Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)

By

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(2005-12-108)

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COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR-680 656

KERALA, INDIA

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THESIS

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DEPARTMENT OF PROCESSING TECHNOLOGY

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2008

DECLARATION

I hereby declare that the thesis entitled **"Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)"** 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 **"Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)"** is a record of research work done independently by Mrs. Anu Mary Markose (2005-12-108) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Anu Mary Markose

★★★★★★★★★★

Dedicated to my
beloved family

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Introduction

1. INTRODUCTION

India is emerging as a major stake holder in the global horticulture scenario accounting for 10 % of the world production in fruits and 13.38 % in vegetable production (Shikamany, 2006). Apart from major fruit crops, many minor fruits also contribute to this national wealth. They are categorised as underutilized as they lack recognised orcharding and little is known about their utilization and value addition.

Even though India possess a variety of underutilized fruits like gooseberry, guava, sapota, pummelo, rose apple, passion fruit, pomegranate, jackfruit, *etc*., concerted efforts have been taken up only to a limited extend to bring out their phytonutrient and phytoceutical properties and standardization of technology for processing and value addition.

In recent years there is considerable awareness about the nutritional security and food safety and in this context more emphasis is given to underutilized fruit and vegetable crops due to their high nutritional and medicinal value (Peter *et al*., 2006).

Watery rose apple and Malay apple belong to the group of underexploited fruit crops which have high potential for promotion to put into wide variety of uses. Watery rose apple (*Syzygium aqueum* (Burm) Alston) occurs in tropical countries. It is easily propagated from fresh seed and cuttings. Fruiting is seasonal but there can be two or three crops per year. Malay apple (*Syzygium malaccense* (L.) Mernil and Perry) is indigenous to Malay Archipelago. Flowers are crimson pink with numerous long stamens (Radha and Mathew, 2007).

They are grown mainly in homesteads of Kerala and the fruits are consumed mainly in their fresh form. A single tree bears 21 to 85 kg per tree and a major chunk of production (90%) is being wasted (Whistler and Elevitch, 2006). This is mainly due to lack of scientific post harvest handling, processing and value addition technique for watery rose apple fruits. Very little is known about their physico chemical attributes and possibility of exploiting the different types for preparation of products. Unlike in major fruit crops works highlighting the type suitability for product development is lacking in minor fruits. For exploiting the potential of minor fruits in full for product development this knowledge is prime important and hence in the present study attempts were made to identify the types suitable for preparation of different value added products. The quality of products depends upon the optimised processes and hence different processes were tried to develop quality products. Considering the various aspects the present study was taken up with the following objectives:

1. Analyzing the physico chemical attributes of watery rose apple (pink and white watery rose apple) and Malay apple
2. Identifying the product suitability of different types
3. Developing processes for extraction of quality pulp/juice
4. Standardizing technology for preparation of value added products
5. Extracting colour from Malay apple flowers and pink watery rose apple fruits and utilizing the colour in products

In the present scenario of changing food habits, health awareness, increased demand of new and improved processed products, assessment of nutritional properties of rose apple and standardization of technology for processing and value addition will be of immense use.

Review of Literature

2. REVIEW OF LITERATURE

Two species of *Syzygium* are commonly seen in the homestead gardens of Asia. They are watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry*)*. Both belong to the family of Myrtaceae.

2.1. Description

Watery rose apple grows as a tree of eight to ten meters height, leaves are opposite, subsessile and oblong to lanceolate. Flowers are produced terminally or as axillary cymes, 2 to 3 cm long, white in colour. Fruits are flattened at ends, white, rose or red in colour, juicy, spongy, sweet acidic, watery, seeds 2 to 6 in number (Radha and Mathew, 2007). There are two types with pale rose fruits and white fruits. Flowering season is February-March and fruits become mature during May-June. Red and white Jambu are seen in Indonesia. Ripe fruits are eaten fresh or can be made into syrup and beverages. Red types are small, sweet and juicy while white types are very acidic (Elizabeth and Hyde, 2007). Fruit is about one inch long and one and a half inch wide and they are pear shaped with narrow neck and wide apex.

Malay apple is a beautiful tree which grows 6 to 20 m height with deep green glossy foliage. Flowers are produced in cymes on older branches, crimson pink sessile and 5 to 7 cm in diameter with numerous long stamens. Fruits of Malay apple are oblong or pyriform, 8 cm long, reddish pink or white striped crimson pink, flesh white, seeds are large with one or two in number. Fruit flesh is thick, juicy and fragrant. Fruits are eaten in fresh forms or can be used with other fruits for making jams and pickles (Radha and Mathew, 2007).

2.2. Importance of fruits in our diet

Fruits, as a source of nutrition have a very important role in the human diet. In the developing countries, fruits of high nutritive value must get priority over those having attractive appearance (Purohit, 1991). As per the report of Manson (1994) people who eat more fruits and vegetables have 54 per cent lower risk of getting heart stroke when compared to those who eat the least.

There are some trace elements required by the body like copper, manganese and zinc which act as enzyme cofactors. These are found in appreciable amounts in fruits. Fruits in general provide dietary fibre essential for bowel movement and possibly for prevention of diseases like appendicitis, colon cancer, diabetes, obesity, *etc.* (Roy, 2001a).

Fruits are essential for normal physiological well being and help in maintaining health status through development of resistance against pathogens. They also contain mineral salts, the deficiency of which can lead to disturbance of metabolism. Their pectin and cellulose contents help in stimulating the intestinal activity (Bal, 2002).

Among the well known phytochemicals found in fruits, β carotene and lycopene are the most powerful antioxidants. Recently, β carotene has been approved for the general treatment of erythropoetic protoporphyria, a genetically inherited light sensitive disease (Sarma, 2003). As most of the fruits are eaten in fresh forms, some of the digestive enzymes such as proteolytic enzymes may help in better digestion of the nutrients in foods (Singh, 2004).

2.3. Need for processing of fruits

Processing of fruits can be defined as adding value to conventional and innovative fruit items, through various permutations and combinations providing protection, preservation, packaging, convenience, carriage and disposability (Rao, 1989).

In addition to major fruits a large number of minor fruits, accounting for about 5.53 million tones are produced in the country but the utilization of fruits by processing industry is only one per cent (Sethi, 1993). Food processing have to play an increasing market role, as demand credited both by population growth and by requirement for improved nutrition, generates a need for an estimated 60 per cent increase in available food stuffs (Walker, 1993). The food industry can provide processed fruit products at reasonable and steady prices throughout the year, meeting the requirements of defense forces in border area and earning foreign exchange for the country by development of exports (Shaw *et al*., 1993).

Fruits are perishable and are available in surplus during certain parts of the year in different regions and are wasted due to absence of facilities and know how for proper handling, distribution, marketing and storage. The processing of indigenous fruits like the bael, kiwi, phalsa, aonla, passion fruit, papaya, jamun, karonda, *etc.* could help the even distribution of fruits from place of abundance to the place of scarcity.The availability of fruit products even during offseason and at reasonable price could be ensured thereby improving the percapita availability as well as consumption (Roy and Pal, 2000).

Apart from traditional fruits, there are numerous nontraditional fruits such as jack fruit, phalsa, pumello, aonla, bael and jamun which can supplement carotene, vitamin C, riboflavin, calcium and iron which could help to satisfy our dietary needs of nutrition (Rathore, 2001).

India is the largest producer of fruits in the world accounting for 10 per cent of the world production (Peter *et al*., 2006). In spite of the highest fruit production the average Indians do not get the basic daily requirement of fruits due to wastage and value destruction. If the fresh and the processed fruits are evenly marketed from the place of abundance to the place of scarcity, not only will the consumer get the produce at a reasonable price but also the producer will not be forced to sell at throw away prices (Roy, 2001b).

The underutilized fruits like tamarind, aonla, karonda, jack fruit etc have the ability to grow under average conditions and are known for their therapeutic and nutritive values. However some of these fruits are not acceptable in fresh form due to their acidic nature and astringent taste. There is a need to create demand for such crops in domestic and international markets. This to some extend can be achieved through processing (Gajanana, 2006).

2.4. Variability in processing attributes of minor fruits

A study was made on different physico chemical aspects of guava by Chan and Kowk (1975). Predominant sugars present in guava were fructose 59 per cent, glucose 36 per cent and sucrose 5 per cent Mazumdar (1979) studied the physico chemical properties of rose apple. It was reported that the average weight per fruit was 11 to 38 g with total titrable acidity 0.1 per cent, total soluble solids (TSS) 10.2 °Brix, total sugars 4.58 per cent, reducing sugars 4.11 per cent and non reducing sugars 0.44 per cent. Fruits were round or oval, 2.5 to 5 cm in length.

Mitra (1983) reported that guava fruit showed a variation in TSS from 8.2 to 10.5 °Brix and pink fleshed cultivars had low ascorbic acid content than white fleshed. Shulman *et al.* (1984) observed that total soluble solids and anthocyanins increased during maturation while acidity reduced in jambolan fruits.

Jamun fruits of smaller types are used in beverage industry as they contain high amount of tannin and anthocyanins (Anon, 1986). Keskar *et al.* (1989) reported wide variability in fruit weight (3.5 to 16.5 g), pulp content (54.29 to 85.7 per cent), TSS (4.5 to 17 per cent) and acidity (0.16 to 0.554 per cent) in jamun.

Studies in physico chemical properties of fruits are very important. Apart from studies in major fruit crops in this area, studies in minor fruits had also been done for putting them to use. At Regional Research Station Aruppukottai, Tamil Nadu, twenty types of jamun were collected which exhibited wide variability in size of the fruit, pulp content, seed size, stem colour, juice colour and also regularity in bearing (Subramaniyam *et al.,* 1989).

Starch, non reducing sugars, chlorophyll, carotenoids and phenols showed a declining trend while anthocyanins and TSS increased during ripening of jambolan fruit (Venkitakrishnan *et al*. 1997). It was concluded that in jambolan fruit, starch and non reducing sugar declined whereas the total soluble sugar content increased with increase in reducing sugar. Nakasone and Paul (1998) reported that ascorbic acid was located mainly in skin and in lower concentration in the flesh of guava fruit.

Singh *et al.* (1999) examined eight genotypes of jamun. Based on the fruit shape, they were grouped into two categories as ovoid and oblong. Oblong types had more fruit weight and less seed weight. Pectin content was also more in oblong group.

Neog and Mohan (1991) observed that the fruits of carambola contained moisture 91.4 per cent, TSS 8 °Brix, titrable acidity 0.57 per cent, reducing sugar 6.25 per cent and total sugars 10.85 per cent. Ghosh and Chattopadhyay (1993) analyzed the different characters of loquat fruit. The fruit weight recorded was 10.28 g, pulp thickness 1.02 cm, specific gravity 0.85, TSS content 6.9 °Brix and ascorbic acid concentration 3.93 mg/100g edible pulp.

Shanker *et al*. (1999) and Chanbey (2001) studied the physical changes such as weight, volume, colour and specific gravity of litchi fruit. Arce *et al*. (2000) observed that total soluble content was 10 to 12 per cent, acidity 0.15 per cent and total sugar was 3 to 4.5 per cent in sapota mamey fruit. Anthocyanin content of litchi fruit was negatively correlated with pH, titrable acidity and TSS content of pulp (Bhattacharjee *et al.*, 2001). Narain *et al.* (2001) noticed that the fruit of carombola was oblong in shape with an average length of 7.92 cm and width of 5.24 cm.

Matsura *et al.* (2001) analyzed the physico chemical characteristics of Barbados cherry and reported that this minor fruit had high vitamin C content. Al-Maiman and Ahmed (2002) studied the physico chemical characteristics of pomegranate and reported that edible portion of pomegranate comprised 63.58 per cent of juice and 36.21 per cent of seeds.

2.5. Significance and value addition of underexploited fruits

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

2.6. Production of quality pulp/juice

2.6.1. Heat Treatment

Blanching accelerates the actual drying process and helps in maintaining the quality of the product during processing and storage (Pawar *et al.,* 1985). Siddappa *et al.* (1986) defined blanching as treating the fruits and vegetables with boiling water and steam for short period, followed by cooling before processing.

According to Kalra (1990) blanching was a partial precooking method in which fruits and vegetables were usually heated in water or on live steam. It was further reported that blanching may extend shelf life quality and the organoleptic quality of the products. A decrease in volume, nutritive value, loss of natural colour and flavour were also observed due to blanching.

A comparative study was carried out by Scow *et al*. (1991) on the effect of low and high temperature blanching on the firmness of canned and frozen fruits. The study revealed that low temperature blanched canned guava and papaya were significantly firmer than high temperature blanched products.

Blanching is reported to conserve nutrients as revealed in studies conducted by Sian and Ishak (1991). Better retention of carotenoids was recorded in papaya and pineapple after blanching. It was further observed that carotenoids decreased progressively as the blanching temperature (100 °C) and time (14 minutes) increased and carotenoids were found to be retained well with higher moisture, and sugar.

Experiment conducted by Shah and Bains (1992) on peach and apricot pulps, showed that blanching prior to pulping at a temperature of 92.5±21.5 °C for 3-5 minutes resulted in better shelf life qualities. Sharma *et al.* (1993) reported that blanched apricots, while drying showed low discolouration compared to untreated fruits.

Maximum yield of jamun juice with a high level of anthocyanin and other soluble constituents was obtained by grating the fruits, heating them to 70 °C and passing the heated mass through a basket press (Farooqi and Sadhu, 1999). It could be concentrated in an open pan evaporator or a vacuum concentrator.

Shashikumar and Khurdiya (2002) conducted studies on extraction of juice from aonla. Blanching of fruits at 100 °C for 6 minutes prior to juice extraction improved the juice recovery but reduced vitamin C by 12 per cent as compared to unblanched fruits. The density and tannin content of the juice were also more. This might be due to slight concentration and better extraction of soluble constituents in the juice upon heating. TSS, acidity and pH of the juice did not differ significantly due to blanching.

Jain and Asati (2004) evaluated the suitability of different guava cultivars for pulp preparation. The fruit pieces were boiled before pulping. Sensory evaluation of pulp was carried out by a panel of judges. Method given by Amerine *et al.* (1965) was adopted with a 9 point Hedonic scale. TSS, acidity and ascorbic acid content were determined according to AOAC (1980) methods. They concluded that Allahabad Safeda was best for pulp preparation. Effect of pretreatments on the quality of dried litchis was studied by Agarwal and Nath

(2006). It was reported that blanching in boiling water reduced the browning during storage.

2.6.2. Enzyme Treatment

Munyanganizi and Coppens (1976) compared two methods of extracting banana juice *viz*. treating banana pulp with rapidase 0.01 to 0.05 per cent and CaO treatment. The enzymatic process gave a juice yield of 88 per cent. The juice was dark brown with more flavour while the CaO treatment gave a juice yield of 82 per cent which was pale yellow with less flavour.

