.1 (yellow passion fruit).

In the case of carbonated drink from Acc.7 (purple) and Kaveri passion fruit, the mean score values for all the attributes was high for T1. Hence T1 (carbonated drink prepared by blending of passion fruit juice and cashew apple juice in 3:1 ratio) was selected as the best treatment for preparation of carbonated drink in Acc.7 (purple type) and Kaveri.

The carbonated drink from different treatments were also subjected to quality analysis (Table 13). The quality attributes of carbonated drink differed

Table 11. Quality attributes of RTS beverages

Treatments		TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)
Acc.1 (yellow)	T1	10.2	0.33	12.51	0.53
	T2	10.0	0.36	14.61	0.52
	T3	10.2	0.35	19.50	0.51
	T4	10.3	0.31	80.04	0.21
	T5	10.4	0.36	10.34	0.51
	CD (0.05)	0.03	0.02	0.61	0.05
Acc.7 (purple)	T1	10.1	0.32	13.70	0.48
	T2	10.3	0.33	14.99	0.48
	T3	10.2	0.34	20.56	0.47
	T4	10.3	0.31	80.04	0.21
	T5	10.1	0.35	11.58	0.44
	CD (0.05)	0.05	0.02	0.36	0.02
Kaveri	T1	10.1	0.31	13.22	0.45
	T2	10.3	0.33	13.99	0.47
	T3	10.2	0.34	20.02	0.47
	T4	10.3	0.31	80.04	0.21
	T5	10.1`	0.35	11.62	0.43
	CD (0.05)	0.04	0.04	0.61	0.01

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Table 12a. Sensory attributes of carbonated drink (Acc.1 - yellow)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8.3	8.5	6.6	7.6	6.9	7.2	6.6	51.7
T2	7.7	7.2	7.4	7.7	7.3	8.0	7.7	53.0
T3	7.4	6.8	6.9	7.3	6.6	7.0	7.0	49
T4	6.7	6.2	7.0	6.7	5.9	6.7	6.3	45.5
T5	8.0	8.0	7.1	7.3	6.6	7.1	6.8	50.9
Kendall's W (a)	0.74	0.89	0.15	0.53	0.47	0.27	0.24	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 12b. Sensory attributes of carbonated drink (Acc.7 - purple)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8.0	8.0	7.6	7.7	7.3	7.6	7.0	53.2
T2	7.3	7.0	7.2	6.8	7.0	6.9	6.6	49.8
T3	6.6	6.1	6.6	6.7	6.3	6.3	6.0	44.6
T4	6.2	5.8	5.2	6.7	5.0	5.0	4.6	38.5
T5	7.6	7.7	5.4	6.4	5.2	5.2	4.6	42.1
Kendall's W (a)	0.85	0.89	0.54	0.48	0.84	0.83	0.87	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Table 12c. Sensory attributes of carbonated drink (Kaveri)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	8.0	7.9	7.4	7.7	7.2	7.6	7.0	52.8
T2	7.1	7.2	7.2	6.5	7.1	6.8	6.6	48.5
T3	6.6	5.8	6.5	6.5	6.1	6.5	5.9	43.9
T4	6.2	5.8	5.3	6.7	5.0	4.7	4.9	38.6
T5	7.6	7.7	5.3	6.5	5.2	5.2	4.6	42.1
Kendall's W (a)	0.84	0.80	0.49	0.41	0.73	0.75	0.70	

a- Kendall's coefficient of concordance

T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Plate 8. Carbonated drink

Acc. 1 (yellow)

Acc. 7 (purple)

Kaveri

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

significantly with respect to treatments. The quality attributes *viz.* TSS and titratable acidity showed no specific difference in response to blending done for preparations of carbonated drink. The total soluble solids of carbonated drink ranged from 11.2 to 11.6^0 Brix. The titratable acidity varied from 0.95 to 1.2%. The total carotenoid and ascorbic acid content were not present at detected level.

4.3.4 Jam

The mean sensory scores for sensory attributes of jam are given in Table 14. In yellow passion fruit (Acc.1) rind jam, the mean sensory scores for quality parameters were highest for T3. The overall acceptability was also found to be high for the jam in T3 (50.0) followed by that with T4 (44.1). Thus T3 (jam prepared by mixing rind pulp of passion fruit (Acc.1) and cashew apple pulp in 1:3 ratio) was selected as the best treatment for preparation of jam in yellow passion fruit and subjected to storage studies.

In Acc.7 (purple passion fruit) rind jam, the mean sensory scores for quality parameters except for appearance and colour was highest for T1. Considering appearance and colour the highest score was for T4. The overall acceptability of jam was highest with the T1 (47.7) and the least for T3 (42.6). Hence T1 (jam prepared by mixing rind pulp of passion fruit and cashew apple pulp in 3:1 ratio) was selected as the best treatment for preparation of jam in Acc.7 (purple type). The jam prepared with T1 was subjected to storage studies.

In Kaveri, the mean sensory scores for quality parameters were high for jam under T2. Thus the overall acceptability was also highest for T2 (47.4) followed by T4 (42.3) and the least score for overall acceptability was for T3 (32.5). Based on the mean sensory scores, T2 was adjudged the best treatment for preparation of jam in Kaveri and this used for storage studies.

The treatments were also subjected to quality analysis for TSS, titratable acidity, ascorbic acid and total carotenoid content (Table 15). The total soluble

Table 13. Quality attributes of carbonated drinks

Treatments		TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)
Acc.1 (yellow)	**T1**	11.2	0.98	ND	ND
	T2	11.2	0.96		
	T3	11.3	0.95		
	T4	11.3	1.2		
	T5	11.2	0.96		
	CD (0.05)	0.04	0.05		
Acc.7 (purple)	**T1**	11.2	0.96		
	T2	11.2	0.97		
	T3	11.4	0.95		
	T4	11.3	1.2		
	T5	11.2	0.96		
	CD (0.05)	0.05	0.04		
Kaveri	**T1**	11.2	0.94		
	T2	11.4	0.96		
	T3	11.2	0.95		
	T4	11.3	1.2		
	T5	11.6	0.96		
	CD (0.05)	0.05	0.02		

ND- Not Detected

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Table 14a. Sensory attributes of jam (Acc.1 - yellow)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	6.3	5.8	5.8	5.4	4.5	5.3	4.4	37.5
T2	6.2	7.0	5.4	5.4	5.2	5.5	5.0	39.7
T3	7.6	7.0	7.3	7.0	7.2	7.1	6.8	50.0
T4	5.9	6.2	6.4	5.6	7.0	6.5	6.5	44.1
Kendall's W (a)	0.21	0.21	0.41	0.40	0.51	0.37	0.53	

a- Kendall's coefficient of concordance

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio
T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio
T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio
T4- Cashew apple pulp alone

Table 14b. Sensory attributes of jam (Acc. 7- purple)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	6.7	6.6	6.2	7.2	6.8	7.0	7.2	47.7
T2	6.4	6.0	5.6	6.9	5.9	6.1	6.0	42.9
T3	6.8	6.5	5.5	6.5	5.6	5.8	5.9	42.6
T4	7.0	7.3	6.0	6.0	5.6	5.4	5.8	43.1
Kendall's W (a)	0.03	0.28	0.03	0.25	0.12	0.12	0.16	

a- Kendall's coefficient of concordance

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

T4- Cashew apple pulp alone

Table 14c. Sensory attributes of jam (Kaveri)

Treatments	Mean sensory scores							Overall acceptability (Total score)
	Appearance	Colour	Flavour	Consistency	Odour	Taste	After taste	
T1	6.5	6.1	5.2	5.0	5.1	5.1	4.7	37.7
T2	7.4	7.1	6.9	6.9	6.2	6.6	6.3	47.4
T3	5.8	5.1	4.1	4.1	4.3	4.7	4.4	32.5
T4	6.7	6.9	5.8	5.9	5.7	5.6	5.7	42.3
Kendall's W (a)	0.37	0.55	0.65	0.68	0.31	0.25	0.50	

a- Kendall's coefficient of concordance

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

T4- Cashew apple pulp alone

Plate 9. Jam

Acc. 1 (yellow)

Acc. 7 (purple)

Kaveri

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

T4- Cashew apple pulp alone

solids of jam ranged from 68.5 to 69^0 Brix. The titratable acidity of jam varied from 0.55 to 0.62%. Jam prepared of cashew apple pulp alone (T4) recorded the maximum (5.62 mg $100g^{-1}$) ascorbic acid content. The total carotenoid content was not present at detectable levels in jam.

4.4 STORAGE STUDIES

4.4.1 RTS beverage

Data on mean sensory scores of RTS beverage stored in glass bottle for different durations of storage are given in Table 16. Sensory quality of RTS beverage decreased during storage in all the treatments. After three months of storage, overall acceptability scores of T1, T2 and T3 were 42.2, 42.3 and 42.3 respectively which were on par. The maximum mean sensory score for colour and appearance were recorded for T2 (6.3) followed by T1 (6.2). Flavour for the RTS beverage was maximum for T3 (6.3). Considering taste and after taste the highest score was for T3 (6.1).

The quality analysis of RTS beverages stored for different durations of storage are given in Table 17. The total soluble solids in all treatments of RTS beverage increased throughout the storage period. After three months of storage, T1 and T3 (11^0 Brix) showed highest TSS. Titratable acidity of RTS beverage showed decreasing trend throughout the storage period in all the treatments. After three months of storage, 0.33% (T3) of titratable acidity was reduced to 0.22% (T3). Ascorbic acid and total carotenoid content in all treatments of RTS beverage decreased throughout the storage period. After three months of storage, T2 (9.82 mg $100g^{-1}$) retained highest amount of ascorbic acid content. Total carotenoid content of 0.17 mg $100g^{-1}$, 0.16 mg $100g^{-1}$ and 0.20 mg $100g^{-1}$ was recorded for T1, T2 and T3 respectively after three months of storage.

The microbial load in the samples stored in glass bottle for different durations of storage are given in Table 18. Up to one month, no microbial load was

Table 15. Quality attributes of jam

Treatments		TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg 100g^{-1})	Total carotenoids (mg 100g^{-1})
Acc.1 (yellow)	T1	69.0	0.58	4.20	ND
	T2	68.7	0.56	4.59	
	T3	68.7	0.60	4.19	
	T4	68.5	0.59	5.62	
	CD (0.05)	0.03	0.01	0.02	
Acc.7 (purple)	T1	68.9	0.62	4.78	
	T2	68.6	0.58	4.67	
	T3	68.6	0.59	4.52	
	T4	68.5	0.59	5.62	
	CD (0.05)	0.03	0.02	0.02	
Kaveri	T1	68.8	0.59	4.93	
	T2	68.6	0.53	4.89	
	T3	68.6	0.55	4.67	
	T4	68.5	0.59	5.62	
	CD (0.05)	0.02	0.03	0.01	

ND- Not Detected

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

T4- Cashew apple pulp alone

Table 16. Effect of storage on sensory attributes of RTS beverage

Treatments	Appearance (mean sensory scores)				Colour (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	8.0	7.8	7.2	6.2	7.2	7.0	6.6	6.2
T2	7.9	7.8	7.4	6.3	7.3	7.2	7.0	6.3
T3	7.4	7.4	7.2	5.7	7.2	7.1	6.9	5.8
Kendall's W (a)	0.51	0.40	0.01	0.06	0.10	0.14	0.10	0.14

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 16 continued...

Effect of storage on sensory attributes of RTS beverage

Treatments	Flavour (mean sensory scores)				Consistency (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.5	7.3	7.1	5.6	7.4	7.1	7.1	6.6
T2	7.6	7.4	7.2	5.5	7.3	7.1	7.1	6.6
T3	7.7	7.6	7.6	6.3	7.2	7.0	7.0	6.4
Kendall's W (a)	0.10	0.08	0.17	0.04	0.10	0.04	0.04	0.12

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 16 continued...

Effect of storage on sensory attributes of RTS beverage

Treatments	Odour (mean sensory scores)				Taste (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.3	7.2	6.9	6.1	7.7	7.6	7.2	5.6
T2	7.2	7.2	7.1	6.1	7.6	7.5	7.0	5.5
T3	7.2	7.2	6.9	5.9	7.6	7.6	7.1	6.1
Kendall's W (a)	0.05	0.00	0.03	0.04	0.05	0.03	0.02	0.04

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 16 continued...