Viquez *et al.* (1981) found that treatment of banana pulp with ultrazyme 0.025 per cent by weight at 45 °C for two hours gave juice yields of more than 66 per cent while the untreated pulp gave juice yields of only 5 to 27 per cent.

An enzymatic treatment method has been developed to hasten the production of clear juice from grapes. Juice was treated with 0.04 per cent ultrazyme 100 G at 45 °C for 2 hours and cold stored for 2 days at 2 °C and clear juice filtered and bottled (Khalil, 1990).

Pheantaveerat and Anprung (1993) compared commercially available pectinases, cellulases, and amylases for hydrolysis of ripe banana pulp. Juice yield of 73 per cent was obtained when banana pulp was incubated with 0.06 per cent cellulases and 0.05 per cent pectinases at 45 °C for two hours. Results suggested that amylases were not effective in the production of banana juice.

Sims and Bates (1994) found that a combination of pectinase, cellulase and hemicellulase were the most effective of all enzyme system in reducing viscosity and improving filterability of banana juice. Shahadan and Abdhullah (1995) found that the optimal juice extraction conditions in banana were 0.42 per cent pectinase enzyme, pulp pH of 3.4 and incubation at 35 °C for 4 hours.

Among various methods evaluated for extraction of pulp, the recovery of sapota pulp was higher (82.3 %) in enzyme extraction process but quality was found better in cold extraction process with a recovery percentage of 79.74 per cent (Dengale *et al.,* 1998).

Thakur *et al.* (1999) obtained higher serum yield in kinnow treated with 0.8 per cent pectinolytic enzyme at 40 °C for four hours. Treatment of ber pulp with 0.6 per cent pectinase 3 XL or 0.4 per cent Trizyme P- 50 gave higher recoveries of clarified juice (Wasker and Garande, 1999).

Singh *et al.* (2000) reported that 30 minute liquefaction of mango pulp with 1.1 ml of pectinase enzyme per kg was optimal for recovery of clear mango juice. Devaraju *et al.* (2002) obtained clarified ber juice by treating ber pulp with pectinase at the rate of 4 g/kg for 12 to 24 hours.

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. Gowda (2002) studied the enzymatic liquefaction of jack fruit pulp. Highest juice yield was observed with 0.12 per cent pectinex-ultra incubated at 45 °C for 3 hours.

Process development for production of clarified juice in guava was done by Anantha and Shukla (2005). Pulp was treated with 5 levels of pectinase enzyme (by weight of fruit pulp). Maximum juice yield (94 per cent) was obtained at 2 per cent enzyme concentration, 20 hours of incubation time at a pH 4.5 and temperature 30 °C.

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/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.

2.7. Osmotic dehydration

Osmotic dehydration is a novel technique for partial dehydration of fruits which consists of placing fruit pieces in dry or concentrated solution of sugar for a period of time resulting in water loss accompanied by solute impregnation. Literature related to osmotic dehydration of fruit in general is reviewed here.

The fruit immersed either as whole or in slice in sugar syrup lost about 50 per cent of its original weight by osmotic dehydration after which it was drained and either frozen or vacuum dried. The resultant product was with superior quality in terms of colour and flavour than conventionally dried food products (Ponting *et al.*, 1966).

Osmotic dehydration of banana slices in sugar syrup of concentration varying from 60 to 80 °Brix at temperature of 27, 40, 50 and 60 °C revealed that fruit weight was reduced to 50 per cent of its original weight at 50 °C. The extent and rate of osmosis was greater when dry sucrose powder was used at the rate 1:2 (fruit: sugar) than in the syrups, but for convenience in handling and economy a ratio of 1:1 seemed to be suitable. The reconstitution of osmotically dehydrated banana slices was only 50 to 60 per cent as compared to 63 to 65 per cent for air dried slice (Bongirwar and Sreenivasan, 1977).

According to Setty *et al.* (1978) the main principle involved in osmotic dehydration is partial dehydration of fruits and vegetables by osmosis at comparatively lower temperature. This reduced the severity of thermal treatment in the production of dehydrated fruits and vegetables and the product obtained was near to fresh produce.

Preparation of intermediate moisture banana by air drying of sulphited banana slices revealed that SO_2 treatment increased the firmness of banana by inactivating the proteolytic enzymes and also increased the dehydration rate by affecting the permeability of certain cellular membrane in banana tissue (Levi *et al.*, 1980).

Thapa (1980) attempted osmotic dehydration of segmented sapota and recommended 25 hours of osmotic dehydration at room temperature with a fruit:syrup ratio of 1:3 and subsequent oven drying for eight hours as the best among all the treatments. Sundried product did not retain the flavour, whereas air dried product retained the flavour. In order to reconstitute fully, six hours of soaking the product in 20 °Brix syrup was recommended.

Contreras and Smyrl (1981) noted that osmosis was effective in preventing fruit discoloration by enzymatic and oxidative browning. Drying time needed for cabinet drying after osmotic drying was considerably shortened and significantly saved energy (Levi *et al.*, 1983). Bolin *et al.* (1983) revealed that syrup remaining after osmotic dehydration could be recycled as table syrup, concentrated beverage, wines and jellies. Levi *et al.* (1985) reported that retention of ascorbic acid was high in osmo air dried papaya slices compared to sun dried slices.

Vaghani and Chundawat (1986) opined that sapota slices steeped in 40 per cent sugar solution containing KMS (1 per cent) for 20 minutes or dipped in KMS 20 per cent for 2 minutes when dried in sun gave the most stable and quality product. Osmotic dehydration would reduce the processing time in blueberry according to Angela *et al.* (1987)

Tomar *et al.* (1990) reported that osmotically dehydrated 7.5 mm thick pear rings by steeping in sugar syrups of 40, 50, 60 and 70 °Brix resulted in a weight reduction of 32 to 40 per cent. Shahabuddin and Hawladaar (1990) reported that osmotic dehydration alone could remove 30 to 40 per cent water content of pineapple fruit. Rahman (1992) pointed out that osmotic dehydration improved the quality of products in terms of colour, flavour, aroma and texture.

According to Chaudhari *et al.* (1993) in osmotic dehydration process, there is a simultaneous counter current mass transfer of water from solution to hypertonic solution and of solute from solution in to the sample. It was stated that osmotic dehydration process could be applied to fruits like apple, apricot, banana, blueberry, citrus fruits, grapes, guava, mango, melon, papaya and pineapple.

As compared to single drying process, osmotic dehydration results in a two fold transformation of food items by both, a decrease in water content and solute incorporation. Solute uptake during osmotic dehydration modifies the composition and taste of final product. Further partial dehydration and solute uptake protect fruit slices against structural collapse during terminal drying (Raoult, 1994). Papaya slices of 15 mm thickness osmotically dehydrated by moisture infusion technique by overnight soaking in a solution containing 60 per cent sucrose, 0.1 per cent citric acid and 0.1 per cent potassium sorbate reached equilibrium at 44 °Brix (Ahmed and Choudhary, 1995).

Osmotic dehydration of sapota slices (0.5 to 1 cm thick) using dry sugar containing 1500 ppm SO_2 and 0.3 per cent citric acid in the ratio of 1:1 for eight hours followed by oven drying for eight hours yielded good quality sapota chunks (Maya, 1999). Heating of ripe mango (cv. Dasehari) slices in an equal weight of sugar syrup (70 °Brix) containing 0.1 per cent KMS at 90 °C for 2 minutes followed by drying in cabinet drier at 60 °C gave the best dehydrated product (Sagar and Khurdiya, 2000).

Amitabh *et al*. (2000) reported that mango slices of Dashehari steeped for 18 hours in 70 °Brix sugar syrup containing 0.5 per cent citric acid gave better dehydrated product. Pokharkar and Mahale (2000) observed that osmotic dehydration of banana slices in 65 °Brix followed by cabinet drying at 46 °C for 9 to 16 hours gave a bright yellow product which was chewy with moisture content of 19.4 per cent.

Bawa and Gujral (2000) evaluated the effect of some osmotic solutions (sucrose and honey) on water loss and solid gain of raisins. The rate of moisture loss in the fruit varied with both the osmotic agents as well as their concentration. The sensory scores indicated that honey treated samples gave better flavour while sugar treated ones gave better colour and overall acceptability.

Dehydration ratio of dehydrated potato slices was good in osmotic dehydration followed by brine blanching and KMS (Kad *et al.*, 2001). Kalsi and

Dhawan (2001) prepared guava powder by osmotic dehydration. Guava slices were blanched in boiling water for two minutes and immersed in 70 °Brix sugar syrup overnight followed by cabinet drying at 65 °C. The recovery percentage was found to be 5.7 per cent.

Osmotic drying caused a reduction in anthocyanin in cranberries due to leaching in the syrup (Gir bowsk *et al.*, 2002). Janowicz *et al.* (2002) analyzed mass exchange during osmotic dehydration of fruits with different internal structures. Strawberry (Ducat), cherries (Groniasta), black currants (Ojebyn) and plums (Wegierha) were analyzed. Lowering of water content in cherries was maximum upto 57 per cent after 24 hours. The lowest water removal was observed in black currants, at about 9 per cent after 24 hours.

Cashew apples (*Anacardium occidentale*) were dried under the sun after osmotic pretreatment in order to obtain a product with intermediate moisture content. Four osmotic pretreatments were tested *viz.,* immersion in sucrose solutions of 45, 55 and 65 °Brix and immersion in sequenced solutions of 45, 55, 65 °Brix. The processing involved enzymatic inactivation of fruits, osmotic dehydration in sucrose solutions (added with preservatives) and solar drying. After drying, the products were packed and stored for 180 days at room temperature (28 °C). During the entire processing and after obtaining the final product, physico chemical, microbiological and sensory analyses were conducted. The results showed that the products have good stability under all the conditions studied (Brandao *et al.,* 2003).

Osmotic dehydration is rather a new innovation for producing better quality dehydrated products. It is a technique that makes possible the processing of fruits, obtaining self stable products or even functional foods by incorporation of physiologically active substance. In addition, combination of osmotic dehydration with traditional process, such as drying or freeze drying, has showed to reduce time of processing and improve the characteristics of final product (Sousa *et al.*, 2003).

Rashmi *et al*. (2005) standardized the osmo air dehydration of pineapple fruits. Sugar syrup of 50, 60 and 70 °Brix were prepared and while boiling the syrup, 0.2 per cent of citric acid was added. Prepared fruit pieces were put in sugar solution in 1:2 proportion and left for 24 hours for osmosis. After osmosis, fruit pieces were dried in a tray drier initially at a temperature of 60 °C followed by 40 to 45 °C. It was reported that the physico chemical composition and sensory quality of pineapple fruits was better in 60 °Brix. Various pretreatment and drying techniques were employed for dehydration of fig (Habeeba, 2005). Osmotic dehydration was found to be the best method of drying for both local and commercial types.

Osmotic drying consists of removing a percentage of moisture from fruits or vegetables by placing them in a concentrated solution of sugar, salt or a combination of both. Products get reduced to 50 per cent of original weight. This partial drying is accompanied by solar drying, vacuum drying, freeze drying or cabinet drying. Sugar syrup will protect the colour and flavour during drying process. Product had a porous texture and retains a large percentage of flavour volatiles of fresh food (Sudheer and Indira, 2007).

2.8. Storage study of osmotically dehydrated fruit

Keeping the osmotic dehydrated mango slices above 64.8 per cent and below 75.7 per cent relative humidity could prolong the shelf life. Relative humidity would be conducive to the retention of colour and flavour (Amitabh and Tomar, 2000). According to Bera *et al*. (2001) the growth of fungi and bacteria in the food samples were influenced by moisture content, high or low relative humidity, temperature of storage and type of samples. Saima (2002) reported that candy, preserve, jelly and tuti fruit under ambient and refrigerated storage were found to be free from fungi and bacteria up to six months.

During storage of dried figs in air the rates of oxygen uptake and ethylene production declined substantially and fruit weight loss increased up to 2.1 per cent. Storage in two per cent oxygen resulted in further reduction of oxygen uptake and ethylene production rates. Fruits stored in air showed decreased firmness, ethylene production rate but no significant changes in respiratory quotient, oxygen uptake and CO_2 production rates, soluble solids content, titrable acidity. Two per cent O_2 is recommended for better firmness retention during storage for longer than eight days (Tsantilli *et al*., 2003).

Between the packaging materials tried, aluminium foil laminated pouches was better than polyethylene and among the packaging methods, vacuum packed samples in aluminium foil laminated pouches retained the maximum quality of osmodehydrated fig throughout the storage period (Habeeba, 2005). It was also reported that there were no traces of yeast found in the osmodehydrated fig up to four months of storage.

2.9. Products from minor fruits

Jamun is an indigenous fruit having an attractive colour and excellent taste. It could be profitably used for beverage industry. The juice of ripe jamun fruit was used for preparing syrup and wine (Khurdiya and Roy, 1985). According to Jain *et al.* (1984) a good quality guava RTS beverage could be prepared with fruit pulp content of 5 to 10 per cent, TSS 12.5 per cent and acidity 0.25 per cent. Products like syrup, jam and jelly were prepared from fig other than dried and dehydrated products (Woodroof, 1985). Ramdas (1988) prepared squashes, cordials, syrups and jellies from the pulp of passion fruit.

A product containing five to six per cent alcohol, three to four per cent sugar and 0.35 per cent acid was prepared from litchi. This was chilled and used as an appetizing soft drink (Vyas and Joshi, 1982). Jack fruit could be utilized for making squash, preserve, pickle, dehydrated leather and thin papads (Lavania, 1990). Papaya RTS containing 25 per cent pulp, 9.5 per cent sugar (15 °Brix) and 65 per cent water was highly acceptable (Thirumaran *et al.*, 1992). Majeed (1995) used karonda for making pickles, chutney, candy and wine. Fruit colour is an important quality trait for consumer preference in litchi. Litchi fruit peel was found to have more than 70 sugar acid ratio and 35 milligram per 100 gram anthocyanin which was highly useful for preparation of good quality and a consumer appealing product (Hans and Chattopadhyay, 1997). Pomegranate was suitable for making jam, marmalade, jelly, squash *etc.* (Artes and Barberan, 2000).

Joy (2003) made an attempt for the utilization of selected underexploited fruits like bilimbi, rose apple and lovi-lovi for product development. Products prepared were bilimbi jam, bilimbi pickle, rose apple squash, lovi-lovi preserve in sugar and brine. Regarding the sensory evaluation of the products, products from rose apple had highest overall acceptability followed by lovi-lovi and the least for bilimbi.

Fresh fruits of aonla were commonly used for making murabba, pickles and jelly. An alternate product, aonla segments in syrup had been developed at Central Institute for Subtropical Horticulture, Lucknow. It took only seven to eight days for the preparation of segments in syrup as against 20 to 25 days required for preparing the aonla preserve. This product was devoid of any fibre and stone. Here the segments were separated from the fruit by blanching (Tandon and Kumar, 2005).