Effect of storage on sensory attributes of RTS beverage

Treatments	After taste (mean sensory scores)				Overall acceptability (Total score)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.4	7.2	6.8	5.9	52.5	51.2	48.9	42.2
T2	7.1	6.8	6.4	6.0	52	51.0	49.2	42.3
T3	7.5	7.2	6.7	6.1	51.8	51.1	49.4	42.3
Kendall's W (a)	0.150	0.140	0.079	0.022	-	-	-	-

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 17 a. Total Soluble Solids (TSS) and acidity of RTS beverage during storage

Treatments	Total soluble solids (°Brix)				Titratable acidity (%)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	10.1	10.5	10.9	11	0.32	0.31	0.29	0.25
T2	10.1	10.4	10.7	10.9	0.31	0.30	0.29	0.24
T3	10.2	10.4	10.9	11	0.33	0.30	0.28	0.22
CD (0.05)	0.01	0.03	0.05	0.08	0.02	0.01	0.01	0.01

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 17b. Ascorbic acid and total carotenoid content of RTS beverage during storage

Treatments	Ascorbic acid (mg $100g^{-1}$)				Total carotenoids (mg $100g^{-1}$)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	13.70	11.89	11.04	9.73	0.48	0.36	0.28	0.17
T2	13.22	11.05	10.95	9.82	0.45	0.31	0.26	0.16
T3	12.51	10.71	8.38	6.93	0.53	0.44	0.29	0.20
CD (0.05)	0.04	0.02	0.01	0.04	0.03	0.05	0.03	0.06

MAS: Months after storage

NS - Non Significant

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

observed in any of the samples. After two months of storage, fungi and yeast were detected. Bacteria did not survive up to two months after storage, in any of the treatments. However, the microbial load in all the samples was within the acceptable limits up to three months after storage. Bacteria, fungi and yeast showed an increasing trend throughout the storage period. After four months of storage, fungi population in all the samples recoded more than the acceptable limits (10 x 10^3 cfu g^{-1}).

After two months of storage, the average number of colony forming units (CFU) of the fungus per gram of the T1 was recorded as 0.30 x10^3. It increased up to 12 x 10^3 cfu g^{-1} by four months of storage. For T2, 0.25 x 10^3 cfu g^{-1} fungi was recorded after two months of storage. It increased up to 11 x 10^3 cfu g^{-1} by four months of storage. After two months of storage, 0.10 x 10^3 cfu g^{-1} fungi was observed in T3 and it increased up to 10 x 10^3 cfu g^{-1} by four months of storage. Yeast load was maximum in T3 (3.5 x 10^3 cfu g^{-1}) after four months of storage whereas, the minimum load was observed in T1 (0.20 x 10^3 cfu g^{-1}) after two months of storage. After four months of storage, T3 (0.90 x 10^5 cfu g^{-1}) showed the highest bacterial load while the lowest was seen in T1 (0.20 x 10^5 cfu g^{-1}) after three months of storage.

4.4.2 Jam

Data on mean sensory scores of jam stored in glass bottle for different durations of storage are given in Table 19. Sensory quality of jam decreased during storage in all the treatments. Drastic reduction in sensory attributes was recorded one month after storage of jam.

Enumeration of microbial population (bacteria, fungi and yeast) in the jam samples stored in glass bottle for different durations of storage are given in Table 20. Yeast were not detected up to three months of storage and bacteria did not survive up to two months of storage, in any of the treatments. Even though, fungi

Table 18. Microbial population in RTS beverage during storage

Treatments	Bacterial load (10^5 cfu g^{-1})					Fungal load (10^3 cfu g^{-1})					Yeast load (10^3 cfu g^{-1})				
	Initial	1 MAS	2 MAS	3 MAS	4 MAS	Initial	1 MAS	2 MAS	3 MAS	4 MAS	Initial	1 MAS	2 MAS	3 MAS	4 MAS
T1	ND	ND	ND	0.20	0.50	ND	ND	0.30	0.50	12	ND	ND	0.20	1.5	3.2
T2	ND	ND	ND	0.25	0.40	ND	ND	0.25	0.40	11	ND	ND	ND	0.75	3.0
T3	ND	ND	ND	0.40	0.90	ND	ND	0.10	0.30	10	ND	ND	ND	0.90	3.5
CD (0.05)	-	-	-	NS	NS	-	-	NS	NS	NS	-	-	NS	NS	NS

MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Table 19. Effect of storage on sensory attributes of jam

Treatments	Appearance (mean sensory scores)				Colour (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.6	6.8	6.3	5.8	7.0	6.6	6.4	6.2
T2	6.7	6.2	5.8	4.6	6.6	5.8	5.6	5.2
T3	7.4	6.3	6.0	4.7	7.1	5.8	5.6	4.8
Kendall's W (a)	0.25	0.06	0.06	0.29	0.11	0.09	0.14	0.25

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Table 19 continued...

Effect of storage on sensory attributes of jam

Treatments	Flavour (mean sensory scores)				Consistency (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.3	6.7	6.4	6.1	7.0	6.7	6.6	6.4
T2	6.2	5.9	5.6	5.1	7.2	6.9	6.0	5.1
T3	6.9	5.9	5.7	5.0	6.9	6.8	6.0	5.2
Kendall's W (a)	0.15	0.26	0.18	0.10	0.07	0.04	0.19	0.36

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Table 19 continued...

Effect of storage on sensory attributes of jam

Treatments	Odour (mean sensory scores)				Taste (mean sensory scores)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	7.2	6.6	6.4	6.2	7.1	6.7	6.5	6.2
T2	6.8	6.2	6.0	5.1	7.0	6.2	6.2	5.5
T3	6.2	6.1	5.8	4.5	6.6	6.4	6.3	5.2
Kendall's W (a)	0.18	0.02	0.03	0.32	0.02	0.07	0.01	0.24

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Table 19 continued...

Effect of storage on sensory attributes of jam

Treatments	After taste (mean sensory scores)				Overall acceptability (Total score)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	6.8	6.4	6.3	6.3	50.0	46.5	44.9	43.2
T2	7.2	6.6	6.0	5.7	47.7	43.8	41.2	36.3
T3	6.3	6.1	5.9	5.7	47.4	43.4	41.3	35.1
Kendall's W (a)	0.21	0.07	0.04	0.11	-	-	-	-

a- Kendall's coefficient of concordance

MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Table 20. Microbial population in jam during storage

Treatments	Bacterial load (10^5 cfu g^{-1})				Fungal load (10^3 cfu g^{-1})				Yeast load (10^3 cfu g^{-1})			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	ND	ND	ND	0.30	ND	ND	0.20	1.0	ND	ND	ND	ND
T2	ND	ND	ND	0.35	ND	ND	0.55	0.90	ND	ND	ND	ND
T3	ND	ND	ND	0.50	ND	ND	0.40	1.0	ND	ND	ND	ND
CD (0.05)	-	-	-	NS	-	-	NS	NS	-	-	NS	NS

MAS: Months after storage

NS – Non significant

ND – Not detected

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

were not detected one month after storage, it was found two months after storage. The microbial load in all the treatments were within the acceptable limits up to three months of storage. After three months of storage, T3 (0.50×10^5 cfu g^{-1}) showed the highest bacterial load. The lowest bacterial load was observed in T1 (0.30×10^5 cfu g^{-1}) after three months of storage.

The quality analysis of jam stored for different durations of storage are given in Table 21. The total soluble solids in all treatments of jam decreased throughout the storage period. After three months of storage, T2 (68.6^0 Brix) showed highest TSS. Titratable acidity of jam showed decreasing trend throughout the storage period in all the treatments. After three months of storage, T2 recorded the maximum titratable acidity of 0.55%. The ascorbic acid content in all treatments of jam decreased throughout the storage period. After three months of storage, T3 (1.99 mg $100g^{-1}$) showed maximum retention of ascorbic acid content followed by T2 (1.84 mg $100g^{-1}$). Total carotenoids could not be detected in the treatments of the different passion fruit rind jam.

Table 21. TSS, acidity and ascorbic acid content of jam during storage

Treatments	Total soluble solids (°Brix)				Titratable acidity (%)				Ascorbic acid (mg $100g^{-1}$)			
	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS	Initial	1 MAS	2 MAS	3 MAS
T1	68.7	68.6	68.5	68.4	0.60	0.59	0.52	0.51	4.19	3.01	2.86	1.05
T2	68.9	68.7	68.7	68.6	0.62	0.60	0.59	0.55	4.78	3.21	2.77	1.84
T3	68.6	68.4	68.3	68.2	0.59	0.58	0.55	0.54	4.67	3.52	2.80	1.99
CD (0.05)	0.01	0.04	0.02	0.06	0.01	0.01	0.03	0.02	0.02	0.02	0.01	0.03

Total carotenoids (mg 100g¯1) – Not detected

MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Discussion

5. DISCUSSION

Passion fruit (*Passiflora edulis* Sims) belongs to the family Passifloraceae, which although native to Brazil, is now cultivated in many tropical and subtropical regions of the world. It was first introduced to India near Western Ghats, Nilgiris and Wayanad (Kerala) regions of south India during twentieth century. Purple and yellow are the two main types of passion fruit grown commercially all around the world. The fruits are valued for its captivating flavour, nutritional benefits and medicinal properties. In the recent past cultivation and consumption of passion fruit have increased and in this context, the present investigation "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" was taken up with accessions of passion fruit collected from different parts of Kerala. These accessions were compared with Kaveri, the only one variety of passion fruit released in India. For the study of physico-chemical attributes of different accessions were analysed and organoleptic evaluation of products were conducted.

5.1 SELECTION OF ACCESSIONS FOR POSTHARVEST QUALITY ATTRIBUTES

Passion fruit has about 400 species out of which few are of economic importance. Within these species there are two distinct forms, the standard purple (*Passiflora edulis* Sims f. *edulis*) and the yellow (*Passiflora edulis* f. *flavicarpa*) (Nath *et al.,* 2009). Yellow passion fruit is reported to be more popular (Sandi *et al.,* 2004) as it possess larger fruit size, greater yield, attractive fruit and juice colour and high acidity. At the same time the purple types are reported to possess excellent medicinal properties and is used for the treatment of hypertension, menopausal symptoms, colic of infants *etc.* (Dhawan *et al.,* 2004). As these two distinct types are cultivated and used widely for direct consumption and product preparation screening of ideal types possessing favourable postharvest quality attributes has become necessary.

As the cultivation and consumption of passion fruit is gaining momentum in the recent past, identifying types with favourable quality attributes will be of immense help both to the cultivators and processors. Hence an attempt was made in the present study to identify desirable type from yellow and purple fruited passion fruit with ideal postharvest quality attributes.

5.1.1 Collection and evaluation of passion fruits

5.1.1.1 *Physical characters*

In the present study five yellow and five purple accessions were collected from different localities were evaluated for their physico-chemical attributes. The only one variety, Kaveri (purple type) released by the Central Horticultural Experiment Station (CHES), Chettali (substation of the Indian Institute of Horticulture Research (IIHR), Bengaluru) was also included in the study for comparison. The study revealed that, the accessions differed significantly for different physical and biochemical traits studied. Among five different yellow accessions, Acc.1 collected from orange and vegetable farm, Nelliyampathi recorded the most favourable physical quality attributes. This particular accession possessed the highest mean fruit weight (98.27 g) and percentage juice recovery (35.38%), whereas the rind content was low (46.05%). Among the purple accessions, Acc.9 recorded highest fruit weight (104.50 g), whereas percentage juice recovery was highest for Acc.7 (36.79 %). Rind content was also low for Acc.7 (46.55%). Among the eleven accessions (including yellow and purple) evaluated, the variety Kaveri recorded the lowest fruit weight (71.90 g) and juice content (24.04 %). Among the different purple accessions evaluated the variety Kaveri recorded the highest percentage of rind (55.67%). Percentage recovery of juice is a very important criteria to be taken into account for product development. Different accessions were also evaluated for the seed content which has a say on processing characters. The Acc.3 which possessed lowest percentage juice recovery recorded the highest seed content (15.05%) among yellow accessions. Similarly the

variety Kaveri which recorded lowest juice content had the highest seed content among purple accessions (Table 1).