Quality juice was made from the rind of *Garcinia indica* (Rao *et al*., 2006). This juice contain high antioxidants and radical scavenging capacities due to their higher flavonoids, anthocyanins and phenol contents The processed products like murabba and candy prepared from bael fruit, achieved market acceptability (Tandon and Kumar, 2006). Rokhade *et al.* (2006) standardized a highly acceptable RTS beverage from jamun consisting of juice 14 per cent, citric acid 0.15 per cent and total soluble solids 14 °Brix.

A study was made on the value addition and quality evaluation of West Indian cherry by Jyothi (2006). One fruit of West Indian cherry was found to furnish 53 to 176 milligram of ascorbic acid and thus supply the daily requirement. In this study, products such as squash, pickle, sauce and preserve were made. Even though products showed high acceptability initially, the products showed a decrease in acceptability with storage.

2.10. Natural food colour-Anthocyanin

Anthocyanins are one of the major flavonoid classes which are a very widespread group of phytochemicals (Gross, 1987). They are water soluble pigments responsible for blue, purple, violet, magenta, red and orange colours. The use of this natural colour is limited due to its instability due to pH, temperature and light. However, the recent concern over the safety of using synthetic colours in food industry has encouraged the development and application of natural food colorants. The natural food colorants are considered safer than the synthetic colours since they are produced by edible plants. Furthermore, toxicological data on anthocyanins support the claim that anthocyanins are harmless to human health (Jackman and Smith, 1996).

The word 'anthocyanin' is derived from two Greek words, 'anthos' (flower) and 'kyanos' (blue). While there are numerous compounds belonging to anthocyanin group of biochemicals, only a few possess the specific chemical structures which maximize their stability and hence their suitability for extraction (Francis, 1989).

Moreover, intake of anthocyanins lead to health benefits such as antioxidation (Kahkonen *et al.,* 2003), the ability to inhibit oxidation of human low density lipoprotein (Heinonen *et al.,* 1998; Tomera, 1999), suppression of tumour cell growth (Kamei *et al.,* 1995) contribution factor in reduction of age-related deficits (Goyarzu *et al.,* 2004), antibacterial, antiviral and vasodilatory effects (Chaudhuri *et al.,* 2004).

The primary function of anthocyanins in plant cell is protection. Anthocyanins are also involved in resistance to varied stresses such as drought, frost, photo oxidation, and heavy metal (Gould, 2004). Furthermore, the accumulation of this pigment at the injured sites suggests that anthocyanins help defending against viral or microbial infection. This particular function is of interest due to the potential use in functional foods.

2.10.1. Distribution

Anthocyanins in nature are found to be the characteristic of flowering plants and occur mostly in both flowers and fruits. The major sources of anthocyanins as a food component for humans are included under the families Vitaceae (grape), Rosaceae (cherry, plum, raspberry, strawberry, blackberry, apple, and peach), and Ericaceae (blueberry and cranberry). Many of food plants also contain other pigments apart from anthocyanins such as chalcones, aurones, carotenoids, and chlorophylls (Jackman and Smith, 1996).

2.10.2. Factors that affect anthocyanin colour and stability

pH

Anthocyanin was found to behave as pH-indicator in aqueous media. With changes of pH, anthocyanin exhibited intermolecular transformation. At pH 1, they are highly coloured as flavylium cations. With increase in pH, the colour gradually faded to colourless. At pH higher than six they expressed colours (Gross, 1987; Jackman and Smith, 1996).

Temperature

Markakis *et al.*, (1957) recommended high temperature-short time heat treatment, for preparation of strawberry preserve which caused less pigment destruction than the low temperature-long time treatment. Interactions among heat, anthocyanin content, and food composition may significantly affect the stability of anthocyanins in foods (Keith and Powers, 1965).

As for most chemical reactions, the stability of anthocyanins and the rate of their degradation were significantly influenced by temperature. Methoxylation, glycosylation and acylation, helped to increase thermal stability of anthocyanins (Hrazdina *et al.*, 1970).

Anthocyanin degradation was found to be pH-independent under anaerobic conditions (Adams, 1973). The number and nature of glycosyl groups influenced the rate and the mechanism of thermal degradation of anthocyanin. When the degradation occurred, all anthocyanidins underwent a similar pattern with chalcone as an intermediate product. Further breakdown of chalcone produces carboxylic acids (Jackman and Smith, 1996).

Oxygen and hydrogen peroxide

The destruction of anthocyanins resulted from indirect oxidation by hydrogen peroxide (H_2O_2) which was formed during aerobic oxidation of ascorbic acid (Sondheimer and Kertesz, 1952). Precipitate or cloudiness development in fruit juices resulted from direct oxidation of hemiacetal or chalcone species (Lukton *et al*., 1956).

Keith and Powers (1965) found that addition of H_2O_2 caused rapid discolouration of pelargonidn 3-glucoside solution. Oxygen caused degradation of anthocyanins by a direct oxidation mechanism or by indirect oxidation. Ascorbic acid and oxygen acted synergistically in anthocyanin degradation. Maximum pigment loss occurred under high concentrations of oxygen and ascorbic acid (Taylor, 1984). The oxidation products could affect further degradation or polymerization reaction of anthocyanins (Jackman and Smith, 1996).

Light

Anthocyanins are reported to be generally unstable when exposed to UV or visible light or other sources of ionizing radiation (Sweeny *et al*., 1981). Co-pigmentation could accelerate or retard the decomposition depending on the nature of the co-pigment. For example, Polyhydroxylated flavone, isoflavone, or auronesulfonates are used as co-pigment to improve the photostability in cyanidin 3-rutinoside. Light causes an increase in the rate at which anthocyanins undergo thermal degradation by formation of a flavylium cation excited state (Furtado *et al*., 1993). Photoxidation of anthocyanins yielded the same products as thermal degradation, such as 2, 4, 6-trihydroxybenzaldehyde and substituted benzoic acids (Piffault *et al*., 1994).

Enzymes

Fungal anthocyanases were used to remove excess anthocyanins from blackberry jams and jellies that were too dark and unattractive (Yang and Steel, 1958). The same preparation was also recommended for the use in the processing of white wine from mature red grapes (Huang, 1959). In contrast, anthocyanase activity could be a problem if maximum pigment retention was required. Steam blanching prior to processing or increasing the concentration of sugar in the foods was proven to be effective in destroying and inhibiting the enzymatic activity, respectively (Siegel *et al*., 1971).

Enzymes that took part in anthocyanin degradation were generally called anthocyanases. Two groups of enzymes in plant tissue were found responsible for anthocyanin degradation (Mathew and Parpia, 1971). The enzymes were polyphenol oxidases and glycosidases. PPO, which commonly occur in plant tissue catalyse the oxidative transformation of catechol and other o-dihydroxyphenols to o-quinines, which subsequently react with, amino acids, or other phenolic compounds including anthocyanins. Glycosidases hydrolyzed the glycosidic bond of anthocyanins yielded free sugar and aglycone (Piffault *et al*., 1994).

Sugars and their degradation products

The rate of anthocyanin degradation was found associated with the rate at which the sugar degraded to furfural-type compounds (Markakis *et al*., 1957) such as furfural and 5-hydroxymethylfurfural (HMF). Fructose, arabinose, lactose and sorbose had greater degradative effects on anthocyanin than glucose, sucrose or maltose (Tinsley and Bockian, 1960).

Reduced water activity (aw) was found associated with a reduced rate of anthocyanin degradation (Erlandson and Wrolstad, 1972). Dried anthocyanin powders in hermetically sealed containers at aw lower than 0.3 were found relatively stable at room temperature for several years (Main *et al*., 1978).

Sugars and their degradation products above 100 ppm accelerated the degradation of anthocyanins (Calvi and Francis, 1978). Anthocyanins degradation in the presence of furfural and hydroxymethylfurfural was found temperature dependent and more obvious in natural systems, such as fruit juice. The use of high sugar concentration or syrups to preserve fruits and fruit products had an overall protective effect on anthocyanins (Wrolstad *et al*., 1990). Oxygen enhanced the degradative effects of all sugars and sugar derivatives (Jackman and Smith, 1996) which in turn cause instability of anthocyanin.

Co-pigmentation

In aqueous media anthocyanins were known to form weak complexes with numerous compounds such as proteins, tannins, other flavonoids, organic acids, nucleic acids, alkaloids, polysaccharides and metal ions through "intermolecular co-pigmentation" (Brouillard, 1982). For example, colour behaviour and stability of five anthocyanins, and five phenolic acids acting as co-pigments were investigated and found that the greatest co-pigmentation reactions took place in malvadin 3-glucoside solutions. All anthocyanins were ionically bound in the cell vacuole to aliphatic acids such as malonic, malic or citric acid. Such interaction could provide a mechanism of colour stabilization *in vivo* (Jackman and Smith, 1996).

The strongest co-pigments for all anthocyanins were ferulic and rosmarinic acid. The immediate reaction of rosmarinic acid with malvidin 3-glucoside resulted in the biggest bathochromic shift and the strongest hyperchromic effect (Erio and Heinomen, 2002).

2.10.3. Potential sources and uses

The physiology of presence of anthocyanin in grape skin was studied by (Counsell *et al.*, 1981). It was reported that grapes were the best known commercial source of anthocyanin as food colorant. In grape skin, anthocyanins were found concentrated in the vacuole. This pigment was not found in cytoplasm and cell wall. When cells die, anthocyanins diffuse from vacuoles and colour the tissues. Both spray dried power and a concentrated solution containing grape anthocyanins, have been marketed for years. Economically, the best commercial sources of anthocyanins could be prepared from by-products of the processes such as juice and wine making (Francis, 1989).

In order to produce anthocyanins commercially as a food colour, several potential sources were investigated. The main problems were the limited availability of raw materials and overall economic consideration. However, research was done on a large number of food plants such as grape skin, cranberry, red cabbage, roselle, bilberry, black olives, leaves of cherry-plum and purple-hulled sunflower in order to find commercial sources (Wiesenborn *et al*., 1993). As food colourants, anthocyanins added to food systems trigger reactions that interfere with food composition (Jackman and Smith, 1996). However a wide range of high quality products can be attractively coloured by anthocyanins with careful selection of ingredients, choice of appropriate stages to add the colourant during formulation, control of processing, and storage conditions.

2.10.4. Food applications of anthocyanin

Confectionery

Anthocyanins at the concentration of 0.1 % or less provided a ruby red shade in chewing gums. In hard candies, anthocyanins were used only in the traditional technique of candy production due to the temperature factor during processing (Counsell *et al*., 1981).

Beverages

Anthocyanins were shown to provide acceptable colour stability when used in a number of clear beverages where the pH of the product varied upto 4.2. Anthocyanins were also used to compensate for natural variations in the colour of some wines and other alcoholic beverages (Counsell *et al*., 1981).

2.10.5. Stability in food products

Markakis *et al*. (1957) tested 19 different potential stabilizers. It was found that only thiourea showed a significant stabilizing effect in strawberry juice and a buffered pigment solution, while propyl gallate and quercetin showed a slight protective effect on the colour of both samples. However thiourea is toxic and cannot be used as a food additive.

Cysteine, which could act as a reducing agent and PPO inhibitor, was shown to inhibit anthocyanin degradation in Concord grape juice at the temperature below 75 °C (Skalski and Sistrunk, 1973). Anthocyanins stabilized during processing and uniformly penetrated the flesh of the fruit such as cocktail cherry. However the pH of the syrup had to be adjusted to 2.0 in order to achieve a suitable colour (Counsell *et al*., 1981).

There were attempts to add chemicals or modify processing conditions in order to stabilize natural colorants in foods. Ascorbic acid was claimed to be a pigment stabilizer and degrader. As a pigment stabilizer, ascorbic acid, absorbed oxygen and prevented oxidation of anthocyanins. In contrast, enzymatic reaction with ascorbic acid yields hydrogen peroxide which oxidized and discolored the anthocyanins (Taylor, 1984). Tartaric acid and glutathione were found to have a protective effect on anthocyanins by being mildly acidic and antioxidant, respectively (Maccarone and Rapisarda., 1985).

2.10.6. Extraction of anthocyanins

Janick (1999) analyzed the anthocyanin in red basil using HPLC, spectral data and plasma description mass spectrometry. According to him red basil was an abundant source of acylated and glycosylated anthocyanins and could provide a unique source of stable red pigments.

Flower pigment analysis of *Melastoma malabathricum* was carried out by Janna *et al.*, (2000). Extracts exposed to light showed a degradation level of more than 50 %. At different pH values, anthocyanin concentration decreased and color faded at higher pH. From this study the suitable storage conditions for coloured anthocyanin pigments was in acidic solution (pH 0.5 and 1.0), kept in the dark and at low temperature (4 °C).

A new anthocyanin recovery system from plant material such as grape waste based on tartaric acid – alkanol extraction followed by controlled precipitation of excess tartaric acid as potassium hydrogen tartarate was described by Spagna *et al*. (2003). Tartaric acid and citric acid solutions were used to extract anthocyanins from fresh grape (cv. Ancellotta) skins collected from different locations in Italy, in a non continuous process. The type of solvent and concentration were significant factors in the extraction operation, and tartaric acid was more efficient than citric acid in the extraction yield. Comparative trials were conducted using sulfur dioxide and acidified ethanol as solvents. The extraction yields using the optimal tartaric acid solution differed slightly from those obtained with acidified ethanol but were higher than those obtained with sulfur dioxide. Total amounts of polyphenols, proanthocyanidins and flavans were determined in the extracts obtained from the tartaric acid solutions. Solvent concentration was not a significant factor for flavonoids extraction yield but was highly significant for the extraction of the other compounds. The stability of the anthocyanins was evaluated at four different storage temperatures and atmospheric conditions. The combined effects of low pH of the extract (2.4), low temperature (2 °C) and modified atmosphere provided a long storage life. Based on the results, a 0.75 %

tartaric acid solution was recommended for anthocyanin extraction from fresh grape skin, and could substitute the widely used sulfur dioxide.

Findings of acylated anthocyanins with increased stability have shown that these pigments imparted desirable colour and stability for commercial food products (Monica and Wrolstad, 2003). Sources of acylated anthocyanin were radishes, red cabbage, black carrots, purple sweet potatoes, and red potato.

Xueming (2004) developed a cheap and industrially feasible method for purification of anthocyanin from mulberry fruit which could be used as a red food colorant of high colour value (above 100). Extraction and purification was done by acidified ethanol as solvent. The results indicated that total sugars, total acids, and vitamins remained intact in the residual juice after the removal of anthocyanin.

Effects of freezing, storage and cabinet drying on the anthocyanin content and antioxidant activity of blueberries were studied by Virachnee *et al.* (2004). Osmotic treatment followed by a thermal treatment had a greater effect on anthocyanin loss than the thermal treatment alone. In contrast, frozen samples did not show any significant decrease in anthocyanin level during three months of storage. Measurement of antioxidant activity of anthocyanin extracts from blueberries showed there was no significant difference between fresh, dried and frozen blueberries.