Studies on physico-morphological characters of yellow and purple passion fruit has been conducted by many scientists at different part of the country. The physico-chemical attributes of yellow and purple passion fruit recorded great variability. The fruit shape of purple and yellow type passion fruit was found to be round to ovoid in shape (Joy, 2010). The fruit weight, rind weight and juice/pulp percentage of purple type passion fruit (*Passiflora edulis* Sims f. *edulis*) was 59.6 g, 27.6 g and 53.6 percentage respectively, whereas, the corresponding values in yellow type passion fruit (*Passiflora edulis* f. *flavicarpa*) was 56.2 g, 31.1 g and 44.5 percentage respectively (Arjona *et al.*, 1991). Since juice is the most important edible component of passion fruit used for direct consumption and processing its content was taken as the prime criteria for selection with respect to physical attributes. The seed and rind content was also low in these accessions. Thus among yellow accessions, Acc.1 which recorded highest fruit weight and juice yield, low rind and seed content was selected as the ideal one possessing favourable physical attributes. Among purple accessions, Acc.7 possessed the highest percentage juice recovery and low rind content was selected for further studies. The variety Kaveri was also included for comparison of results.

5.1.1.2 *Nutritive and biochemical attributes*

The nutritive and biochemical characters were evaluated for further selection of best accessions. Wide variability with respect to TSS, acidity, total sugars, ascorbic acid and total carotenoids has been reported (Joy, 2010). In the present study, Acc.1 recorded the highest TSS (19.43^0 Brix), ascorbic acid content (25.94 mg $100g^{-1}$) and total carotenoid content (2.81 mg $100g^{-1}$) among yellow accessions. Among purple accessions, Acc.7 recorded the highest TSS (19.20^0 Brix), total sugar content (11.56 %) and ascorbic acid content (32.51 mg $100g^{-1}$). Thus Acc.1 in yellow and Acc.7 in purple types were found to possess the maximum ideal biochemical attributes. Uchao *et al.* (2008) reported 11.76 mg/100g of

ascorbic acid in yellow passion fruit. Ramaiya *et al.* (2012) determined the ascorbic acid content in fresh juice of different passion fruit (*Passiflora* spp.) cultivars: *P. edulis* cultivars Purple, Frederick, Yellow, Pink, *P. edulis* f. *flavicarpa*, *P. maliformis* and *P. quadrangularis*. The juice of purple type (*P. edulis* f. *flavicarpa*) recorded highest mean ascorbic acid content compared to other cultivars. The yellow type recorded highest titratable acidity (3.03 ± 0.19%) whereas; the purple type recorded second lowest titratable acidity (1.80 ± 0.10%) after *P. quadrangularis*.The TSS, acidity and sugar content has a say on the consistency of the product whereas ascorbic acid and carotenoids are important parameters in determining medicinal and nutritive values (Kathiravan *et al.*, 2013). Even though the variety Kaveri recorded low values for physical attributes, its nutritive and biochemical attributes were comparatively good.

5.2 TECHNOLOGY FOR JUICE EXTRACTION

Extraction of juice from passion fruit involves removal of the rind, separating seeds from the juice sacs and pressing out juice from the sacs. The juice sacs has two major membranes and are composed of a single- cell layer which stains for pectin (Florez *et al.*, 2003). Thus juice extraction is a tedious operation and if not done scientifically will affect the juice quality. Hence a viable method of juice extraction is highly necessary for further processing of juice for product preparation (Kotecha and Kadam, 2002). Taking into account of this fact, studies were taken up to bring out an efficient juice extraction method for passion fruit. Enzymatic and mechanical method of juice extraction were tried and compared with conventional method of juice extraction (manual extraction).

5.2.1 Enzymatic method

First the quantity of enzyme required for juice extraction was identified through adding pectinase and cellulase at different concentrations at a particular time and temperature (to the pulp). Among the different concentration of enzymes

(pectinase and cellulase) tried (Table 3), pectinase 5 ml per litre incubated at 50° C for 60 minutes was found to yield more quantity of juice (73.52% in Acc.1, 73% in Acc.7 and 71.01% in Kaveri). Similar results were obtained by Mary (2005) in banana, where addition of pectinase at the rate of 5 ml per kg pulp and incubating for four hours at room temperature resulted in production of more quantity of clarified juice. The juice recovery was comparatively very low in cellulase treatment as well as in mixture of pectinase and cellulase treatments. The presence of lumps in passion fruit juice is due to high cell wall polysaccharides formed mainly due to compounding of pectin. The more effective breaking of this bonds might have happened due to treatment with pectinase resulting in yield of more juice (Florez *et al.*, 2003). According to Rombouts and Pilnik (1978), pectinase hydrolyzes pectin and causes pectin protein complexes to flocculate, while cellulase degrades the cell wall inside. In order to get more precision in incubation time and temperature, the experiment was repeated by varying the duration (45, 60 and 90 minutes) and temperature (40°C and 50° C) of incubation.

Among the different time and temperature tried adding pectinase 5 ml per litre and incubating at 50° C for 90 minutes was found ideal. The experiment have shown that treatment of enzyme with the juice for 90 minutes yielded more juice compared to that for 60 minutes. Incubation at 40°C had no merit than that at 50°C. According to Kilara (1982), temperature may aid in the rate of enzymatic clarification process but the temperature is to be below denaturation temperature (40–60°C). Kotecha and Kadam (2002) studied the effect of different methods for extraction of pulp from tamarind fruits. Methods adopted were cold extraction, hot extraction and hot enzyme extraction. Hot enzymatic extraction in which 0.5 per cent biotropicase given after boiling and cooling the flesh with water at 1:3 proportion at 70°C for 10 minutes and incubated for 6 hours gave highest recovery. Reports on effect of pectinase in extraction of clarified juice from viscous juice of different fruits (Anand *et al.* (2013) in kiwi fruit, Arsad *et al.* (2015) in sugar palm fruit) support the present study.

5.2.2 Best method of juice extraction

Comparison of best enzymatic method of extraction with mechanical and conventional method have shown that enzymatic method yielded more juice compared to the other two (fig. 1). The result was same with the two accessions and the variety Kaveri. The recovery percentage with enzymatic method was 27-28% more than that with mechanical extraction. The increase in juice recovery percentage in enzymatic method was only 2-3% higher than that of manual method. But the juice quality was comparatively good as revealed in biochemical quality analysis. The use of pectic enzymes in fruit processing is essential to get better juice yields with improved filtration rate and clarity (Pilnik and Vorange, 1989). Joshi *et al.* (1991) reported that pectolytic enzymes have been used for increasing the yield of juice from stone fruits like peaches, plums and apricots. Mary (2005) observed that, addition of pectinase enzyme at the rate of 5 ml per kg pulp and incubating for four hours at room temperature resulted in production of more quantity of clarified banana juice.

Among biochemical characters analysed, TSS, acidity and total sugars were high in the juice extracted through enzymatic method, whereas ascorbic acid content and total carotenoids were low compared to other two methods (fig.2). Arsad *et al.* (2015) studied the effect of different enzymatic treatments on sugar palm fruit juice processing and obtained similar results. Sugar palm fruit purees were treated individually and in combination using two types of commercial enzymes like Novozymes cellulase and pectinex ultra SP-L at a concentration of 0.05 (w/w) and incubated at 45°C for 60 minutes. The enzyme treatment reduced the juice viscosity and promoted juice clarification. The ascorbic acid content was reduced whereas the TSS and sugar content was increased. According to Ramadan and Moersel (2007), in enzymatic treatments the middle lamella and cell wall pectin of the fruit are degraded with exogene enzymes and transformed to soluble materials such as acid and neutral sugar. This results in increased juice extraction and subsequent clarification.

Fig.1. Effect of extraction method on recovery of juice

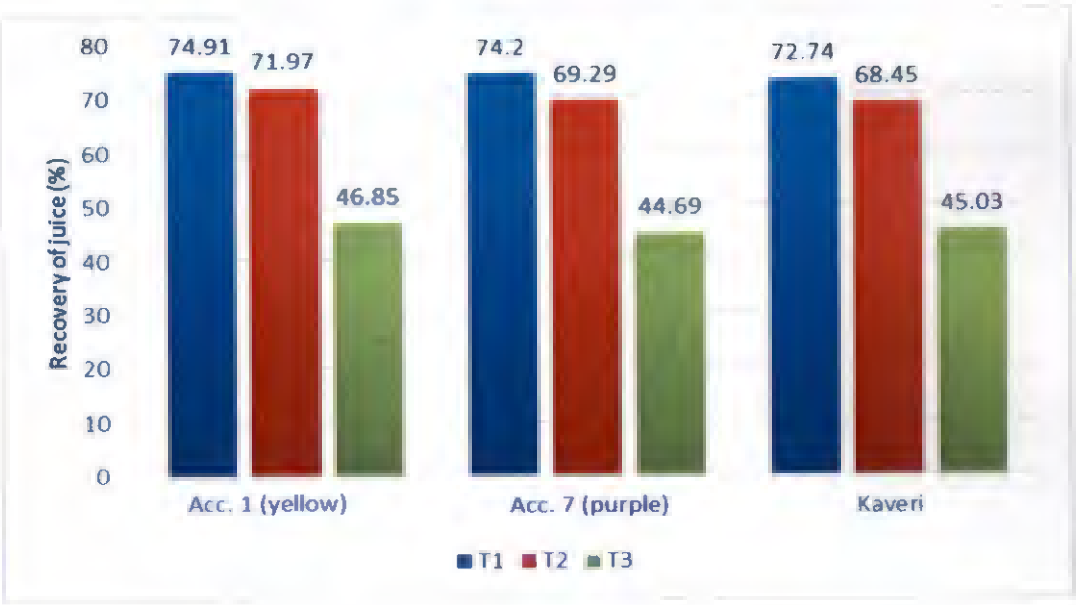
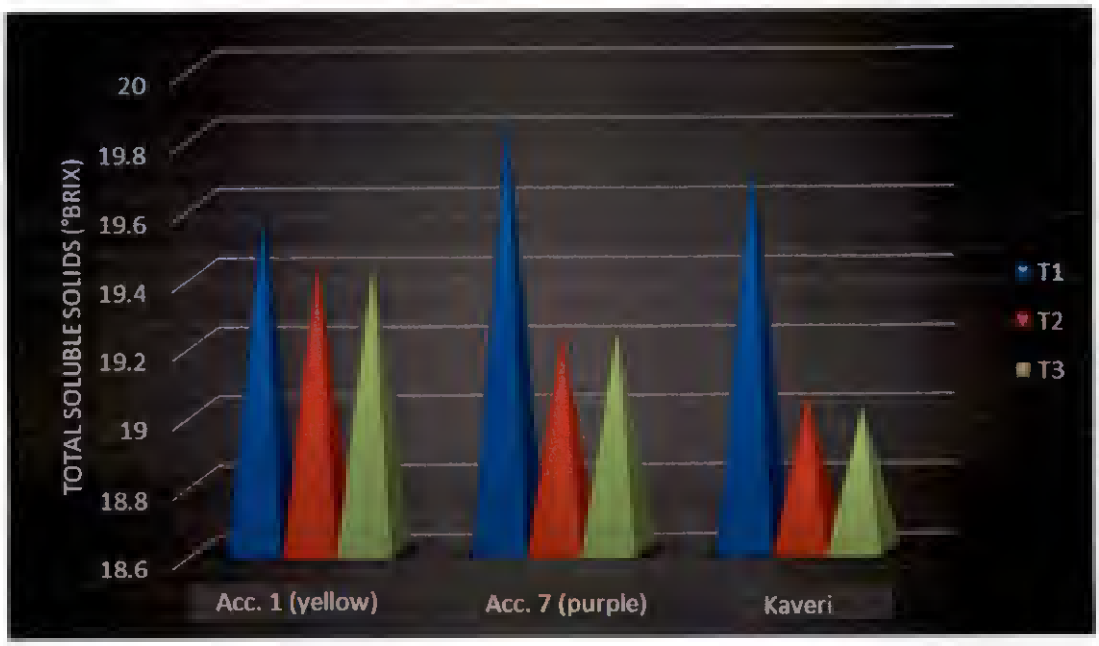