The effects of temperature on colour formation of pink wax apple fruit discs by using constant, slow increase, fast increase, transient shifting to high temperature, shift to high temperature for different length of time and different day/night temperature regimes was studied by (Pana and Shub, 2006). Anthocyanins and TSS were greatest in the 20 °C treated discs under constant temperature.

Chang *et al*. (2006) showed differential effects on diameter, weight, soluble solids, skin colour of wax apple *(Syzygium samarangense* Merr. R. Perry) incubated with and without sucrose. Soluble solids and anthocyanin concentration increased in a sucrose medium.

Anthocyanin pigment was extracted from three different berries (*Morus nigra*, *Morus alba var nigar* and *Fragaria* L.) using the soaking and wetting in ethanol which was one per cent acidified. The extracted anthocyanins were exposed to 20, 40, 60 per cent sugar concentration. In this study primary concentration *i.e.* 20 per cent sucrose had a protective effect on anthocyanin but in higher concentration this effect was reduced (Nikkah *et al*., 2007).

Paul (2007) described the process of formation of anthocyanin pigments in plants. Phenyl alanine and malonyl coenzyme A joined to form the base material for anthocyanin called chalcones that led to production of anthocyanin after a series of enzyme steps.

Blueberries were known for their high anthocyanin content and health benefits (Virachnee, 2007). Various drying treatments were compared with regard to drying time and quality of dried product in terms of anthocyanin and polyphenolic compounds as well as antioxidant property. Pretreatments included osmotic dehydration and skin abrasion. Mechanical skin abrasion was more effective than osmotic dehydration in reducing the drying time and minimizing loss of anthocyanins. There was no significant difference between total anthocyanin content of blueberries and mulberries. Skin abrasion and high temperature drying resulted in the fastest drying rate and highest anthocyanin retention.

Materials and Methods

3. MATERIALS AND METHODS

The investigation on "Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)" was carried out in the Department of Processing Technology, College of Horticulture, Kerala Agricultural University, Vellanikkara during the period 2006-2008. The study comprised of the following experiments:

1. Evaluation of watery rose apple and Malay apple for processing attributes.
2. Production of quality pulp/juice
3. Standardization of value added products
4. Extraction and utilization of natural colour from watery rose apple fruit and Malay apple flowers.

3.1. Evaluation of watery rose apple and Malay apple for processing attributes

3.1.1. Collection of fruits and grouping

A survey was conducted in and around Thrissur district for collecting watery rose apple and Malay apple types. The types available in the College orchard were also collected. The collected fruits were grouped based on their colour and weight.

3.1.1.1. Grouping based on colour

a) Watery rose apple: Pink and pinkish red coloured fruits

b) Watery rose apple: White coloured fruits

c) Malay apple: Light and dark pink coloured fruits.

Colour was assessed based on visual observation.

3.1.1.2. Grouping based on weight

Fruits belonging to different colour groups were further classified based on their weight. Weight of ten fruits from each accession was taken and the mean weight was calculated and expressed in grams. The fruits were arranged in the ascending order of weight and grouped into four quartiles. The fruits which fall below the first quartile were classified as small, between first and third quartile as medium and above third quartile as large.

3.1.2. Physical characters

3.1.2.1. Percentage recovery of pulp

Hundred grams of ripe fruit was taken and crushed in a mixie and the weight of pulp was recorded in a weighing machine. Based on the values, percentage recovery of pulp was worked out.

3.1.3 Biochemical characters

TSS, acidity, ascorbic acid and sugar content (reducing, non reducing and total) were estimated.

3.1.3.1 Total Soluble Solids (TSS)

Total Soluble Solids (TSS) of the pulp was recorded using a hand refractometer and expressed in degree Brix (AOAC, 1980).

3.1.3.2. Titrable acidity

Acidity was determined by titration with standard sodium hydroxide (0.1 N) and expressed as percent of citric acid as per Ranganna (1997).

3.1.3.3. Ascorbic acid

Five grams of fruit was taken and extracted with four percent oxalic acid. Ascorbic acid was estimated by using standard indicator dye 2, 6-dichlorophenol indophenol and expressed as mg/100g of fruit (Sadasivam and Manickam, 1996).

Based on the physico-chemical attributes of the fruits, the types suitable for the production of quality pulp and juice and also for the preparation of various products were selected.

3.1.3.4. Total sugars

Estimation of total sugars was done and expressed as grams of glucose per 100 grams of pulp (Ranganna, 1997).

3.1.3.5. Reducing sugars

Estimation of reducing sugars was done and expressed as grams of glucose per 100 grams of pulp (Ranganna, 1997).

3.1.3.6. Non reducing sugars

Estimation of non reducing sugars was done by subtracting the reducing sugars from total sugars and expressed as grams of glucose per 100 grams of pulp.

3.2. Production of quality pulp/juice

The fruits of accessions selected statistically through physico chemical analysis were subjected to different treatments *viz.,* blanching and osmoextraction as follows:

3.2.1. Hot water blanching

The whole fruits as such and halved fruits of selected accessions after removal of seeds were subjected to blanching in hot water at 60 to 70°C and allowed to cool. Fruits of uniform size belonging to each accession were selected for the study.

3.2.2. Steam blanching

The whole and sliced fruits of same accession used for experiment 3.2.1 after removal of seeds were subjected to steaming in a hot water bath for different periods *viz.,* 1, 2 and 3 minutes.

The blanched fruits were then crushed in a mixie and the weight of the pulp was recorded. Based on this percentage recovery of pulp was calculated. The pulp was squeezed through a muslin cloth and weight of the juice was recorded. Based on this percentage recovery of juice was worked out. Pulp and juice of fresh fruit served as control. Sensory attributes of the pulp was assessed by serving it to a semi trained panel of judges. The score card used for assessing the quality is given in Appendix I.

Thus under blanching there were 13 treatments replicated thrice.

3.2.3. Osmoextraction

The fresh fruits after removal of seeds were crushed in a commercial mixer and mixed with equal amount of sugar. Citric acid was added at the rate of 1g/kg of fruit pulp and weight of the mixture was recorded and kept overnight. Next day mixture was crushed thoroughly and the weight was taken. Based on this percentage recovery of pulp was calculated. The mixture was squeezed through a muslin cloth and weight of juice was recorded. Based on this recovery of juice was calculated. Biochemical characters *viz.*, TSS, acidity and ascorbic acid content were recorded. Also the sensory attributes of the pulp was assessed by serving it to a semi trained panel of judges. The score card used for assessing is given in Appendix I.

3.3. Standardization of value added products

3.3.1. Osmodehydrated products

The fruits of different types available in the college orchard were used for this study. Osmodehydrated products were prepared by dehydration of whole as well as sliced fruits. Sound fruits of uniform size with appealing colour were selected and used. Osmodehydration was done by two methods *viz.*, immersion of fruits/pieces in sugar syrup and dry blending with sugar of fruits/pieces with sugar.

3.3.1.1. Immersion in sugar syrup

Sugar syrup of strength 50 °Brix (50 g sugar dissolved in 50 ml of water), 60 °Brix (60 g sugar dissolved in 40 ml of water) and 70 °Brix (70 g sugar dissolved in 30 ml of water) were prepared. The whole and the sliced fruits (100 g in each treatment) were put in the sugar syrup of different concentration in the ratio 1:2. For each 100 g fruit, 200 ml of syrup was added.

3.3.1.2. Dry blending with sugar

Whole and the sliced fruits were blended with dry sugar in the ratio 1:1 *i.e.*, for every 100 g fruit, 100 g sugar was used.

Whole fruits and sliced fruits put in sugar syrup as well as blended with dry sugar were left for twelve hours for osmodehydration. After this, the whole fruit and the fruit slices were taken out and rinsed quickly with warm water to remove the adhering sugar syrup and dried in a vacuum oven set at 50 °C till the moisture is reduced to 18 %. Whole and sliced fruits dehydrated in a vacuum oven served as the control. There were 10 treatments replicated thrice.

3.3.1.3. Observations

The recovery percentage of the osmodehydrated product and their sensory attributes were recorded. Method used for scoring the sensory attributes is given in Appendix I. Kendalls co-efficient of concordance was worked out to asses the degree of agreement among the judges about the pretreatment procedures of Malay, pink and white watery rose apples.

3.3.1.4. Storage study of osmodehydrated fruit

The best treatment identified through scoring technique was then subjected to storage study. The sample was stored in two different containers *viz.*, glass bottle and plastic bottle. The quantitative assay of microflora present in the above two samples was carried out by serial dilution plate count method as described by

Agarwal and Hasija (1986). One gram sample was added to 9 ml distilled water and shaken well to form a suspension. From this suspension, 1 ml was again transferred to 9 ml distilled water. This gave 10^{-1} dilution. From the filtrate 1 ml was then transferred to test tube containing 9 ml distilled water. This gave a dilution of 10^{-2}. Later 10^{-3}, 10^{-4}, 10^{-5} dilutions were prepared from this by serial dilutions.

Enumeration of total microflora was carried out using Nutrient agar media for bacteria, Rose Bengal agar media for fungi, and Sabouraud Dextrose agar media for yeast. The dilution used for bacteria was 10^{-5}, for fungi 10^{-4} and for yeast it was 10^{-3}.

From each dilution (10^{-3}, 10^{-4} and 10^{-5}) of the two samples 1 ml was transferred to a Petri dish and the medium as suggested for each dilution was poured and mixed well with the media and allowed to solidify. Each Petri dish was closed and marked and kept for storage. All the above operations were done under laminar air flow chamber. There were 18 treatments replicated thrice.

Number of colonies in each Petri dish was counted at monthly interval. This was continued up to 3 months.

Number of Colony Forming Units (CFU) per gram of the sample

$$= \frac{\text{Mean number of CFU x dilution factor}}{\text{Quantity of the sample on weight basis}}$$

Composition of Nutrient agar, Rose Bengal agar and Sabouraud Dextrose agar medium are given in Appendix II.

3.3.1.4. Pickle

The selected type of fruits were washed and sliced in to pieces of 1 cm^2 size. Fruit weight taken for each treatment was 25 g. The fruit slices were pickled after giving pretreatments as follows:

1) Blanching in hot water for 1 minute

2) Blanching in steam for three minutes

3) Dipping in four per cent salt solution for 12 hours

4) Dipping in four per cent salt solution for 12 hours followed by drying in a cabinet drier for two hours

5) Fresh sliced fruits served as control

In hot water blanching, the prepared fruit slices were taken in a muslin cloth bag and dipped in plain boiling water for 1 minute. After that muslin cloth bag was withdrawn and fruit pieces were allowed to cool. In steam blanching the fruit slices were put in a steam bath set at 100 °C. After that slices were taken out and cooled.

Salt solution was prepared by dissolving 4 g of salt in 100 ml of water. 25 g of sliced fruit was dipped in this salt solution for 12 hours. Then it was withdrawn and washed and pickled. Another batch of 25 g of sliced fruits were dipped in salt solution for 12 hours and dried in a cabinet drier for two hours. Fresh sliced fruits served as control.

Thus there were 5 treatments replicated thrice. Pickle was made using a common recipe given in Appendix III.

3.3.1.5. Wine

First, the wine was prepared from the selected accessions of Malay apple. The treatments adopted were

1. Sliced fruits + equal quantity of sugar + half quantity of water as that of fruits
2. Sliced fruit + equal quantity of sugar and water as that of fruit
3. Sliced fruit + half the quantity of sugar and water as that of fruit

4. Crushed fruit + equal quantity of sugar + half the quantity of water as that of fruit

5. Crushed fruit + equal quantity of sugar and water as that of fruit

6. Crushed fruit + half the quantity of sugar and water as that of fruit

The treated fruits were taken in a Buchners funnel and starter solution was prepared and kept for 10 to 15 minutes until frothing was observed. After that, this starter solution was added to the treated fruits and tied airtight. The contents were tilted to give a slight shaking for 7 days. After 7 days, the wine was poured in to glass bottles and kept for clarification. The clear wine was decanted again to sterilized bottles and sealed airtight.

Sensory attributes of the wine were evaluated on a five point scale as done for other products. Based on the quality evaluation, treatments were selected for preparation of wine with watery rose apples.

3.3.1.6. Pulp and juice based products

3.3.1.6.1. Preparation of squash

Selection and preparation of fruits

Fully ripe fruits of pink, white and Malay apples selected were used for preparation of beverage. The fruits were washed thoroughly to remove the adhering dirt and other extraneous matter. Then the fruits were cut in to pieces.

Extraction of juice

Juice was extracted using the best method selected in the experiment 3.2.

1. Weight of extracted juice was taken and recorded as A ml.

2. The TSS of the extracted juice was recorded using hand refractometer as B °Brix.

3. From the TSS, quantity of sugar present in the juice was calculated. It was calculated as $C = A \times B / 100$.

4. Quantity of actual juice content in the mixture was worked as D = A - C ml.

5. Quantity of squash that can be prepared from this D ml of juice was calculated as E = D x 4.

6. Water to be added was calculated as quantity of squash (E) - the quantity of juice (A).

Calculated quantity of water was boiled, cooled and added to the mixture. TSS of the final product was noted. The quantity of water to be added was restricted so that the TSS of the product was maintained as 40 °Brix prescribed for squash as per FPO specifications.

Observations

The biochemical attributes (acidity, ascorbic acid content, and colour) and sensory attributes of the product were recorded.

3.3.1.6.2. Preparation of RTS beverage

Selection of fruits

Fully ripe fruits of selected accessions were used for RTS beverage preparation. Selection of fruits was done based on the physico chemical attributes of different types in each colour group. Fruits were washed, sliced and seeds were removed.

Extraction of juice

Juice was extracted using the best method as described in experiment 3.2.

Procedure

1. Weight of extracted juice was measured as A ml.

2. TSS was measured as T °Brix.

3. Juice was diluted to get the required TSS of 12 to 15 °Brix.

Observations

Biochemical attributes (TSS, acidity, ascorbic acid content) and sensory attributes of the product were recorded.

3.3.1.6.3. Jam

Extraction of pulp

Pulp for jam was extracted using the best method as described in 3.2. The extracted pulp was cooked over fire and pectin extracted from guava fruit at the rate of 200 ml/kg of pulp or two per cent pectin solution was added. Jam was removed from fire after reaching the required consistency.

Observations

Biochemical attributes (TSS, acidity, ascorbic acid content) and sensory attributes of the product were analyzed.

3.4. Extraction and utilization of natural colour

3.4.1. Extraction

The major colouring pigment anthocyanin present in pink watery rose apple fruits and Malay apple flowers were extracted using the solvent extraction and acidified aqueous extraction methods. The solvents used were methanolic HCl and citric acid.

3.4.1.2. Solvent extraction using methanolic HCl

Two methods were adopted for the extraction of anthocyanin pigment using methanolic HCl.