Fig.2. Effect of method of extraction on TSS



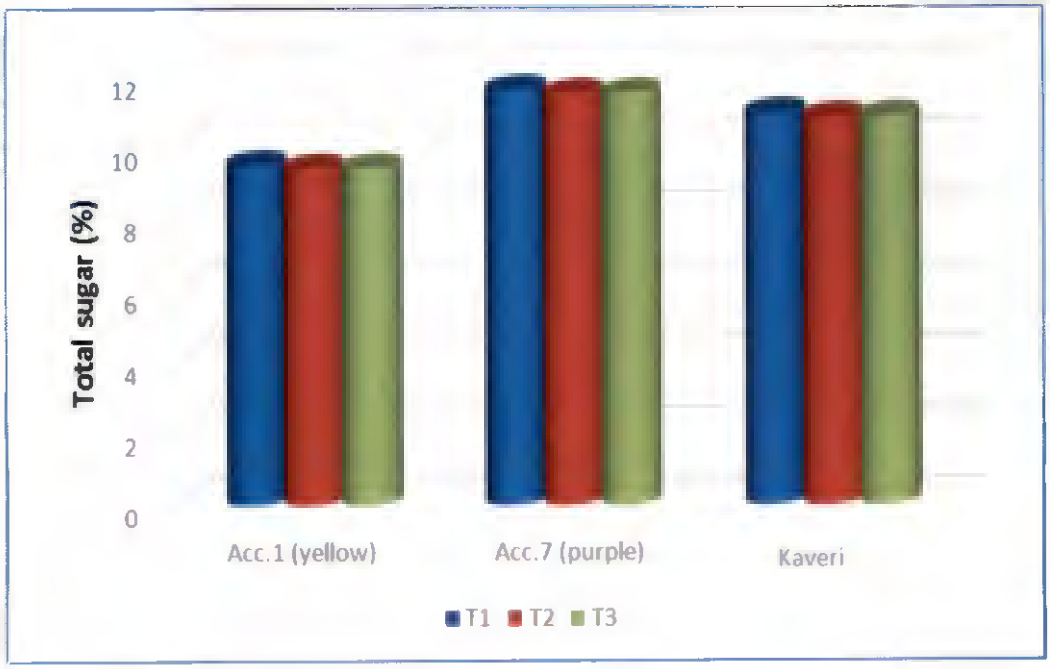
T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Fig.3. Effect of method of extraction on acidity

Fig.4. Effect of method of extraction on total sugar

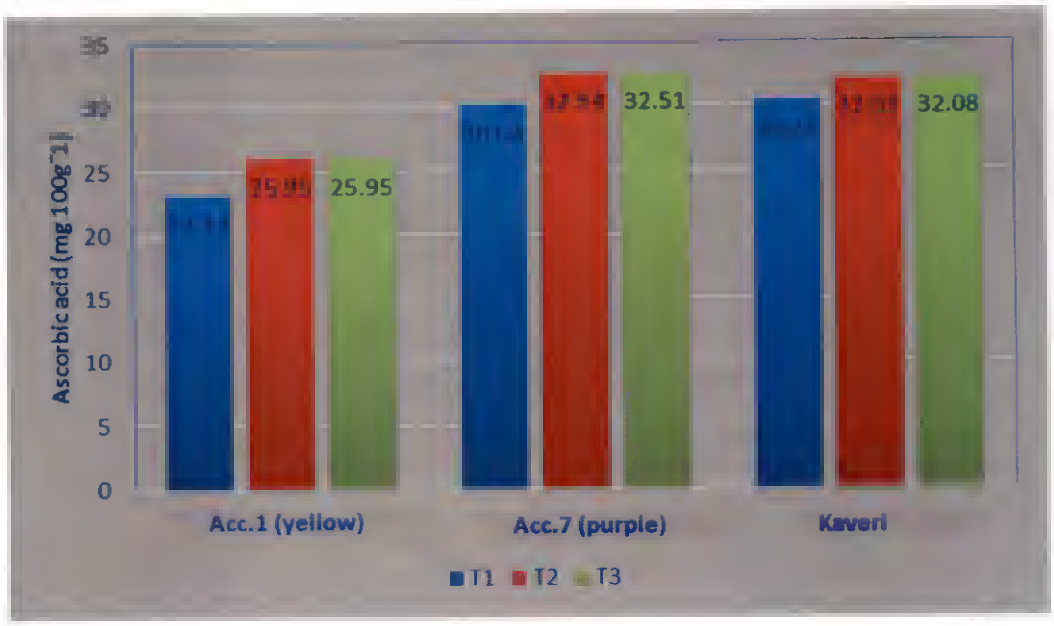


T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Fig.5. Effect of method of extraction on ascorbic acid content



T1- Pectinase 5ml per L incubated at 50° C for 90 minutes at 200 rpm

T2- Conventional method (manual juice extraction)

T3- Mechanical juice extraction

Schobinger *et al.* (1981) reported that, the rise in TSS in enzymatically extracted juice could be partially due to the increment of soluble sugars, which may result from the conversion of insoluble pectin by pectinolytic enzymes and the action of cellulase on cellulose to produce soluble sugars. According to Acar *et al.* (1999) the juice treated with enzyme became more acidic, which might be due to the formation of galacturonic acid by the enzymatic breakdown of pectin. During enzyme treatment, the number of reduction groups increased according to the increase in galacturonic acid and oligosaccharides (Landbo *et al.*, 2007). These substances are determined as sugars, so the sugar content of the final product was found to be higher. Arsad *et al.* (2015) reported that the untreated juices had slightly higher ascorbic acid content than enzyme treated juices. The amounts of ascorbic acid degraded when the pulp was subjected to enzymatic treatment. According to Moser and Bendich (1990), the degradation of ascorbic acid may be due to the heat treatment in processing steps and exposed to the oxygen long which is the common cause in the loss of ascorbic acid content in a fruit juice. The studies substantially support the changes in biochemical characters of the juice extracted through specified enzyme treatment.

The different sensory attributes studied revealed the superiority of enzymatically extracted juice with respect to appearance. This may be due to the rupturing of the cell walls of juice sacs and subsequent sedimentation in enzymatic method (Florez *et al.*, 2003). In mechanical and manual method the presence of suspended solids in the juice resulted in low score for appearance. Even though manual method of juice extraction was comparable with the enzymatic method, it was labour intensive and the quality of juice obtained was low. Apart from low juice yield in mechanical method, the juice quality was also not good as that of enzymatic method. Hence enzymatic method was selected for extracting juice for product development.

5.3 PRODUCT DEVELOPMENT

The whole passion fruit has a very low shelf life of one week (Wu *et al.*, 2005) and because of this huge loss occur after harvest. Hence processing and value addition is the only alternative to prevent the loss of this valuable commodity. The technology developed for production of clarified juice from this fruit opened an avenue for production of good quality beverage. Passion fruit juice and its concentrate are more popular in the international market. The juice could be processed into squash, ready to serve beverages, nectars, syrups *etc.* by mixing with other tropical fruit juices/pulps as it has excellent blending property. In India, Mizoram, Manipur and Nagaland leads in the production of passion fruit processed products (Kulkarni and Vijayanand, 2009).

5.3.1 Beverages

The different beverages tried in the present study were sweetened juice, RTS beverage and carbonated drink. For sweetened juice preparation, the passion fruit juice alone and that blended with cashew apple at different levels were tried. The cashew apple is a fruit which is wasted in large quantity in spite of its health benefits. Blending of juices is an art and science to get more acceptable product than that prepared with single fruit juice. Dhaliwal and Hira (2001) reported that blending of fruit juices with vegetable juices like carrot and beetroot produce more acceptable beverage. In the present study sweetened juice prepared by blending of passion fruit juice (Acc. 1, Acc. 7 and Kaveri) and cashew apple juice in 3:1 ratio was found more acceptable than that prepared with passion fruit juice or cashew apple juice alone. Blending of passion fruit juice with cashew apple juice in other levels tried, reduced the consistency and odour resulting in reduction of overall acceptability. As the content of cashew apple juice was increased in the product the acceptability was found decreased. The results of the study indicated that blending with clarified cashew apple juice at a level which will not mask the desirable qualities of passion fruit is only possible.

Plate 10. Best treatment - sweetened juice

T1- Acc. 1 (yellow) T1- Acc. 7 (purple) T1- Kaveri

Plate 11. Best treatment - RTS beverage

T1- Acc. 1 (yellow) T1- Acc. 7 (purple) T1- Kaveri

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

In the case of RTS beverage also, blending of passion fruit juice (Acc. 1, Acc. 7 and Kaveri) and cashew apple juice in 3:1 ratio was found to be more advantageous (fig.6). This treatment was adjudged as the best one scoring maximum value for overall acceptability. This may be due to the masking of unpleasant sensory attributes of the cashew apple juice by passion fruit juice. Blending of fruit juices with cashew apple juice is reported to produce more acceptable product (Sobhana *et al.*, 2015). Standardisation of cashew apple RTS beverages by blending cashew apple juice with other fruit juices like orange, pineapple and lime was attempted by Remyamol (2006). The beverage prepared by blending 75 percent cashew apple juice and 25 percent lime juice was found to be more acceptable.

For preparing carbonated drink, blending of passion fruit juice and cashew apple juice in 1:1 ratio was found better in the case of Acc. 1 (yellow type) whereas blending of passion fruit juice and cashew apple juice in 3:1 ratio was good for Acc.7 (purple type) and Kaveri (fig.9). As the colour of yellow passion fruit juice and cashew apple juice blend very well, using more cashew apple juice in passion fruit juice and carbonating may not make much difference in appearance and overall acceptability. In purple types, addition of more cashew apple juice decreased the appearance, colour, flavour, taste and thus the overall acceptability of the carbonated drinks (fig 10).

The quality attributes of different beverages *viz.*, sweetened juice, RTS beverage and carbonated drink differed significantly with respect to treatments. The quality attributes *viz.*, TSS, titratable acidity and total carotenoids showed no specific difference in response to blending done for preparations of beverages. But the ascorbic acid recorded variation among the treatments and beverages prepared with cashew apple juice alone was found to contain 86.09 mg $100g^{-1}$ and 80.04 mg $100g^{-1}$ ascorbic acid in sweetened juice and RTS beverage respectively. This may be attributed to the presence of 203.5 mg per 100 ml ascorbic acid in cashew apple juice (Lowor and Agyente-Badu, 2009).

Fig.6. Sensory attributes of RTS beverage (Acc.1 – yellow)

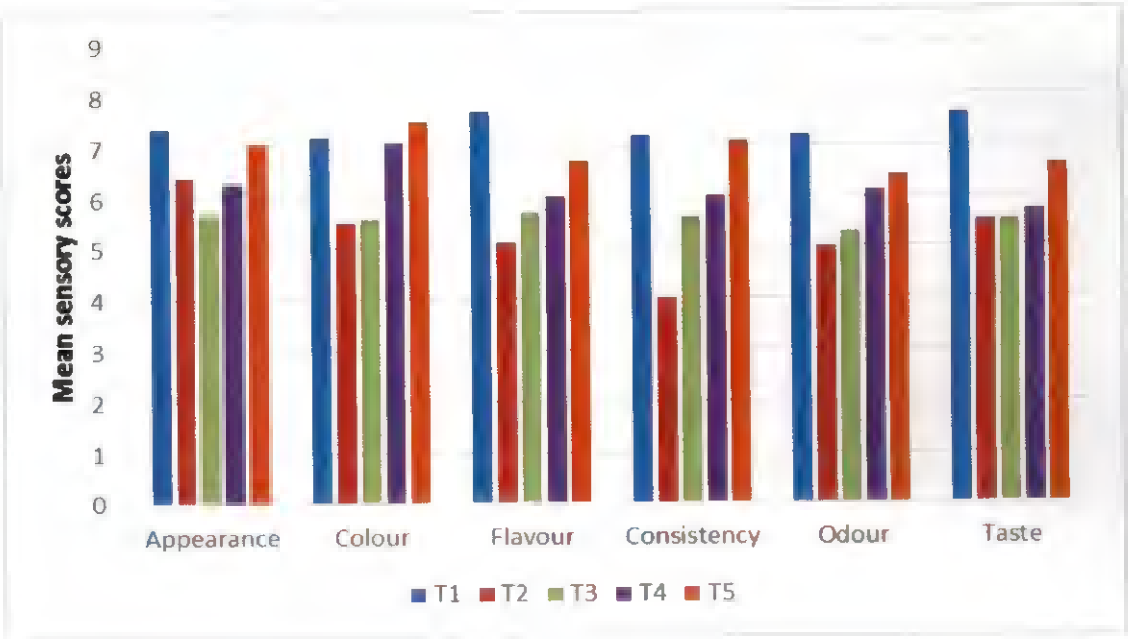
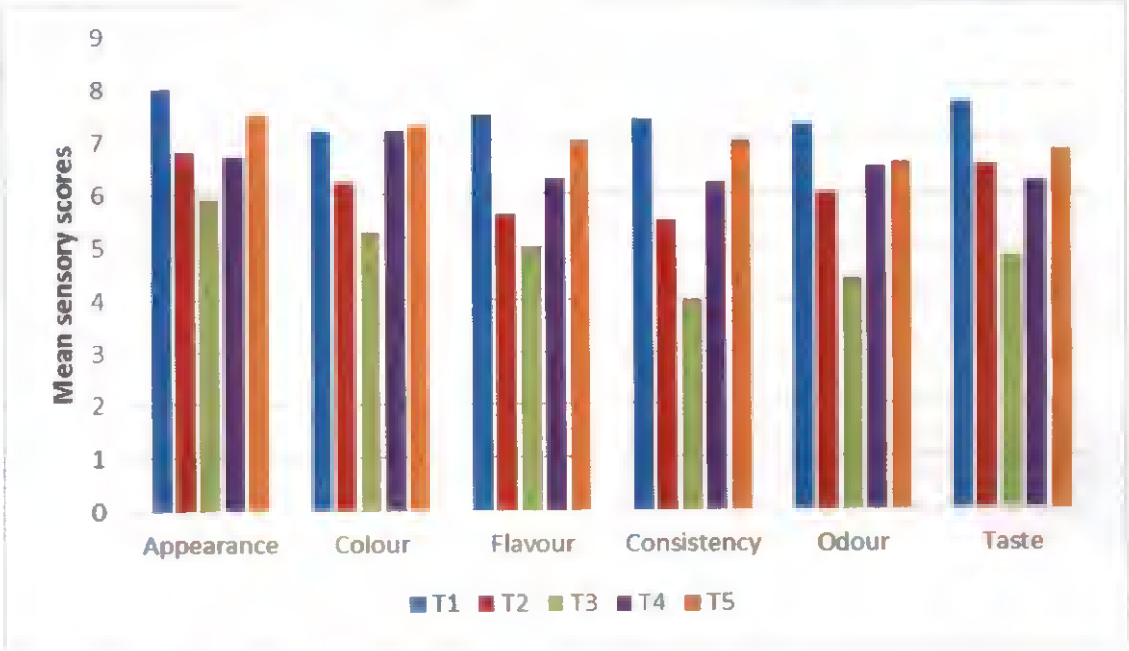
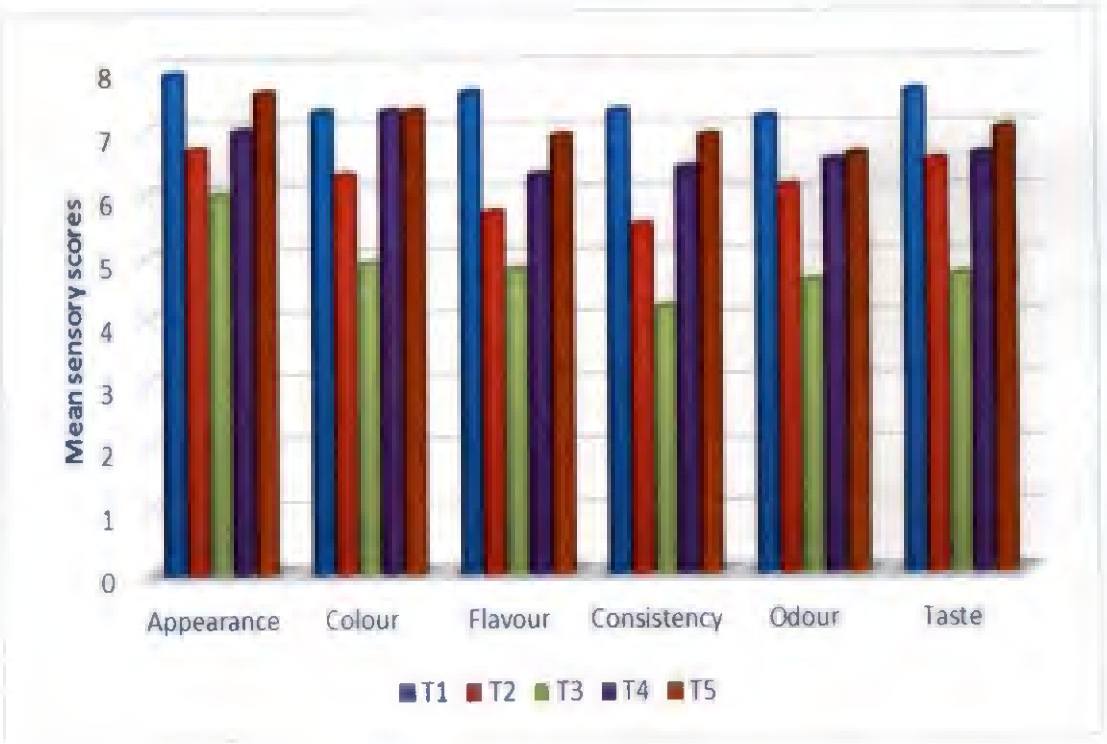


Fig.7. Sensory attributes of RTS beverage (Acc.7 – purple)



T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Fig.8. Sensory attributes of RTS beverage (Kaveri)



T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

T3- Passion fruit juice and cashew apple juice in 1:3 ratio

T4- Cashew apple juice alone

T5- Passion fruit juice alone

Fig.9. Sensory attributes of carbonated drink (Acc.7 - purple)

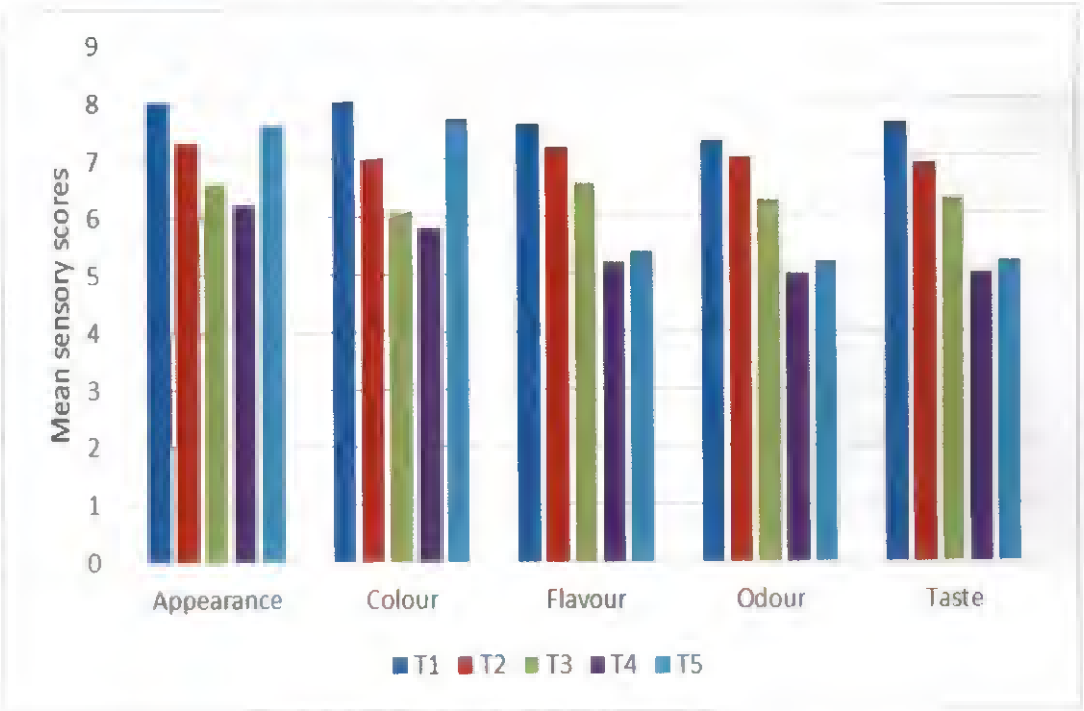
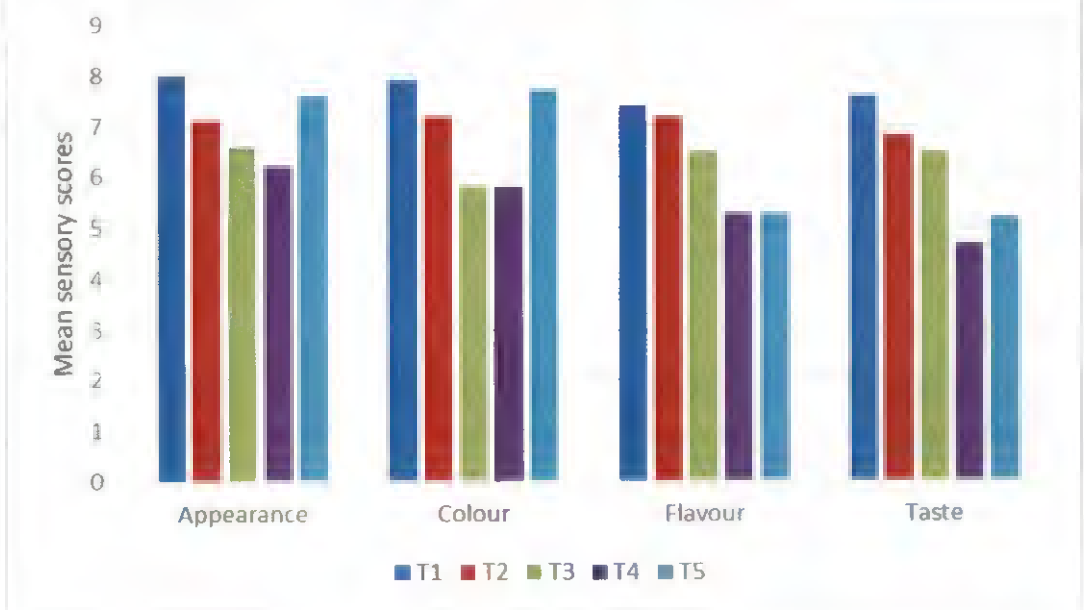


Fig.10. Sensory attributes of carbonated drink (Kaveri)



T1- Passion fruit juice and cashew apple juice in 3:1 ratio
T2- Passion fruit juice and cashew apple juice in 1:1 ratio
T3- Passion fruit juice and cashew apple juice in 1:3 ratio
T4- Cashew apple juice alone
T5- Passion fruit juice alone

Plate 12. Best treatment - carbonated drink

T2- Acc. 1 (yellow)

T1- Acc. 7 (purple)

T1- Kaveri

T1- Passion fruit juice and cashew apple juice in 3:1 ratio

T2- Passion fruit juice and cashew apple juice in 1:1 ratio

5.3.2 Jam

The passion fruit contain considerable quantity of rind which is rich in pectin (Madhav, 2001). In the present study the rind content of different accessions varied between 46-60%. This may serve as a source of raw material for product preparation which otherwise get wasted. The product tried with rind was jam, which demand pectin for good consistency. Cashew apple is yet another fruit which is wasted after extraction of nut. The sensory quality of jam prepared from cashew apple is poor, due to astringency induced by the tannins present in the fruit. Hence the feasibility of utilising passion fruit rind for preparation of jam after blending with cashew apple pulp at different levels was studied.

The rind pulp of Acc.1 (yellow passion fruit) produced good quality jam when mixed with cashew apple pulp in the ratio 1:3 (plate 13). The quality of jam was decreased as the content of cashew apple pulp was decreased. Jam prepared with cashew apple pulp mixed with mango pulp at 1:1 ratio was found to better than that prepared with cashew apple pulp alone (Mini *et al.*, 2008). The pectin in the rind of passion fruit might have helped to give better appearance, consistency, colour, flavour and taste for jam resulting in increased overall acceptability.

The result was different in the case of jam prepared with Acc.7 (purple passion fruit) and the variety Kaveri. In Acc.7 (purple passion fruit), mixing rind pulp with cashew apple pulp in the ratio 3:1 was advantageous as it improved the consistency, taste, after taste and overall acceptability. In Kaveri mixing rind pulp with equal quantity of cashew apple pulp was found to produce more acceptable jam. The main reason for this variation with treatments can be attributed to the pectin content of the rind of different accessions tried and their colour. As the jam was prepared by adding sugar and acid at specified level (Ranganna, 1997) the quality attributes ascorbic acid content, TSS and acidity did not recorded much variation. The presence of high ascorbic acid in cashew apple resulted in jam with more ascorbic acid content even though a substantial quantity was lost in heating process.