In the first method, 1 g of the sample was weighed, cut into pieces and blended in 10 ml of methanol. Filtered the extract through Whatman no.1 filter paper and ground the left over residue by adding alcohol and the process was repeated. Then the extract was boiled in hot water until the total volume was reduced to 1 to 2 ml and the volume was made up to 25 ml with distilled water. This was known as alcohol extraction and used for anthocyanin estimation. After that 1 ml of the extract was taken in a test tube, and added 3 ml of reagent B, 1 ml of reagent A and C. For blank, 1 ml of distilled water was used. Then the test tubes were incubated in dark for 15 to 20 minutes and measured the absorbance at 525 nm (Francis, 1982) using a thermospectronic (Genesys 20). Reagents used and their composition is given in Appendix IV.

Calculation

1. Total anthocyanin content (mg/g) = $\frac{150\ A}{98.2}$ where A is the absorbance

In the second method, 2 g of ground sample was taken in a conical flask. Then 25 ml of 1% methanolic HCl was added and kept for overnight incubation. The material was decanted to a funnel using a cotton wool. Again the material was treated with 10 ml of 1% methanolic HCl and kept for 1 hour and decanted. Volume was made up to 50 ml and absorbance was measured at 540 nm (Fuleki and Francis, 1968) using a thermospectronic (Genesys 20).

Calculation

2. Total anthocyanin (mg/g) = $\frac{25\ A}{98.2}$ where A is the absorbance

3.4.1.3. Acidified aqueous extraction

Different concentrations of citric acid were used in this extraction. About 2 g of sample was taken and dipped in the citric acid solution at different strengths of 1, 2, 3, 4 and 5 % (Main *et al.*, 1978). Five samples of each treatment were prepared. The absorbance was noted at different intervals of time at 0, 3, 6 and 12 hours using the different samples. Before taking the reading, the sample was crushed well with hand for better extraction and recovery. Absorbance was taken at 540 nm using a thermospectronic (Genesys 20).

Calculation

1. Total anthocyanin (mg/g) = $\frac{25\ A}{98.2}$ where A is the absorbance

Thus the major colouring pigment present, the best method of extraction and also the amount present in the sample was quantified.

3.4.2. Utilization of colour

The colour was extracted using the best method identified in experiment 3.4. This colour was used in products like wine and squash for the expression of colour. Ten millilitres each of Malay apple wine and Malay apple squash was taken. Colour extract at the rate of 2, 4, and 6 ml was added to wine and squash until an appealing colour was obtained. The absorbance of the product was noted at the time of addition of colour extract and again after one month. The best concentration was identified.

Statistical analyses of data

Data was analyzed as a completely randomized design (CRD) for all the parameters under consideration. For organoleptic test, Kendalls co-efficient of concordance was performed and the mean rank scores were taken to differentiate the methods.

Results

4. RESULTS

The results of the present study entitled “Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)” are presented in this chapter under the following sections.

1. Processing attributes of watery rose apple and Malay apple
2. Production of quality pulp/juice
3. Value added products
4. Extraction and utilization of natural colour

4.1. Processing attributes of watery rose apple and Malay apple

4.1.1. Collection of fruits

The details of different accessions collected are given in Table 1. Eight accessions of pink watery rose apple were collected from in and around Thrissur district. AC.1 and 8 were obtained from Chalakudy. AC.2 from Mundur, AC.3 from Mannuthy, AC.4 from M.G.Road and AC.5 from College orchard. AC.6 and 7 were collected from Mulayam. In white watery rose apple, all the five accessions were collected from the College orchard. In Malay apple, out of the four accessions, AC.1 was collected from Perumbavoor, AC.2 from M.G.Road and AC.3 and 4 from College orchard.

4.1.2. Grouping of accessions

4.1.2.1. Based on colour

The fruits collected were classified based on their colour (Table 2). Among the 8 accessions collected in pink watery rose apple, AC. 1, 2, 6, 7 and 8 were pink in colour. Three accessions *viz*., AC.3, 4 and 5 were pinkish red. In white watery rose apple types, no colour variation was noticed. In Malay apple,

Table 1 Accessions collected under watery rose apple and Malay apple

Type	Accessions	Place of collection	Number collected
Pink watery rose apple	AC. 1	Chalakudy, Thrissur	1
	AC. 2	Mundur, Thrissur	1
	AC. 3	Mannuthy, Thrissur	1
	AC. 4	M.G. Road, Thrissur	1
	AC. 5	College orchard	1
	AC.6 and 7	Mulayam, Thrissur	2
	AC. 8	Chalakudy, Thrissur	1
	Total accessions		8
White watery rose apple	AC.1, 2, 3, 4 and 5	College orchard	5
	Total accessions		5
Malay apple	AC.1	Perumbavoor, Ernakulam	1
	AC.2	M.G. Road, Thrissur	1
	AC.3 and 4	College orchard	2
	Total accessions		4

AC- Accession

Table 2 Colour characteristics of different accessions

Type	Accession number	Colour
Pink watery rose apple	AC.1, 2, 6, 7 and 8	Pink
	AC.3,4 and 5	Pinkish red
White watery rose apple	AC. 1, 2, 3, 4 and 5	White
Malay apple	AC.1 and 2	Pink
	AC.3 and 4	Light pink

out of the four accessions collected two were pink (AC.1 and 2) and two were light pink in colour (AC. 3 and 4). Analyses of pooled data on various parameters of accessions within the type (grouped with respect to colour) were insignificant. Hence the quality parameters of three types were considered.

4.1.2.2. Based on size

The different accessions collected under each type were classified into big, medium and small fruit bearing types based on their fruit weight and given in Table 3. Among the eight accessions of pink watery rose apple, those weighing 145 g and above were classified as big (AC.1 and 3), between 80.6 and 145 g were classified as medium (AC. 4, 5, 6, 7 and 8) and between 50 and 80.6 g were grouped as small. Fruits of AC.2 were the smallest with a weight of 50 g.

In the case of white watery rose apple, those weighing 135 g and above were classified as big fruits (AC.1 and 4) and between 122.5 and 135 g were grouped under medium (AC.2 and 3) and between 100 and 122.5 g were grouped as small (AC.5).

In Malay apple, fruits weighing above 970 g (AC.1) were classified as big, between 505 and 970 g were classified as medium (AC.3 and 4) and those weighing between 390 and 505 g were grouped as small (AC.2).

4.1.3. Physico chemical attributes

4.1.3.1. Percentage recovery of pulp

Percentage recovery of pulp did not differ significantly among the three different types *viz*., pink watery rose apple, white watery rose apple and Malay apple (Table 4). However mean percentage recovery of pulp was highest for Malay apple (90.13 %) and lowest for pink watery rose apple (83.24 %). When the recovery percentage of pulp between different accessions within each type is considered, there was no significant difference between accessions of white and

Table 3 Classification of accessions based on size

Type	Classification	Mean weight of 10 fruits (g)	Accession
Pink watery rose apple	Big	145	1 and 3
	Medium	80.6	4, 5, 6, 7 and 8
	Small	50	2
White watery rose apple	Big	135	1 and 4
	Medium	122.5	2 and 3
	Small	100	5
Malay apple	Big	970	1
	Medium	505	3 and 4
	Small	390	2

Table 4 Physico chemical attributes of different accessions of fruits

Accession	Fruit colour	Mean weight of 10 fruits (g)	Recovery of pulp (%)	TSS (°Brix)	Titrable acidity (%)	Ascorbic acid content mg/100g	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
Pink watery rose apple									
AC.1	Pink	145^{a}	86.50^{b}	5^{a}	0.92^{dc}	83.87^{a}	1.52^{cd}	0.95^{bc}	2.47^{a}
AC.2	Pink	50^{f}	85.18^{b}	4^{a}	1.84^{b}	48.38^{b}	1.56^{bcd}	0.49^{d}	2.05^{a}
AC.3	Pinkish red	145^{a}	78.32^{c}	5^{a}	1.54^{bc}	9.60^{g}	1.78^{abcd}	0.42^{d}	2.20^{a}
AC.4	Pinkish red	103^{b}	98.20^{a}	4^{a}	2.86^{a}	19.30^{e}	1.45^{c}	0.60^{cd}	2.05^{a}
AC.5	Pinkish red	65^{e}	95.60^{a}	5^{a}	0.82^{d}	38.71^{c}	2.12^{a}	1.26^{a}	3.38^{a}
AC.6	Pink	85^{c}	60.00^{d}	5^{a}	1.74^{b}	19.30^{e}	1.20^{d}	1.05^{ab}	2.25^{a}
AC.7	Pink	75^{d}	80.00^{c}	5^{a}	2.20^{ab}	22.59^{d}	1.60^{bcd}	1.26^{a}	2.86^{a}
AC.8	Pink	75^{d}	82.15^{bc}	4^{a}	1.69^{b}	16.12^{f}	1.93^{ab}	1.08^{ab}	3.01^{a}
Mean values		**92.87**	**83.24**	**4.63**	**1.70**	**32.23**	**1.64**	**0.90**	**2.53**
White watery rose apple									
AC.1	White	145^{a}	87.80^{a}	4^{a}	0.36^{b}	6.45^{b}	1.45^{a}	0.73^{c}	2.17^{ab}
AC.2	White	125^{bc}	85.65^{a}	5^{a}	0.26^{c}	16.13^{a}	0.58^{b}	1.02^{bc}	1.59^{bc}
AC.3	White	120^{c}	89.08^{a}	5^{a}	0.36^{b}	12.90^{a}	0.60^{b}	0.80^{c}	1.40^{c}
AC.4	White	133^{b}	90.50^{a}	3^{a}	0.51^{a}	16.13^{a}	1.32^{a}	1.26^{ab}	2.58^{a}
AC.5	White	100^{a}	91.56^{a}	3^{a}	0.38^{b}	12.90^{a}	1.14^{a}	1.47^{a}	2.61^{a}
Mean values		**124.60**	**88.92**	**4.00**	**0.37**	**12.90**	**1.02**	**1.05**	**2.07**
Malay apple									
AC.1	Pink	970^{a}	92.56^{a}	4^{a}	0.15^{d}	42.20^{a}	1.01^{b}	2.32^{a}	3.33^{a}
AC.2	Pink	390^{c}	85.40^{a}	5^{a}	1.38^{c}	19.30^{b}	1.61^{a}	0.34^{d}	1.95^{b}
AC.3	Light pink	545^{b}	91.60^{a}	3^{a}	2.20^{a}	16.13^{c}	0.51^{c}	1.66^{b}	2.16^{b}
AC.4	Light pink	465^{c}	90.96^{a}	3^{a}	1.84^{b}	12.90^{d}	1.35^{a}	1.01^{c}	2.36^{b}
Mean values		**592.50**	**90.13**	**3.75**	**1.39**	**22.63**	**1.12**	**1.33**	**2.45**
CD for comparing types		**293.3**	**20.34**	**1.87**	**1.04**	**43.97**	**0.88**	**1.17**	**1.29**

Figures with even letters form a homogenous group

Malay apple. However in white watery rose apple, maximum mean recovery of pulp was recorded in AC.5 (91.56 %) while the least recovery of pulp was recorded in AC.2 (85.65 %). In Malay apple, the maximum percentage recovery of pulp was recorded in AC.1 (92.56 %). This was followed by AC.3 (91.6 %) and least pulp recovery was in AC.2 (85.4 %). Significant difference was noticed in recovery percentage of pulp in pink watery rose apple. The maximum percentage recovery of pulp was recorded by AC.4 (98.2 %) followed by AC.5 (95.6 %). The least pulp recovery was in AC.6 (60 %).

When pulp recovery in relation to size of fruits is considered, (Table 4a), in pink and white watery rose apple there was no significant difference in big, medium and small group. However difference was noticed with respect to pulp recovery in Malay apple. In Malay apple fruits of big group exhibited the highest recovery of pulp (92.56 %) while least recovery was in fruits of small group (85.4 %).

4.1.3.2. Total Soluble Solids (TSS)

Total soluble solids did not differ significantly between the different types as well as between the different accessions within types (Table 4). However the maximum TSS of 5 °Brix was recorded for AC.1, 3, 5, 6 and 7 in pink watery rose apple, AC.2 and 3 in white watery rose apple and AC.2 in Malay apple.

There was no significant difference between size of fruits within types (Table 4a). However maximum mean TSS of 5 °Brix was observed in big group followed by medium group (4.6 °Brix) and small group (4 °Brix) in pink watery rose apple. Considering the white watery rose apple the maximum mean TSS of 5 °Brix was possessed in medium group, followed by big group (3.5 °Brix) and small group (3 °Brix). In Malay apple small fruits exhibited the maximum TSS (5 °Brix) followed by big group (4 °Brix) and the least TSS was recorded by the medium group (3 °Brix).

Table 4a Group means of important attributes of watery rose apple and Malay apple types with respect to size of fruits

Type	Classification	Recovery of pulp (%)	TSS (°Brix)	Titrable acidity (%)	Ascorbic acid content (mg/100g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
Pink watery rose apple	Big	82.40^{a}	5.0^{a}	1.23^{a}	46.73^{a}	1.65^{a}	0.69^{a}	2.34^{a}
	Medium	83.19^{a}	4.6^{a}	1.86^{a}	23.20^{a}	1.66^{a}	1.05^{a}	2.71^{a}
	Small	85.18^{a}	4.0^{a}	1.84^{a}	48.38^{a}	1.56^{a}	0.49^{a}	2.05^{a}
White watery rose apple	Big	89.19^{A}	3.5^{A}	0.26^{A}	11.29^{A}	1.39^{A}	0.99^{A}	2.38^{A}
	Medium	87.36^{A}	5.0^{A}	0.31^{A}	14.52^{A}	0.59^{A}	1.82^{A}	1.49^{A}
	Small	91.56^{A}	3.0^{A}	0.38^{A}	12.90^{A}	1.14^{A}	1.47^{A}	2.61^{A}
Malay apple	Big	92.56^{a}	4.0^{a}	0.15^{c}	42.20^{a}	1.01^{a}	2.32^{a}	3.33^{a}
	Medium	91.28^{b}	3.0^{a}	2.02^{a}	14.51^{c}	0.93^{a}	1.34^{b}	2.26^{b}
	Small	85.40^{c}	5.0^{a}	1.38^{b}	19.30^{b}	1.61^{a}	0.34^{c}	1.95^{c}

Figures with even letters form a homogenous group

4.1.3.3. Titrable acidity (per cent)

There was significant difference with respect to acidity of different types (Table 4). In general pink watery rose apple recorded the mean maximum acidity of 1.7 % followed by Malay apple 1.39 %. White types recorded the least acidity (0.37 %). When the accessions within types are considered separately, there was significant difference in acidity. The maximum acidity of 2.86 % was observed for AC.4 and a minimum acidity of 0.82 % was recorded for AC.5 in pink watery rose apple. In white watery rose apple, maximum acidity 0.51 % was recorded in AC.4 and the least acidity was recorded in AC.2 (0.26 %). Among the accessions of Malay apple, AC.3 exhibited the maximum acidity of 2.2 % and AC.1 exhibited the least acidity of 0.15 %.

The fruits of different size groups among each type (Table 4a) exhibited difference in acidity for Malay apple. In Malay apple, medium type showed maximum titrable acidity (2.02 %), followed by small type (1.38 %) and big type (0.15 %). Even though there was no significant difference in pink watery rose apple, medium group showed maximum mean acidity of 1.86 %, followed by small group (1.84 %). In white watery rose apple highest titrable acidity was recorded in small types (0.38 %) and the least in big types (0.26 %).

4.1.3.4. Ascorbic acid (mg/100g)

Ascorbic acid content did not differ significantly between the different types (Table 4). There was significant difference in ascorbic acid content among accessions of pink watery rose apple and Malay apple. The maximum ascorbic acid content was observed in AC.1 (83.87 mg/100g) of pink watery rose apple and the minimum content was observed in AC.3 (9.6 mg/100g). In Malay apple, AC.1 recorded the maximum ascorbic acid content (42.2 mg/100g) and the least was observed in AC.4 (12.9 mg/100g). In white watery rose apple ascorbic acid content did not differ significantly among the accessions 2, 3, 4 and 5. AC.1 recorded the least ascorbic acid content.

There was significant difference in ascorbic acid content among size groups of Malay apple (Table 4a). In Malay apple, big type showed the highest vitamin C content of 42.2 mg/100g followed by the small type (19.3 mg/100g). The lowest value for ascorbic acid content was in medium group (14.51 mg/100g). Even though there was no significant difference in pink watery rose apple, small types showed the highest vitamin C content (48.38 mg/100g). Big types exhibited an ascorbic acid content of 46.73 mg/100g and the least was in medium type (23.2 mg/100g). Among the different size groups in white watery rose apple, medium type possessed vitamin C content of 14.52 mg/100g followed by small type (12.9 mg/100g) and big type (11.29 mg/100g).

4.1.3.5. Reducing sugars (per cent)

Statistically reducing sugars did not differ significantly between the different types as well as between the different size groups analyzed (Table 4 and 4a). There was significant difference among accessions within the types. Among the 8 accessions in pink watery rose apple, AC.5 exhibited the maximum reducing sugar (2.12 %) and AC.6 showed the least content of 1.2 %. In white watery rose apple, AC.1 recorded the maximum reducing sugar content of 1.45 % and AC.2 recorded the least (0.58 %). Among the 4 accessions in Malay apple, AC.2 recorded the maximum reducing sugar content of 1.61 % and the minimum was in AC.3 (0.51 %).

Even though there was no significant difference among size groups with respect to reducing sugar content in pink watery rose apple, medium types possessed the highest reducing sugar of 1.66 %. It was followed by big types (1.65 %) and small types (1.56 %) (Table 4a). In white apple big types possessed the highest reducing sugar content of 1.39 %. In Malay apple, small types recorded the maximum reducing sugar content of 1.61 %, followed by big types (1.01 %). The minimum reducing sugar content was recorded in medium types (0.93 %).

4.1.3.6. Non reducing sugars (per cent)

Non reducing sugars did not differ significantly between the different types (Table 4). However significant difference was recorded among the accessions within types. In pink watery rose apple AC.5 and 7 showed the highest non reducing sugar content (1.26 %). In white watery rose apple AC.5 possessed the highest non reducing sugar (1.47 %) and AC.1 showed the least (0.73 %). In Malay apple, AC.1 exhibited the maximum non reducing sugar (2.32 %) and the minimum was in AC.2 (0.34 %).

There was significant difference with respect to non reducing sugar content among the size groups of Malay apple (Table 4a). In Malay apple big group showed the highest non reducing sugar content (2.32 %) and the lowest was in small groups (0.34 %). In pink watery rose apple medium group showed the highest content (1.05 %) and the lowest (0.49 %) was in small group. In white watery rose apple, maximum non reducing sugar was observed in medium group (1.82 %) and the minimum in big group (0.99 %).

4.1.3.7. Total sugars (per cent)

Total sugars did not differ significantly between the different types (Table 4). In pink watery rose apple accessions did not register significant difference. However total sugars in pink watery rose apple was found to be maximum in AC.5 (3.38 %) followed by AC.8 (3.01 %). AC.2 and 4 recorded the lowest total sugar content (2.05 %). In white watery rose apple and Malay apple there was significant difference among accessions. Total sugar was highest in AC.5 (2.61 %) and AC.4 (2.58 %) and the lowest was in AC.3 (1.4 %) in white watery rose apple. In Malay apple the total sugar content ranged between 1.95 and 3.33 % and AC.1 possessed the highest total sugar content of 3.33 %.

There was significant difference with respect to total sugar content among the size groups of Malay apple (Table 4a). In Malay apple, big group showed maximum value of 3.33 %, followed by medium group (2.26 %) and small group

(1.95 %). Among the different size groups in pink watery rose apple, medium types possessed the maximum sugar content (2.71 %), followed by big and small groups (2.34 and 2.05 % respectively). In white watery apple, small groups possessed the highest total sugar of 2.61 %, followed by big group (2.38 %) and medium group (1.49 %).

4.1.3.8. Selection of accessions according to product suitability

Based on the physico chemical attributes of the different accessions of fruits, the types suitable for the preparation of different products were selected (Table 5). Accessions with high pulp recovery (AC.4 in pink watery rose apple, AC.5 in white watery rose apple and AC.1 in Malay apple) were selected for preparing pulp and juice based products (Plates 1a, 1b and 1c). Similarly for preparation of osmodehydrated products accessions possessing big fruits (AC.1 in all types) were selected. For pickle, size and acidity of fruits were given prime concern and small fruits with high acidity were identified and used for preparation of pickle (AC.2 from pink and Malay apple and AC.5 from white watery rose apple). Fruits with high vitamin C and sugar content were used for preparation of wine. Accessions selected were AC.1 in pink and Malay apple and AC.4 in white watery rose apple. For table purpose accessions with big fruits and high sugar acid ratio (AC.1 in three types of fruits) were selected.

4.2. Production of quality pulp/juice

The results of the experiment on different methods for extraction of quality pulp/juice *viz.*, hot water blanching, steam blanching and osmoextraction are given below.

4.2.1. Hot water blanching

The data on percentage recovery of pulp and juice from fruits subjected to hot water blanching (Table 6) have shown that T_5 recorded the highest recovery of pulp in all the types studied. Recovery of pulp was 100 percent in this treatment.

Plate 1 Accessions selected for value added products

1a. Pink watery rose apple

AC.1- Osmodehydrated products, Wine and Table purpose

AC.4- Pulp and juice based products

AC.2- Pickle

1b. White watery rose apple

AC.1- Osmodehydrated products and Table purpose

AC.4- Wine

AC.5- Pulp and juice based products and pickle

1c. Malay apple

AC.1- Pulp and juice based products, Osmodehydrated products, Wine and Table purpose

AC.2- Pickle

Table 5 Product suitability of different accessions

Type	Accessions	Fruit Size	Products
Pink watery rose apple	AC.4	Medium	Pulp and juice based products
	AC.1	Big	Osmodehydrated fruit
	AC.2	Small	Pickle
	AC.1	Big	Wine
	AC.1	Big	Table purpose
White watery rose apple	AC.5	Small	Pulp and juice based products
	AC.1	Big	Osmodehydrated fruit
	AC.5	Small	Pickle
	AC.4	Medium	Wine
	AC.1	Big	Table purpose
Malay apple	AC.1	Medium	Pulp and juice based products
	AC.1	Big	Osmodehydrated fruit
	AC.2	Small	Pickle
	AC.1	Big	Wine
	AC.1	Big	Table purpose

Table 6 Percentage recovery of pulp and juice by hot water and steam blanching

Type	Treatments	Recovery of pulp (%)		Recovery of juice (%)	
		Hot water	Steam	Hot water	Steam
Pink watery rose apple	T_1	79.97	100.00	52.88	86.81
	T_2	66.90	100.00	32.93	72.96
	T_3	87.04	87.11	46.96	66.90
	T_4	92.97	100.00	73.24	80.05
	T_5	100.00	92.96	92.70	80.02
	T_6	86.95	87.03	72.69	72.96
	Control	96.95	96.94	85.03	85.03
		CD: 0.16	**CD: 0.30**	**CD: 0.55**	**CD: 0.23**
White watery rose apple	T_1	100.00	60.13	60.03	40.31
	T_2	100.00	80.23	59.76	40.03
	T_3	80.61	59.81	59.98	40.03
	T_4	82.81	100.00	66.22	66.81
	T_5	100.00	83.35	66.59	66.83
	T_6	83.06	83.34	67.43	66.76
	Control	79.89	79.89	62.19	62.19
		CD: 0.51	**CD: 0.95**	**CD: 1.46**	**CD: 1.36**
Malay apple	T_1	79.92	93.35	63.5	59.85
	T_2	66.91	100.00	64.2	60.82
	T_3	86.95	87.18	63.5	62.41
	T_4	92.94	100.00	60.51	60.87
	T_5	100.00	93.02	64.19	63.01
	T_6	91.04	87.00	64.91	64.07
	Control	91.07	91.07	63.18	63.17
		CD: 0.48	**CD: 4.45**	**CD: 0.87**	**CD: 0.76**

T_1 – Whole fruit dipped in hot water/steamed for 1 minute

T_2 – Whole fruit dipped in hot water/steamed for 2 minutes

T_3 – Whole fruit dipped in hot water/steamed for 3 minutes

T_4 – Sliced fruit dipped in hot water/steamed for 1 minute

T_5 – Sliced fruit dipped in hot water/steamed for 2 minutes

T_6 – Sliced fruit dipped in hot water/steamed for 3 minutes

However in white watery rose apple treatments T_1 and T_2 also recorded the same percentage recovery of pulp. T_2 recorded the lowest recovery of pulp (66.9 %) in pink and Malay apple and in white watery rose apple lowest recovery of pulp (79.89 %) was in control.

Considering the juice recovery from hot water blanching, T_5 recorded the highest recovery (92.7 %) in pink watery rose apple and T_6 in white watery rose apple and Malay apple. Recovery recorded was 67.43 and 64.91 % respectively. This was on the par with T_4 and T_5 in white watery rose apple and T_2 and T_5 in Malay apple. Lowest juice recovery recorded was for T_2 in pink (32.90 %) and white watery rose apple (59.76 %) and T_4 (60.51 %) in Malay apple. Juice recovery from T_2 in white watery rose apple was on the par with T_1 and T_3.

4.2.2. Steam blanching

The percentage recovery of pulp and juice from three types of fruits subjected to steam blanching is given in Table 6. In pink watery rose apple it can be seen that percentage recovery of pulp was maximum in the T_1, T_2 and T_4. In this case pulp recovery recorded was 100 percent. The lowest pulp recovery (87.03 %) was recorded for T_6 which was on the par with T_3.

In white watery rose apple, T_4 was found to be the best for getting maximum pulp. Pulp recovery recorded was 100 percent and the lowest recovery was recorded for T_3 (59.81 %) which was on the par with T_1. Pulp recovery was 20 per cent higher than that in control. In Malay apple, T_2 and T_4 recorded the highest recovery of pulp. The recovery recorded was 100 percent for pulp. This was more than the control by nine per cent. Lowest recovery was recorded for T_6 (87 %). It was on the par with T_3 and control.

Considering the juice recovery it was highest (86.81 %) for fruits under T_1 in pink watery rose apple and that of lowest recovery was for fruits under T_3 (66.9 %). For white watery rose apple maximum juice recovery (66.83 %) was recorded for T_5 which was on the par with T_4 and T_6 and the minimum recovery (40.03 %)

was in T_2 and T_3 which was on the par with T_1. T_6 recorded the highest recovery (64.07 %) in Malay apple and T_1 the least (59.85 %).

Pulp recovery from blanched whole fruits and sliced fruits were compared. Blanching of whole or sliced fruits did not show significant difference in pulp recovery in pink watery rose apple. In white watery rose apple and Malay apple there was significant difference between whole and sliced fruits. Slicing increased the percentage recovery of pulp in many cases of blanching. The sliced fruit blanched in hot water for three minutes produced the highest quantity of pulp (Table 7). In Malay apple difference in pulp recovery between T_1 and T_4 was also significant.

There was significant difference between recovery of juice from whole and sliced fruits due to blanching (Table 8). In pink and white watery rose apple, slicing significantly increased the juice recovery. Thus T_6 was superior to T_3 under hot water and steam blanching in pink watery rose apple. In white watery rose apple T_4, T_5 and T_6 were superior to T_1, T_2 and T_3 in steam blanching. In Malay apple T_5 was significantly superior to T_2 in hot water blanching and T_4 was superior to T_1 in steam blanching.

4.2.3. Osmoextraction

The percentage recovery of pulp and juice made by osmoextraction from three types of fruits are given in Table 9. In pink watery rose apple 96.94 per cent pulp and 79.95 per cent juice was obtained through osmoextraction. For white watery rose apple recovery of pulp and juice were 81.02 and 62.98 per cent respectively. In Malay apple, pulp recovery was 92.32 per cent and that of juice was 62.3 per cent.

The recovery of pulp and juice in osmoextraction and extraction from fresh fruit was compared to the best treatment in hot water and steam blanching (Table 10). It can be seen that the recovery of pulp from hot water and steam

Table 7 Comparison of whole and sliced fruits with respect to recovery of pulp

Type	Hot water pulp	t value	Steamed pulp	t value
White watery rose apple	T_3 and T_6	-39.314**	T_3 and T_6	0.517**
Malay apple			T_1 and T_4	-22.223**
			T_3 and T_6	-13.176**

**Significant at 1% level

Table 8 Comparison of whole and sliced fruits with respect to recovery of juice

Type	Hot water juice	t value	Steamed juice	t value
Pink watery rose apple	T_1 and T_4 T_2 and T_5 T_3 and T_6	48.728** -29.437** -29.598**	T_3 and T_6	-44.677**
White watery rose apple			T_1 and T_4 T_2 and T_5 T_3 and T_6	-8.939** -12.155** -4.581**
Malay apple	T_2 and T_5	-4.732**	T_1 and T_4	0.025**

**Significant at 1% level

Table 9 Percentage recovery of pulp and juice by osmoextraction

Pulp	Recovery of pulp (%)	Recovery of juice (%)
Pink watery rose apple	96.94	79.95
White watery rose apple	81.02	62.98
Malay apple	92.32	62.3

Table 10 Comparison of recovery of pulp and juice in osmoextraction versus best treatments in blanching

Treatments	Pink watery rose apple		White watery rose apple		Malay apple	
	Pulp	Juice	Pulp	Juice	Pulp	Juice
Hot water blanching	100.00	92.70	100.00	66.59	100.00	64.19
Steam blanching	100.00	86.81	100.00	66.81	100.00	64.20
Osmoextraction	96.94	79.95	81.02	62.98	92.32	62.3
Fresh fruit (control)	96.95	80.03	79.89	61.00	91.00	63.17
CD	**0.40**	**0.82**	**1.13**	**2.20**	**2.04**	**0.89**

blanching was 100 percent in pink, white and Malay apples. Recovery of pulp through osmoextraction was lower than blanching by 3, 18 and 8 percent in pink, white and Malay apples respectively. Recovery of pulp from fresh fruit and osmoextraction was on the par in pink, white and Malay apples.