Plate 13. Best treatment - jam

T3- Acc. 1 (yellow)

T1- Acc. 7 (purple)

T2- Kaveri

T1- Rind pulp of passion fruit and cashew apple pulp in 3:1 ratio

T2- Rind pulp of passion fruit and cashew apple pulp in 1:1 ratio

T3- Rind pulp of passion fruit and cashew apple pulp in 1:3 ratio

5.4 STORAGE STUDIES

5.4.1 RTS beverage

The sensory attributes of RTS beverage showed a decreasing trend during storage. Even though quality recorded a decreasing trend there was no significant difference up to one month after storage (fig.12). Among the biochemical parameters studied, the TSS recorded an increasing trend (fig.13). The hydrolysis of bound sugar during storage may be the reason for increase in soluble solids (Singh *et al.*, 2014). The acidity recorded decreasing trend during the storage. This may be due to the increase in soluble solids, which create an imbalance in the TSS acidity ratio of the product during storage. Saikia and Saikia (2002) also observed similar trend with acidity of ripe outenga (*Dillenia indica*) fruit squash during storage. Deka *et al.* (2004) reported decreasing trend in acidity of lime-aonla spiced beverage during 6 months of storage.

Ascorbic acid and carotenoids which are nutritionally very important got reduced during the storage of the RTS beverage (fig.14). The results obtained in storage studies conducted in different fruit beverages is an agreement with that obtained in the present study. Loss in ascorbic acid content was observed from commercial fruit juices like orange, grape fruit, lemon, cocktail-A (orange, peach, grapefruit, pineapple, apple, mango and kiwi) and cocktail-B (orange, apple and apricot) (Kabasakalis *et al.*, 2000). A significant loss in total carotenoid content from 1270 µg/100ml to 520 µg/100ml was observed in sterilized ashgourd-mint leaves juice during eight months of storage at ambient condition, which accounted a total loss of 59.1% of total carotenoid content. But under refrigerated condition the loss of total carotenoid content was only 20% (Majumdar *et al.*, 2012).

The microbial load observed in the RTS beverage stored in glass bottles under ambient condition was at safe level up to three months. Bacteria at detectable level was observed in the RTS beverage at three months after storage and fungi and yeast at two months after storage. Fungal population was present beyond acceptable limit at four months after storage in RTS beverage. The study is in conformation of

Fig.11. Effect of storage on appearance of RTS beverage

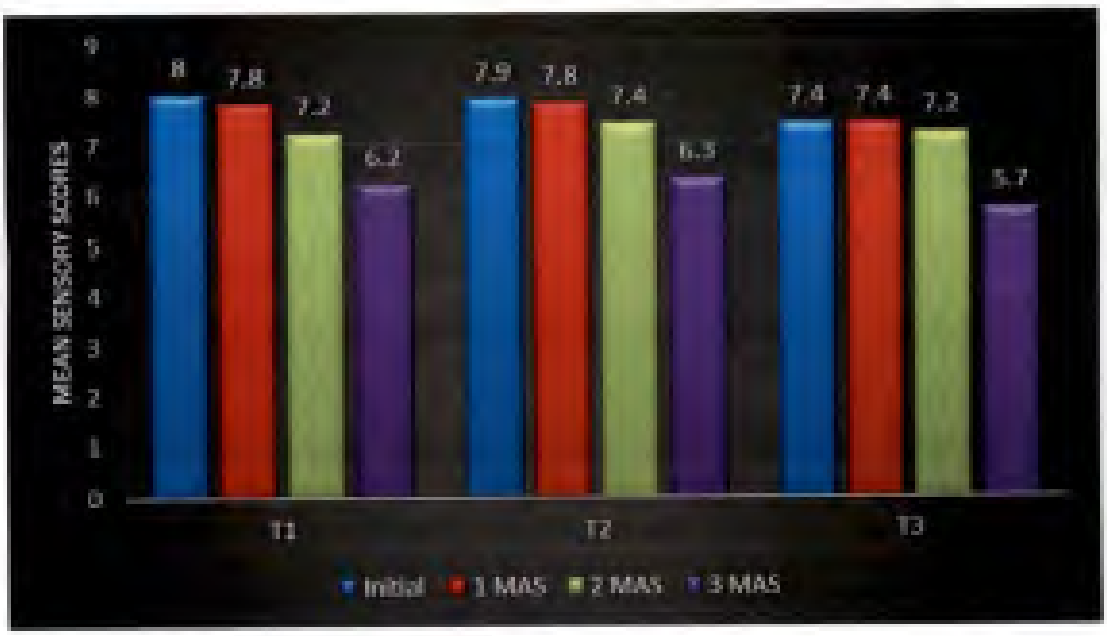
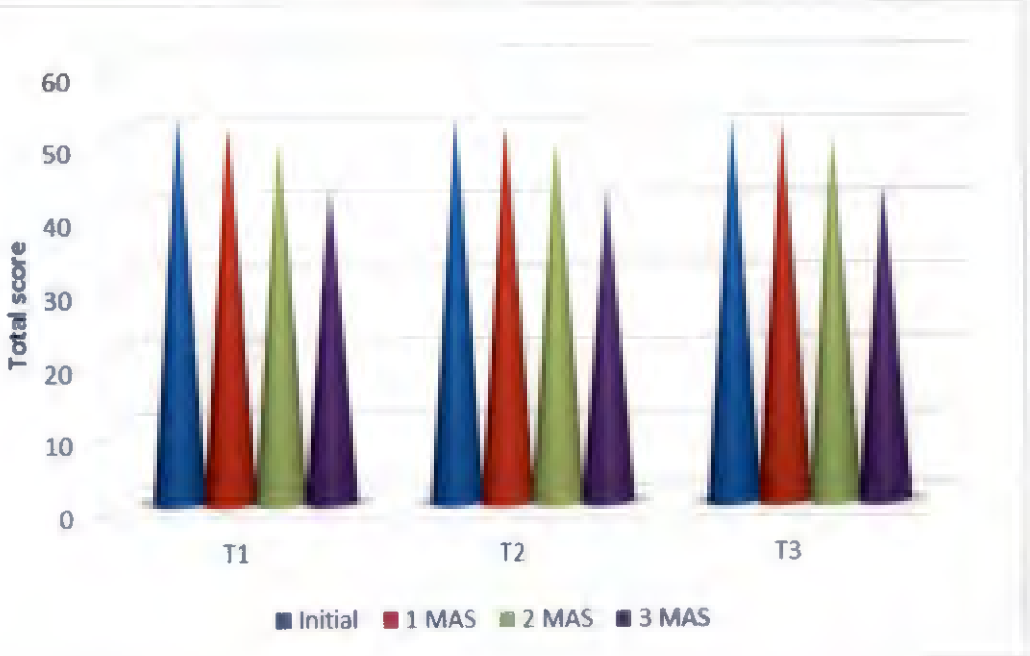


Fig.12. Effect of storage on overall acceptability of RTS beverage



MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

Fig.13. Total Soluble Solids (TSS) of RTS beverage during storage

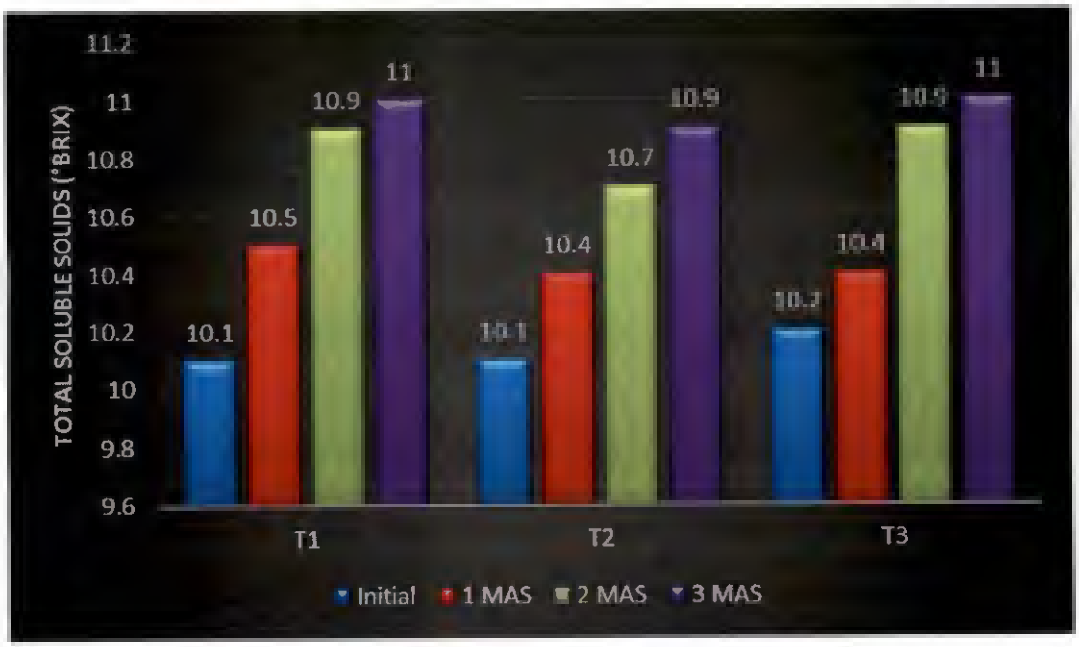
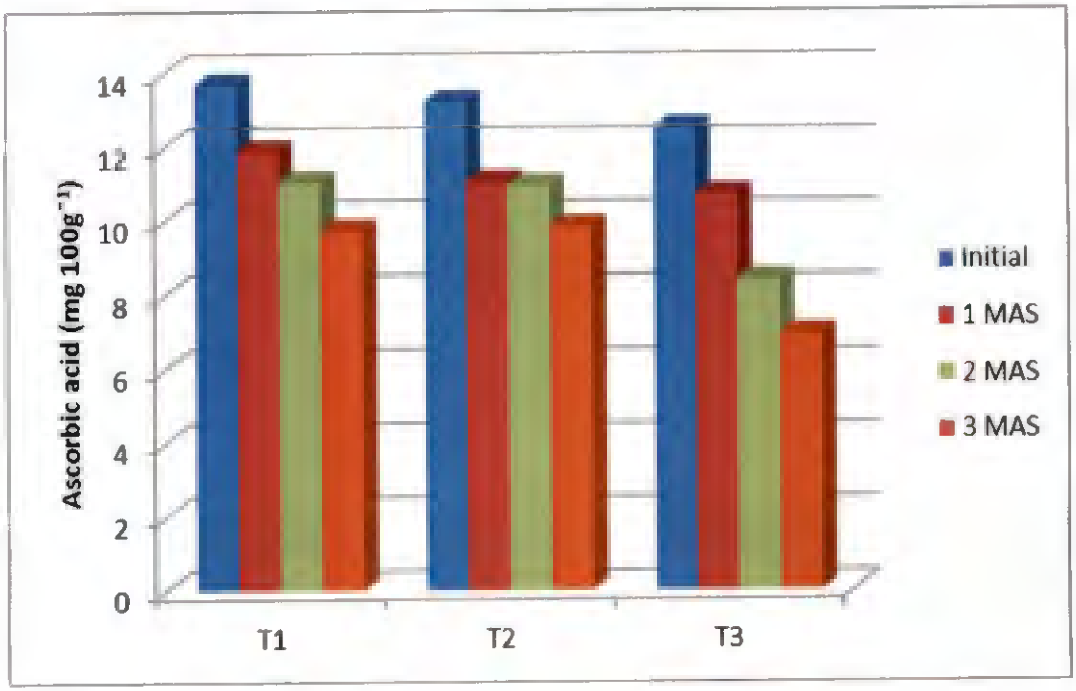


Fig.14. Ascorbic acid content of RTS beverage during storage



MAS: Months after storage

T1- Acc.7 (purple) passion fruit juice and cashew apple juice in 3:1 ratio

T2- Kaveri passion fruit juice and cashew apple juice in 3:1 ratio

T3- Acc.1 (yellow) passion fruit juice and cashew apple juice in 3:1 ratio

the study with Fang *et al.* (1986) that pasteurization of passion fruit juice at 75°C for 40 seconds was sufficient to ensure the microbiological quality up to three months of storage in ambient condition.

5.4.2 Jam

The sensory attributes of the different types of jam reduced during storage and the score values reduced at an unacceptable level one month after storage (fig.18). Among the biochemical parameters studied, the acidity and ascorbic acid content recorded a decreasing trend during the storage (fig.20). The storage of jam might have resulted an imbalance in sugar acid ratio, the most important parameter which determine the consistency, taste and appearance. The stored product also lost its colour may be due to release and action of tannin compounds present both in passion fruit rind and cashew apple. Lowor and Agyente (2009) determined phenol and tannin content in cashew apple. The microbial load observed in the jam stored in glass bottles under ambient condition was at safe level. Bacteria at detectable level was observed at three months after storage and fungi at two months after storage. As a drastic reduction in sensory attributes was recorded one month after storage of jam prepared by blending passion fruit rind and cashew apple pulp at different level, the product can be recommended for consumption immediately after preparation. Further studies are revised to improve the storage and acceptability of jam.

Fig.15. Effect of storage on appearance of jam

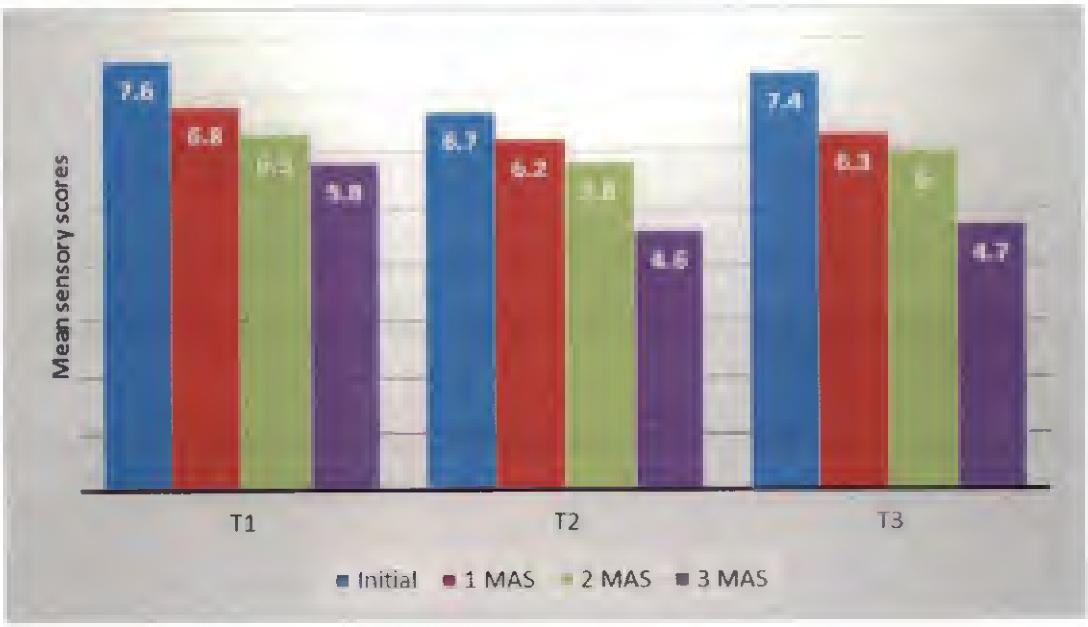
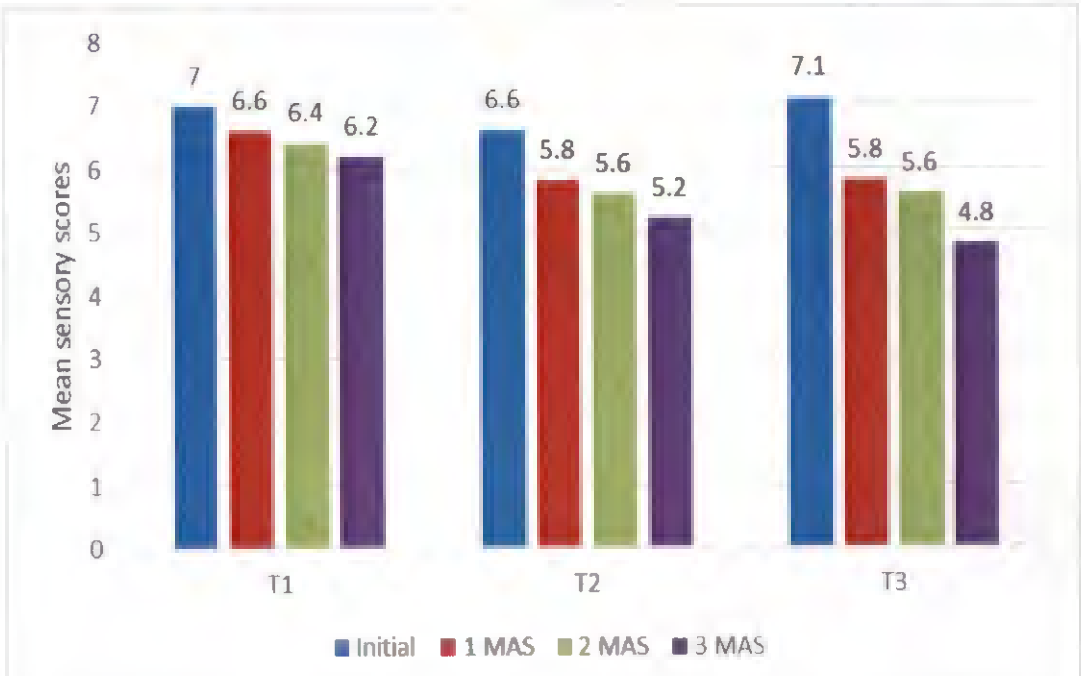


Fig.16. Effect of storage on colour of jam



MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Fig.17. Effect of storage on taste of jam

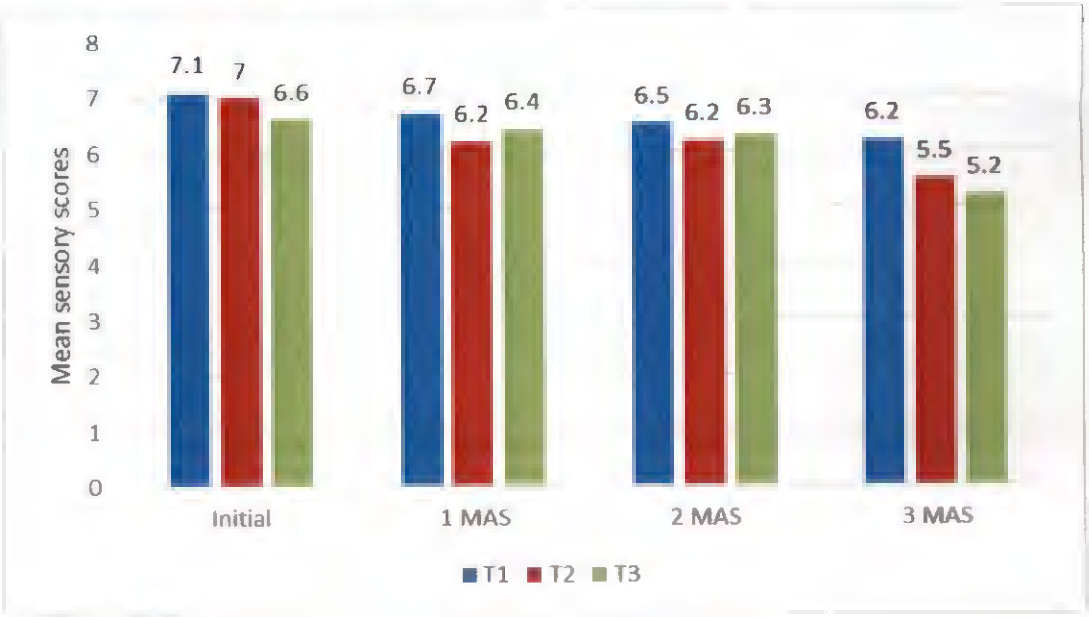
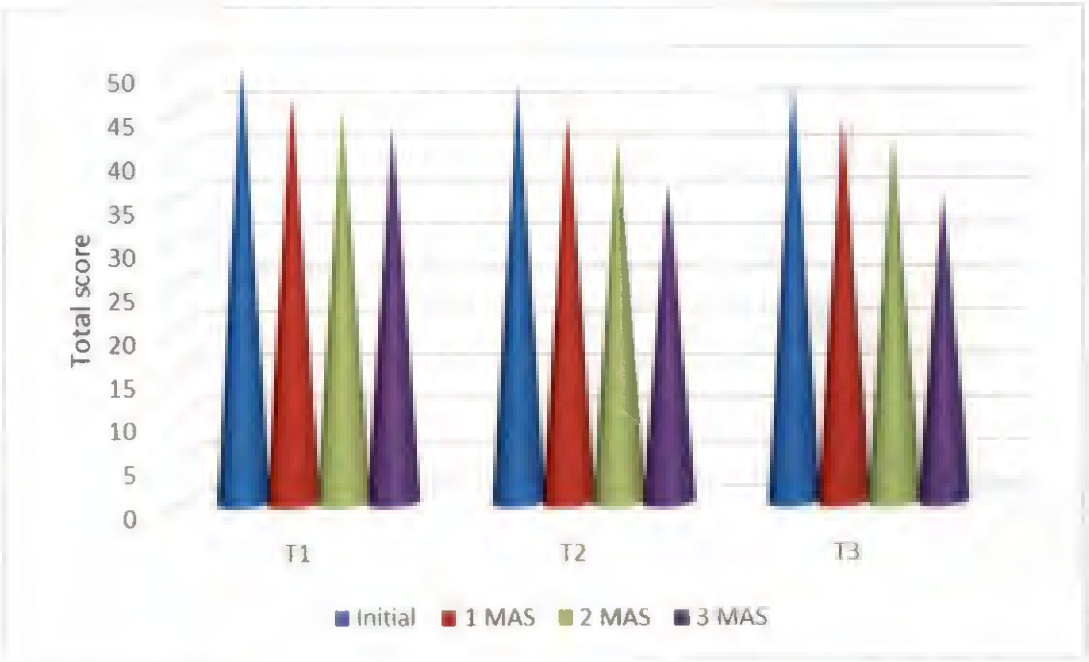


Fig.18. Effect of storage on overall acceptability of jam



MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Fig.19. Total Soluble Solids (TSS) of jam during storage

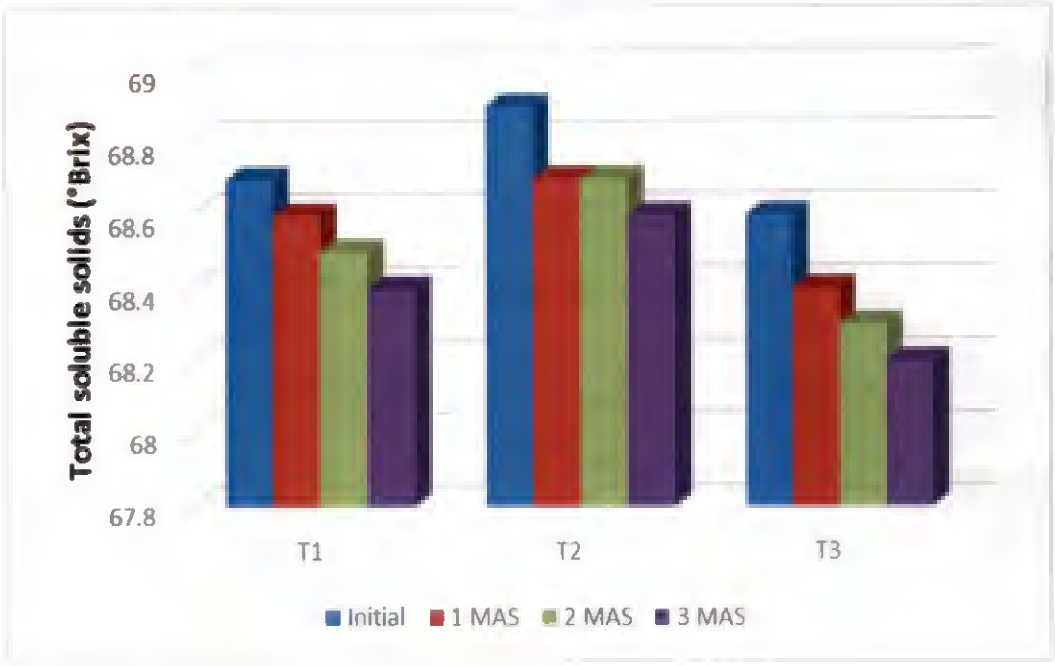
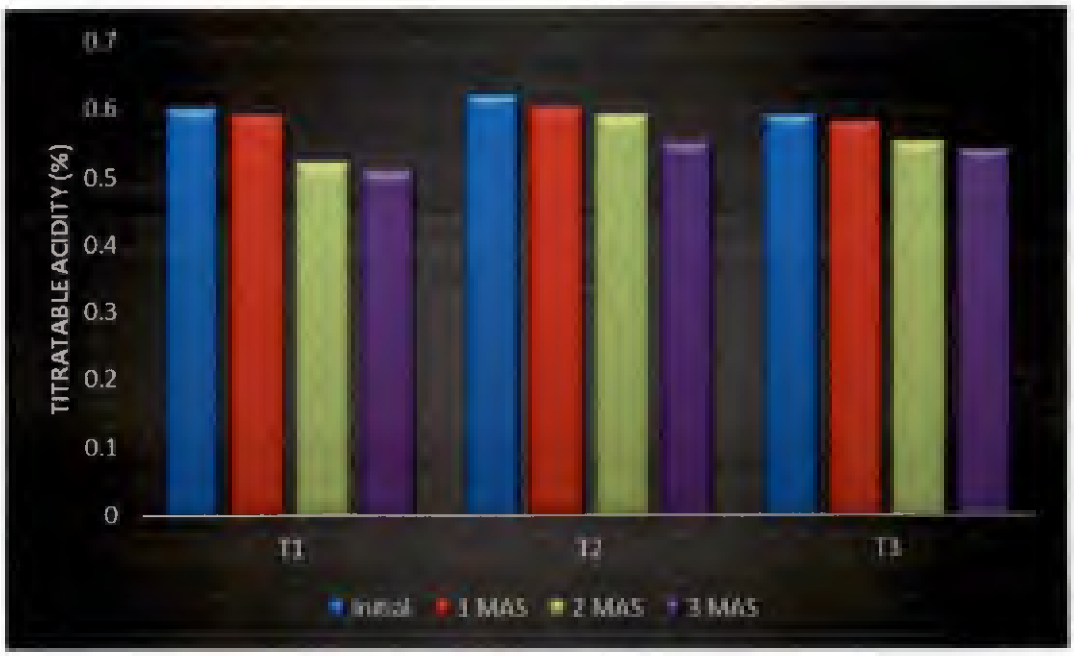