Recovery of juice was also compared against the best treatment in hot water and steam blanching as well as that from osmoextraction and that from fresh fruit pulp (Table 10). The recovery of juice has increased due to blanching in fruits of all the three types. The recovery of juice from fresh fruit and that through osmoextraction was on the par in all the three types of fruits.

The sensory attributes of the pulp made by hot water blanching, steam blanching and that from fresh fruit was assessed for three types using the Kendalls co-efficient of concordance (Table 11). It can be seen from the table that the fresh fruit pulp scored the highest rank in all the three types than the 13 different treatments tried in blanching.

Sensory attributes of fresh fruit pulp was then compared with the pulp made by osmoextraction using the mean score values for each parameter used in sensory evaluation. The mean score values of fresh fruit and osmoextracted pulp is given in Table 12. The mean score values for colour and taste was higher for osmoextracted pulp in all the types. For flavour, the mean score values for fresh fruit pulp scored the maximum. The overall acceptability was highest for osmoextracted pulp in all types of fruits. Hence osmoextraction was selected as the best treatment for extraction of quality pulp and juice.

The biochemical characters of the osmoextracted pulp and juice were analyzed (Table 13) and pulp and juice showed similar biochemical attributes. The TSS was found to be 48 °Brix in pink and white watery rose apple and 50 °Brix in Malay apple. The acidity recorded was 0.92, 0.10, and 0.10 per cent in pink, white and Malay apples respectively. Ascorbic acid content was 16.12, 4.4 and 13.3 mg/100g in pink, white and Malay apples respectively. Absorbance of colour for anthocyanin in osmoextracted pulp of pink watery rose apple was 1.36.

Table 11 Mean rank scores for sensory attributes of blanched and fresh fruit pulp

Pink watery rose apple pulp

Treatments	Colour	Taste	Flavour	Consistency	Overall acceptability
WFHWB1	7.00	8.00	7.56	6.56	29.12
WFHWB2	7.56	8.13	9.06	9.00	33.75
WFHWB3	6.06	8.38	3.81	6.56	24.81
SFHWB4	8.13	7.31	5.25	6.56	27.25
SFHWB5	7.63	5.31	5.88	5.81	24.63
SFHWB6	5.38	5.19	5.56	10.56	26.73
WFSB7	10.00	9.94	7.13	9.06	36.13
WFSB8	6.13	4.63	4.56	4.69	20.01
WFSB9	4.5	4.00	6.94	5.00	20.44
SFSB10	8.38	8.56	8.88	6.63	32.45
SFSB11	5.44	5.44	7.94	5.00	23.82
SFSB12	5.38	4.63	7.13	5.00	22.14
Control	9.44	11.5	11.31	10.56	42.81
Kendalls W (a)	0.316	0.424	0.376	0.446	
Asymmetric significance	0.3	0.012	0.012	0.012	

White watery rose apple pulp

Treatments	Colour	Taste	Flavour	Consistency	Overall acceptability
WFHWB1	5.13	6.25	7.13	5.25	23.76
WFHWB2	6.00	5.44	4.88	6.88	23.2
WFHWB3	5.94	7.00	6.44	6.13	25.51
SFHWB4	6.75	7.00	6.44	5.31	25.5
SFHWB5	7.56	7.00	7.94	7.69	30.19
SFHWB6	7.56	6.19	8.00	6.88	28.63
WFSB7	7.56	7.00	5.69	8.5	27.94
WFSB8	7.56	7.06	6.44	6.88	27.94
WFSB9	7.56	7.00	4.88	6.88	26.32
SFSB10	7.56	7.06	7.25	6.94	28.81
SFSB11	7.56	7.00	6.44	6.88	27.88
SFSB12	5.94	5.44	7.19	7.69	26.26
Control	8.31	11.56	12.31	9.13	41.31
Kendalls W (a)	0.113	0.202	0.304	0.147	
Asymmetric significance	54.0	7.8	0.4	29.6	

Table 11 continued…

Malay apple pulp

Treatments	Colour	Taste	Flavour	Consistency	Overall acceptability
WFHWB1	8.69	6.06	7.00	6.21	27.96
WFHWB2	5.69	6.56	4.75	7.07	24.07
WFHWB3	5.63	6.06	5.69	7.07	24.45
SFHWB4	7.19	7.06	6.19	7.07	27.51
SFHWB5	5.56	10.19	6.94	7.93	30.62
SFHWB6	7.19	6.94	6.19	7.07	27.39
WFSB7	7.19	9.00	7.69	7.07	30.95
WFSB8	7.19	6.75	7.69	7.07	28.7
WFSB9	7.19	5.38	7.00	6.21	25.78
SFSB10	7.19	7.25	7.75	7.07	29.26
SFSB11	7.19	5.5	7.75	6.14	26.58
SFSB12	7.19	4.75	7.00	7.93	26.33
Control	7.94	9.5	9.38	7.07	33.89
Kendalls W (a)	0.242	0.217	0.215	0.103	
Asymmetric significance	2.6	5.2	5.6	73.6	

WFHWB1- whole fruit hot water blanching for one minute

WFHWB2- whole fruit hot water blanching for two minutes

WFHWB3- whole fruit hot water blanching for three minutes

SFHWB4- sliced fruit hot water blanching for one minute

SFHWB5- sliced fruit hot water blanching for two minutes

SFHWB6- sliced fruit hot water blanching for three minutes

WFSB7-whole fruit steam blanching for one minute

WFSB8- whole fruit steam blanching for two minutes

WFSB9- whole fruit steam blanching for three minutes

SFSB10-sliced fruit steam blanching for one minute

SFSB11- sliced fruit steam blanching for two minutes

SFSB12- sliced fruit steam blanching for three minutes

Table 12 Mean score values for sensory attributes of fresh fruit and osmoextracted pulp

Pink watery rose apple	**Fresh fruit pulp**	**Osmoextracted pulp**
Colour	4.25	4.63
Taste	4.25	4.37
Flavour	4.13	4.00
Consistency	3.88	3.88
Overall acceptability	16.51	16.88
White watery rose apple	**Fresh fruit pulp**	**Osmoextracted pulp**
Colour	3.00	3.88
Taste	3.63	4.25
Flavour	3.88	3.00
Consistency	3.13	2.75
Overall acceptability	13.64	13.88
Malay apple	**Fresh fruit pulp**	**Osmoextracted pulp**
Colour	3.10	3.13
Taste	3.63	3.87
Flavour	3.50	3.25
Consistency	3.25	2.88
Overall acceptability	13.48	13.75

Table 13 Biochemical characters of osmoextracted pulp and juice*

Type	TSS (°Brix)	Titrable acidity (%)	Vitamin C content (mg/100g)	Absorbance
Pink apple	48	0.92	16.12	1.36
White apple	48	0.10	4.40	
Malay apple	50	0.10	13.3	

*The biochemical characters of juice were the same as that of pulp

4.3. Value added products

4.3.1. Osmodehydrated products

4.3.1.1. Immersion in sugar syrup

The mean score values for the osmodehydrated products prepared through different treatments are given in Table 14. Whole fruit osmodehydrated in different concentrations of sugar syrup *viz.*, 50, 60 and 70 °Brix was not acceptable (Plate 2). Sliced fruits prepared by dipping in different concentrations of syrup were found to be acceptable (Plate 2) and the best treatment was identified using Kendalls co-efficient of concordance. Based on the rank scores, it was judged that T_2 was the best treatment for pink and Malay apple types and T_3 was best in white watery rose apple for preparation of osmodehydrated products.

The recovery percentage of osmodehydrated fruit was 25 per cent of the fresh fruit weight.

4.3.1.2. Dry blending with sugar

The osmodehydrated product prepared by dry blending in the ratio of 1:1 was not found acceptable in organoleptic evaluation.

4.3.1.3 Shelf life of osmodehydrated products

The microbial load in the samples stored in glass bottle and plastic bottle for different durations of storage are given in Table 15. Fruit pieces of Malay apple dipped in 60 °Brix were used for storage study. Up to one month, no microbial load was observed in any of the sample. After two months of storage, the average number of colony forming units (CFU) of fungus per gram of the sample was recorded as 1.6×10^4. It increased up to 3.1×10^4 CFU by three months of storage. The average number of CFU of bacteria in sample kept in glass bottle after 2 months was 1×10^5 and increased to 3×10^5 CFU after three months of storage.

Plate 2 Osmodehydrated products- Malay apple

Whole fruits

Sliced fruits

Table 14 Mean rank scores for sensory attributes of osmodehydrated products

Pink apple

Treatments	Taste	Consistency	Flavour	Colour	Overall acceptability
T_1	1.81	1.63	1.94	1.63	7.01
T_2	2.44	2.44	2.44	2.50	9.82
T_3	1.75	1.94	1.63	1.88	7.20
Kendalls W (a)	0.21	0.28	0.28	0.33	
Asymmetric significance	18.60	10.40	10.40	7.40	

White apple

Treatments	Taste	Consistency	Flavour	Colour	Overall acceptability
T_1	1.50	2.06	2.31	1.75	7.62
T_2	2.13	2.06	1.81	1.88	7.88
T_3	2.38	1.88	1.88	2.38	8.52
Kendalls W (a)	0.33	0.02	0.10	0.22	
Asymmetric significance	7.40	87.80	43.80	17.40	

Malay apple

Treatments	Taste	Consistency	Flavour	Colour	Overall acceptability
T_1	1.63	1.50	1.63	2.00	6.76
T_2	2.50	2.50	2.69	2.80	10.49
T_3	1.88	2.00	1.69	1.19	6.76
Kendalls W (a)	0.24	0.50	0.52	0.81	
Asymmetric significance	14.60	1.80	1.60	0.20	

T_1-Sliced fruit dipped in sugar syrup of 50 °Brix
T_2-Sliced fruit dipped in sugar syrup of 60 °Brix
T_3- Sliced fruit dipped in sugar syrup of 70 °Brix

Table 15 Microbial load in sample stored in glass bottle and plastic bottle

Periods of storage in months	Microbial population [CFU (g^{-1})]					
	Bacteria (x 10^5)		Fungi (x 10^4)		Yeast (x 10^3)	
	Glass bottle	Plastic bottle	Glass bottle	Plastic bottle	Glass bottle	Plastic bottle
1 MAS	Nil	Nil	Nil	Nil	Nil	Nil
2 MAS	1	1	1.6	1.2	Nil	Nil
3 MAS	3	2.5	3.1	2.5	Nil	Nil

In the samples stored in plastic bottles the average population of fungus was 1.2 x 10^4 at two months after storage which has increased to 2.5 x 10^4 by three months of storage. The average number of bacterial colony recorded was 1 x 10^5 at two months of storage which has increased up to 2.5 x 10^5 by three months of storage.

Yeast was not observed in the sample stored in the glass bottle and plastic bottle up to three months of storage.

4.3.2. Pickle

The effect of different treatments on quality of pickle (Plate 3a) was analyzed based on the score values for taste, flavour, consistency, colour and overall acceptability. The values are presented in Table 16.

In pink watery rose apple pickle, the maximum score (3.69) for taste was recorded for the pickle under T_5. The score was lowest for the pickle in T_3. Considering the flavour, T_5 (fresh sliced fruit) acquired the maximum score value of 4.06. The score for consistency, colour and overall acceptability were also maximum for T_5. Thus T_5 was selected as the best method for pickling pink watery rose apple.

In white watery rose apple pickle, the maximum score (4.25) for taste was recorded for the pickle under T_5 (fresh sliced fruit). The score was least for pickle in T_4. Flavour for the pickle was maximum for T_1. Considering consistency and colour the highest scores were for T_2 and T_5 (3.31 and 3.88) respectively. The overall acceptability of pickle under T_5 was the highest.

In Malay apple pickle, the highest score for taste was for pickle in T_5 (Fresh sliced fruit). For flavour, pickle made from fruits under T_2 scored the highest (3.38). Considering consistency, colour and overall acceptability the highest score was for pickle in T_5.

Plate 3 Value added products

3a. Pickle

3b. Wine

(Pink watery rose apple) **(White watery rose apple)**

3c. Squash

(Pink watery rose apple) **(White watery rose apple)**

Table 16 Mean rank scores for sensory attributes of pickle

Pink watery rose apple

Treatments	Taste	Flavour	Consistency	Colour	Overall acceptability
T_1	2.88	3.75	3.81	2.88	13.32
T_2	3.19	3.5	2.25	3.19	12.13
T_3	1.75	1.19	1.63	1.75	6.32
T_4	3.5	2.5	3.25	3.50	12.75
T_5	3.69	4.06	4.06	3.69	15.50
Kendalls W(a)	0.309	0.707	0.594	0.309	
Asymmetric significance	4.2	0.001	0.001	4.2	

White watery rose apple

Treatments	Taste	Flavour	Consistency	Colour	Overall acceptability
T_1	3.63	3.56	3.25	3.25	13.69
T_2	3.00	2.63	3.31	2.5	11.44
T_3	2.88	3.25	3.00	2.94	12.07
T_4	2.25	2.06	2.44	2.44	9.19
T_5	4.25	3.5	3.00	3.88	14.63
Kendalls W(a)	0.469	0.371	0.094	0.191	
Asymmetric significance	0.5	1.8	55.6	19.0	

Table 16 continued…

Malay apple pickle

Treatments	Taste	Flavour	Consistency	Colour	Overall acceptability
T_1	2.31	2.69	2.94	3.19	11.13
T_2	2.63	3.38	3.25	2.88	12.14
T_3	2.31	2.69	2.69	2.88	10.57
T_4	3.69	3.00	2.69	2.88	12.26
T_5	4.06	3.25	3.44	3.19	13.94
Kendalls W(a)	0.358	0.066	0.115	0.016	
Asymmetric significance	2.2	71.3	45.1	97.1	

T_1 - Hot water blanching for one minute

T_2 - Steam blanching for 3 minutes.

T_3 - Mixing with salt 4 % and kept for 12 hours

T_4 - Mixing with salt 4 % followed by drying in a cabinet drier for 2 hours

T_5 - Fresh sliced fruit

4.3.3. Wine

The mean rank scores recorded for wine under different treatments are given in Table 17. Among the different treatments, T_1 recorded the maximum score for taste (4.94) for Malay apple wine followed by T_2 (4.75). T_6 recorded the least score (1.5). In the case of flavour, maximum score was for the wine under T_1 and T_5 (4.19). There was no difference with respect to score for colour for the wine under different treatments. The clarity of wine was scored high when wine was prepared using T_1 (4.13) followed by T_2 (4.00). The overall acceptability was maximum for the wine under T_1 followed by T_2 and $T_{5.}$ So T_1 and T_2 were selected as best treatments for preparing wine with pink and white watery rose apple.