Fig.20. Titratable acidity of jam during storage



MAS: Months after storage

T1- Rind pulp of Acc.1 (yellow passion fruit) and cashew apple pulp in 1:3 ratio

T2- Rind pulp of Acc.7 (purple passion fruit) and cashew apple pulp in 3:1 ratio

T3- Rind pulp of Kaveri and cashew apple pulp in 1:1 ratio

Summary

6. SUMMARY

The project entitled "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara.

Yellow and purple accessions collected from different localities were evaluated for their physico-chemical attributes along with the variety, Kaveri (purple type) released by the Central Horticultural Experiment Station (CHES), Chettali. The study revealed that the accessions differed significantly for different physical and biochemical traits analysed. Among the yellow accessions, Acc.1 collected from orange and vegetable farm, Nelliyampathi, possessed the highest mean fruit weight (98.27 g) and percentage juice recovery (35.38%), low rind content (46.05%), highest TSS (19.43^0 Brix), high ascorbic acid (25.94 mg $100g^{-1}$) and total carotenoid content (2.81 mg $100g^{-1}$). Among the purple accessions, Acc.7 recorded highest percentage juice recovery (36.79 %), low rind content (46.55%), high TSS (19.20^0 Brix), total sugar (11.56 %) and ascorbic acid content (32.51 mg $100g^{-1}$). Hence Acc.1 in yellow and Acc.7 in purple types were selected for further studies along with variety Kaveri.

Three methods of juice extraction (enzymatic, mechanical and conventional methods) were compared to identify the most efficient method. Among the different concentration of enzymes (pectinase and cellulase) tried, pectinase 5 ml per litre incubated at 50° C for 60 minutes was found to yield more quantity of juice (73.52% in Acc.1, 73% in Acc.7 and 71.01% in Kaveri). Among the different time and temperature tried adding pectinase 5 ml per litre and incubating at 50° C for 90 minutes was found ideal. Comparison of best enzymatic method of extraction with mechanical and conventional method have shown that enzymatic method yielded more juice compared to the other two. Among biochemical characters analysed, TSS, acidity and total sugars were high in the juice extracted through enzymatic method, whereas ascorbic acid content and total carotenoids were low compared to other two methods. The different sensory attributes studied revealed the superiority

of enzymatically extracted juice with respect to appearance. Hence enzymatic method was selected for extracting juice for product development. The result was same for all the accessions tried.

Sweetened juice, RTS beverage, carbonated drink and jam were prepared as part of product development. Sweetened juice and RTS beverage prepared by blending of passion fruit juice and cashew apple juice in 3:1 ratio was found more acceptable than that prepared with passion fruit juice or cashew apple juice alone. For preparation of carbonated drink blending of passion fruit juice and cashew apple juice in 1:1 ratio was found better in the case of Acc.1 (yellow type) whereas blending of passion fruit juice and cashew apple juice in 3:1 ratio was good for Acc.7 (purple type) and Kaveri. The quality attributes of different beverages *viz.*, sweetened juice, RTS beverage and carbonated drink differed significantly with respect to treatments. The quality attributes *viz.*, TSS, titratable acidity and total carotenoids showed no specific difference in response to blending done for preparations of beverages. But the ascorbic acid recorded variation among the treatments and beverages prepared with cashew apple juice alone was found to contain more ascorbic acid. Blending rind pulp with cashew apple pulp in 1:3 ratio in Acc.1 (yellow), 3:1 ratio in Acc.7 (purple) and 1:1 ratio in Kaveri was found to produce the most acceptable jam. The quality attributes ascorbic acid content, TSS and acidity did not recorded much variation in jam.

The shelf life of RTS beverage and jam was studied by storing the products and taking the observations on biochemical characters, sensory attributes and microbial load at monthly intervals. The sensory attributes of RTS beverage showed a decreasing trend during storage. Even though quality recorded a decreasing trend there was no significant difference up to one month after storage. Among the biochemical parameters studied, the TSS recorded an increasing trend. In RTS beverage fungal population was present beyond acceptable limit at four months after storage. In the case of jam the sensory attributes recorded a drastic reduction after one month of storage. Among the biochemical parameters studied, the acidity and ascorbic acid content recorded a decreasing trend during the storage of jam. As

a drastic reduction in sensory attributes was recorded one month after storage of jam prepared by blending passion fruit rind and cashew apple pulp at different level, the product can be recommended for consumption immediately after preparation. Further studies are required to improve the shelf life and acceptability of RTS and jam.

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Appendices

APPENDIX I

ENZYMES

1. ClariSEB R80L

Description:

ClariSEB R80L is a food grade pectinase preparation produced by controlled fermentation of selected strain of *Aspergillus niger*.

ClariSEB R80L is Kosher-certified, Halal- certified, non-synthetic and bio-degradable.

Product properties:

Form: light brown to brown coloured liquid

Active ingredient: pectinase

Miscibility: ready miscible in water

2. ViscoSEB HTX

Description:

ViscoSEB HTX is a food grade preparation containing cellulose produced by controlled fermentation of selected strain of *Trichoderma citrinoviride* and *Bacillus pumilus*.

ViscoSEB HTX is Kosher-certified, Halal- certified, non-synthetic and bio-degradable.

Product properties:

Form: light brown to brown coloured liquid

Active ingredient: cellulase

Miscibility: ready miscible in water

ClariSEB R80L and ViscoSEB HTX were purchased from advanced enzyme technologies Ltd., Thane.

APPENDIX II

Score card for organoleptic evaluation

Product code	Appearance	Colour	Texture	Flavour	Odour	Taste	After taste	Overall acceptability

Note: You are provided with the samples and you are requested to rank them according to the scale given below as per your liking

Scale: 9 point hedonic scale

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Date: Name:

Signature:

APPENDIX III

Media composition

1. NUTRIENT AGAR MEDIA (FOR BACTERIA)

Beef extract	: 3 g
Peptone	: 5 g
Sodium chloride	: 5 g
Agar	: 18 g
Distilled water	: 1000 ml
pH	: 6.8-7.2

2. ROSE BENGAL AGAR MEDIA (FOR FUNGUS)

Papaic digest of soyabean meal	: 5 g
Dextrose	: 10 g
Monopotassium phosphate	: 1 g
Magnesium sulphate	: 0.50 g
Rose Bengal	: 0.05 g
Agar	: 15 g
pH	: 5.6

3. SABAURAUD DEXTROSE AGAR (FOR YEAST)

Mycological peptone	: 10 g
Dextrose	: 40 g
Agar	: 15 g
Distilled water	: 1000 ml
pH	: 5.6

OPTIMIZATION OF METHODS FOR JUICE EXTRACTION AND VALUE ADDITION OF PASSION FRUIT (*Passiflora edulis* Sims)

By

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(2014-12-120)

ABSTRACT OF THE THESIS

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ABSTRACT

Passion fruit (*Passiflora edulis* Sims) belongs to the family Passifloraceae, which have two distinct forms, the standard purple (*Passiflora edulis* Sims f. *edulis*) and the yellow (*Passiflora edulis* f. *flavicarpa*). The fruits are valued for its captivating flavour, nutritional benefits and medicinal properties. In the recent past cultivation and consumption of passion fruit have increased and in this context, the present investigation "Optimization of methods for juice extraction and value addition of passion fruit (*Passiflora edulis* Sims)" was taken up. The objective of the study was to select types with ideal processing attributes and to standardize technology for juice extraction and value addition.

Yellow and purple accessions collected from different localities were evaluated for their physico-chemical attributes along with the variety, Kaveri (purple type) released by the Central Horticultural Experiment Station (CHES), Chettali. The study revealed that the accessions differed significantly for different physical and biochemical traits analysed. Among the yellow accessions, Acc.1 collected from orange and vegetable farm, Nelliyampathi, possessed the highest mean fruit weight (98.27 g) and percentage juice recovery (35.38%), low rind content (46.05%), highest TSS (19.43^0 Brix), high ascorbic acid (25.94 mg $100g^{-1}$) and total carotenoid content (2.81 mg $100g^{-1}$). Among the purple accessions, Acc.7 recorded highest percentage juice recovery (36.79 %), low rind content (46.55%), high TSS (19.20^0 Brix), total sugar (11.56 %) and ascorbic acid content (32.51 mg $100g^{-1}$). Hence Acc.1 in yellow and Acc.7 in purple types were selected for further studies along with variety Kaveri.

Three methods of juice extraction (enzymatic, mechanical and conventional methods) were compared to identify the most efficient method. Among the different enzymatic treatments tried pectinase 5 ml per litre incubated at 50° C for 90 minutes was found ideal. This treatment yielded more quantity of juice (74.91% in Acc.1, 74.20% in Acc.7 and 72.74% in Kaveri) with high TSS (19.56^0 Brix in Acc.1, 19.83^0 Brix in Acc.7 and 19.7^0 Brix in Kaveri), acidity (3.12% in Acc.1, 3.24% in

Acc.7 and 3.23% in Kaveri) and total sugars (9.51% in Acc.1, 11.61% in Acc.7 and 10.95% in Kaveri). The juice yield was comparatively less in mechanical and conventional method of extraction. The result was same for all the accessions tried.

Sweetened juice, RTS beverage, carbonated drink and jam were prepared as part of product development. Sweetened juice and RTS beverage prepared by blending of passion fruit juice and cashew apple juice in 3:1 ratio was found more acceptable than that prepared with passion fruit juice or cashew apple juice alone. For preparation of carbonated drink blending of passion fruit juice and cashew apple juice in 1:1 ratio was found better in the case of Acc.1 (yellow type) whereas blending of passion fruit juice and cashew apple juice in 3:1 ratio was good for Acc.7 (purple type) and Kaveri. Blending rind pulp with cashew apple pulp in 1:3 ratio in Acc.1 (yellow type), 3:1 ratio in Acc.7 (purple type) and 1:1 ratio in Kaveri was found to produce the most acceptable jam.

The shelf life of RTS beverage and jam was studied by storing the products and taking the observations on biochemical characters, sensory attributes and microbial load at monthly intervals. In RTS beverage fungal population was present beyond acceptable limit at four months after storage. In the case of jam the sensory attributes recorded a drastic reduction at three months after storage. Further studies are required to improve the shelf life and acceptability of RTS and jam.