In white watery rose apple wine (Plate 3b) the maximum score for taste was recorded for T_1. Score for colour and flavour did not show any difference among the treatments. For clarity, again wine under T_1 scored the highest (1.63). The overall acceptability was more for wine under T_1 (6.26).

Considering pink watery rose apple wine (Plate 3b) score for taste was maximum for T_2 while T_1 scored the maximum (1.69) for flavour. There was no difference with respect to score for colour of wine made from both the treatments. Clarity was more for T_2 (1.56) and the score for overall acceptability was more or less same for wine prepared using T_1 (6.01) and T_2 (6.00). Thus T_1 could be recommended for preparation of wine from watery rose apple and Malay apple.

4.4. Pulp and juice based products

4.4.1. Preparation of squash

Kendalls co-efficient of concordance was worked out to assess the degree of agreement of squash among the judges. The mean rank scores are given in Table 18. Squash made from pink watery rose apple (Plate 3c) secured the highest mean rank score in taste, colour, flavour and consistency. It was 2.38, 2.81, 2.38

Table 17 Mean rank scores for sensory attributes of wine

Malay apple					
Treatments	Taste	Flavour	Colour	Clarity	Overall acceptability
T_1	4.94	4.19	3.5	4.13	16.76
T_2	4.75	3.63	3.5	4.00	15.88
T_3	2.44	3.06	3.5	2.75	11.75
T_4	3.25	3.81	3.5	3.69	14.25
T_5	4.13	4.19	3.5	3.4	15.22
T_6	1.5	2.13	3.5	2.4	9.53
Kendalls W(a)	0.580	0.229	3	0.209	
Asymmetric significance	0.001	10.2	.001	13.7	
White watery rose apple					
T_1	1.63	1.5	1.5	1.63	6.26
T_2	1.38	1.5	1.5	1.38	5.76
Kendalls W(a)	0.083	0.001	0	0.25	
Asymmetric significance	29.4	0.001	0	15.7	
Pink watery rose apple					
T_1	1.38	1.69	1.5	1.44	6.01
T_2	1.63	1.31	1.5	1.56	6.00
Kendalls W(a)	0.125	0.225	0	0.025	
Asymmetric significance	3.17	18.0	1.00	65.5	

T_1 – Sliced fruit + equal quantity of sugar + half the quantity of water as that of fruit
T_2 – Sliced fruit + equal quantity of sugar and water as that of fruit
T_3 – Sliced fruit + half the quantity of sugar and water as that of fruit
T_4 – Crushed fruit + equal quantity of sugar + half the quantity of water as that of fruit
T_5 – Crushed fruit + equal quantity of sugar and water as that of fruit
T_6 – Crushed fruit + half the quantity of sugar and water as that of fruit

Table 18 Mean rank scores for sensory attributes of squash prepared from watery rose apple and Malay apple

Type	Taste	Colour	Flavour	Consistency	Overall acceptability
Pink watery rose apple	2.38	2.81	2.38	2.75	10.32
Malay apple	1.75	1.56	1.88	1.75	6.94
White watery rose apple	1.88	1.63	1.75	1.63	6.89
Kendalls W (a)	0.159	0.611	0.159	0.396	
Asymmetric significance	28	0.8	28	4.2	

and 2.75 respectively. The overall acceptability was also maximum (10.32) for squash made using this type. There was no significant difference in score for quality attributes of squash prepared using Malay and white watery rose apple.

The prepared squash had an acidity of 0.31, 0.10 and 0.21 % for pink, white and Malay apples respectively (Table 19). The vitamin C content in pink watery rose apple squash was found to be 12.9, 16.13 in white watery rose apple squash and 16.3 mg/100g in Malay apple. It can be seen from the table that squash prepared from Malay apple retained the maximum vitamin C content.

4.4.2. Preparation of RTS beverage

The mean rank scores of taste, colour, flavour, consistency and overall acceptability of RTS beverage prepared from three types of fruits are given in Table 20. The mean rank scores for quality parameters were highest for RTS beverage prepared using pink watery rose apple (Plate 3d) followed by Malay apple and white watery rose apple. The overall acceptability was also maximum for pink watery rose apple (10.58) and the least for white watery rose apple (6.07).

The titrable acidity and vitamin C content in RTS beverage prepared using different types are given in Table 21. The acidity of pink, white and Malay apple RTS beverage were found to be 0.1, 0.05 and 0.05 % respectively. Ascorbic acid recorded were 13.33 mg/100g for pink, 8.89 mg/100g for white and 17.78 mg/100g for Malay apple. In RTS beverage also, Malay apple RTS retained the maximum vitamin C content as observed in squash and the minimum was for white apple RTS beverage.

4.4.3. Preparation of jam

The mean rank scores for quality attributes of jam (Plate 3e) and the Kendalls co-efficient of concordance are given in Table 22. The mean rank score for taste was maximum for pink watery rose apple (2.44) followed by Malay apple

3d. RTS beverage

(Malay apple)

(Pink watery rose apple)

3e. Jam

(Pink watery rose apple)

(White watery rose apple)

(Malay apple)

Table 19 Titrable acidity and ascorbic acid content of the squash

Type	Titrable acidity (%)	Vitamin C mg/100g	Absorbance
Pink watery rose apple	0.31	12.9	0.61
White watery rose apple	0.102	16.13	
Malay apple	0.21	16.3	

Table 20 Mean rank scores for sensory attributes of RTS beverage prepared from watery rose apple and Malay apple

Type	Taste	Colour	Flavour	Consistency	Overall acceptability
Pink watery rose apple	2.5	2.88	2.81	2.75	10.58
White watery rose apple	1.5	1.38	1.56	1.75	6.07
Malay apple	2.0	1.75	1.63	1.63	7.38
Kendalls W(a)	0.5	0.722	0.611	0.396	
Asymmetric significance	1.8	0.3	0.8	4.2	

Table 21 Titrable acidity and ascorbic acid content of the RTS beverage

Type	Titrable acidity (%)	Ascorbic acid content mg/100g
Pink watery rose apple	0.10	13.33
White watery rose apple	0.05	8.89
Malay apple	0.05	17.78

Table 22 Mean rank scores for sensory attributes of jam prepared from watery rose apple and Malay apple

Type	Taste	Colour	Consistency	Flavour	Overall acceptability
Pink watery rose apple	2.44	2.88	2.19	2.81	10.32
White watery rose apple	1.63	1.44	2.75	1.56	7.38
Malay apple	1.94	1.69	1.06	1.63	6.32
Kendalls W(a)	0.299	0.726	0.875	0.588	
Asymmetric significance	9.2	0.3	0.1	0.9	

(1.94), and white apple (1.63). The overall acceptability of jam was highest (10.32) for pink and the least for Malay (6.32).

The titrable acidity in pink and white watery rose apple jam was recorded as 0.5% and that of Malay apple as 0.46 % (Table 23). Ascorbic acid content in pink and Malay apple jam was 17.78 mg/100g and that prepared with white watery rose apple was 4.44 mg/100g.

4.5. Extraction and colouring of products

4.5.1. Extraction using methanolic HCl

The total anthocyanin content in the Malay apple flower extract prepared using the two methods (3.4.1.2.) recorded the same value which was 0.33 mg/g of the sample.

4.5.2. Acidified aqueous extraction

Acidified aqueous extraction using citric acid was done using Malay apple flowers and pink watery rose apple fruits. The data on the anthocyanin extracted from Malay flower with respect to different concentrations of citric acid (Plate 4) and dipping time are given in Table 24.

As the time of dipping of flowers for extraction was increased from 0 hour to 12 hours the quantity of anthocyanin extracted was also increased except in C_5 where after 6 hours of dipping the anthocyanin content was reduced from 0.39 to 0.27. The anthocyanin content was increased as the concentration of citric acid was increased except in T_4. In T_4 anthocyanin extracted reduced from 0.4 to 0.27 as the concentration of citric acid was increased from four to five per cent. Maximum extraction of anthocyanin (0.4 mg/g) was recorded when the flowers were dipped in 4 % citric acid and kept for 12 hours.

The data on effect of concentration of citric acid and time of dipping the pink watery rose apple fruits (Plate 4) on extraction of anthocyanin is given in Table 25. As the time of dipping of fruits was increased from 0 hour to 12 hours, the extraction of anthocyanin was increased except in C_2, C_3 and C_5. In C_2 and C_3

Plate 4 Colour extracted from Malay apple flowers and pink watery rose apple fruits

Flower bed of shedded flowers- Malay apple

Malay apple flower

Colour in methanolic HCl

Colour- Malay apple flowers in different concentrations of citric acid

Colour- pink watery rose apple fruits in different concentrations of citric acid

Table 23 Titrable acidity and ascorbic acid content of jam

Type	Titrable acidity (%)	Ascorbic acid content mg/100g
Pink watery rose apple	0.5	17.78
White watery rose apple	0.5	4.44
Malay apple	0.46	17.78

Table 24 Quantity of anthocyanin extracted from Malay apple flowers at different concentrations of citric acid (mg/g of sample)

Concentrations of citric acid (%)	Time interval (hours)			
	T_1	T_2	T_3	T_4
C_1	0.01	0.07	0.14	0.19
C_2	0.02	0.13	0.21	0.26
C_3	0.01	0.17	0.19	0.25
C_4	0.02	0.17	0.32	0.40
C_5	0.03	0.33	0.39	0.27
CD = 0.05				

Table 25 Quantity of anthocyanin extracted from pink watery rose apple fruit at different concentrations of citric acid (mg/g of sample)

Concentrations of citric acid (%)	Time interval (hours)			
	T_1	T_2	T_3	T_4
C_1	0.01	0.03	0.05	0.07
C_2	0.01	0.03	0.09	0.09
C_3	0.02	0.07	0.09	0.09
C_4	0.03	0.08	0.09	0.10
C_5	0.04	0.06	0.17	0.10
CD = 0.009				

C_1- One per cent citric acid

C_2- Two per cent citric acid

C_3- Three per cent citric acid

C_4- Four per cent citric acid

C_5- Five per cent citric acid

T_1- 0 hour interval

T_2- 3 hour interval

T_3- 6 hour interval

T_4- 12 hour interval

anthocyanin content remained constant (0.09). In $C_{5,}$ the anthocyanin content reduced from 0.17 to 0.10 as the time interval increased from 6 hours to 12 hours.

The extraction of anthocyanin was increased as the time of dipping was increased except in $T_{2.}$ In T_2 as the concentration increased from four to five percent anthocyanin content was reduced from 0.08 to 0.06. The maximum extraction from pink watery rose apple fruits were obtained when fruits were dipped in 5 % citric acid for a duration of six hours.

4.5.3. Colouring of products

Among the different levels of colour extract tried for imparting an appealing colour, ten milliliters of Malay apple wine required six milliliters of three per cent citric acid for colour expression (Table 26). Higher concentrations *viz.*, four per cent and five per cent imparted a sour taste to the product. The absorbance of the colour added wine (Plate 5) was recorded as 0.99. But after one month of storage time, it was reduced to 0.32. The same procedure was tried for Malay apple squash (Plate 5). Ten milliliters of squash required 20 milliliters of three per cent colour extract for colour expression. The absorbance of colour added squash was recorded as 0.53. But after one month of storage time, the absorbance was reduced to 0.04.

Plate 5 Products coloured with anthocyanin

Wine

Squash

Wine (after one month)

Squash (after one month)

Table 26 Utilization and absorbance of colour extract from Malay apple flowers added in wine and squash

Product	Quantity of colour extract added (ml) / 10 ml	Initial absorbance	Absorbance after one month
Wine	6	0.99	0.32
Squash	20	0.53	0.04

Discussion

5. DISCUSSION

Watery rose apple (*Syzygium aqueum* (Burm) Alston) occurs in many tropical countries (Plate 6). It is a minor fruit in the households of South East Asia. Fruits are flattened at both ends, white, rose or red in colour, juicy, spongy, sweet acidic, watery and seeds two to six in number (Radha and Mathew, 2007) Rose apples bruise quite easily and are highly perishable. They must be freshly picked to be crisp (Morton, 1987). The fruit does not have much of commercial value, but can be used for developing value added products.

Malay apple (*Syzygium malaccense* (L.) Mernil and Perry) has a shiny, thin skin which varies from white to red. The flesh is white or pink in colour, crispy and juicy (Plate 6). Red types are smallest, sweet and juicy while white types are acidic (Elizabeth and Hyde, 2007). Fruits contain vitamins like nicotinic acid, riboflavin, vitamin C and minerals like Ca, P and Fe. Tree possesses medicinal properties as well. Extract taken from the plant affects respiration and blood pressure. Bark is astringent and used for making mouthwashes. Root is diuretic (Radha and Mathew, 2007).

Many of these minor fruits are highly perishable. Therefore the fruits should be processed and preserved immediately after harvest so that the growers get a remunerative price and consumers all over the world get the opportunity to enjoy the fruit in the form of its products.

In watery rose apple research efforts diverted in the area of post harvest handling is negligible. Joy (2003) studied the utilization of selected under exploited fruits like bilimbi, rose apple and lovi lovi for product development The present study was proposed to evaluate the quality parameters of watery rose apple and Malay apple for processing attributes and to develop value added products from these fruits. Emphasis was also given to extract and estimate natural colour from fruits and flowers of *Syzygium* species. Worldwide, especially in developed countries, there is an increasing demand for food not only tasty and safe but also produces additional health benefits. The bright crimson pink flowers

Plate 6 Watery rose apple and Malay apple under study

Pink watery rose apple (*Syzygium aqueum* (Burm) Alston)

White watery rose apple (*Syzygium aqueum* (Burm) Alston)

Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)

which develop on Malay apple tree usually fall down and become a waste. In this context, the possibility of using the natural colour anthocyanin present in the fruits of watery rose apple and flowers of Malay apple for colouring the food stuffs was explored.

5.1. Evaluation of physico chemical attributes for processing

Unlike other fruit crops, in watery rose apple released varieties are not available. However types possessing distinct and variable characters have been reported in rose apple (Mazumdar, 1979) and in Malay apple (Whistler and Elevitch, 2006). In the present study efforts were taken to collect different accessions which exhibit wide variability of watery rose apple and Malay apple from in and around Thrissur district and to analyze the quality parameters.

The different accessions of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry) were primarily classified based on their colour to analyze the quality variation existing in relation to colour. Variability in physico chemical attributes with respect to colour of fruits was reported by Singh *et al*. (1999) in monkey jack and karonda. In the present study, variation in colour of fruits among the different accessions within the types was found negligible. In pink watery rose apple apart from clear pink types, pinkish red types were available. No colour variation in white watery rose apple was noticed. In Malay apple apart from deep pink types only light pink types could be located. In this context the attributes of three prominent types *viz*., pink watery rose apple, white watery rose apple and Malay apple existing based on clear cut variation in colour and quality of fruits were taken into account. In each type quality attributes of different accessions were studied separately (Table 4).

Obviously there was variation with respect to size of fruits. In each type criteria for identifying big, medium and small fruits were fixed and based on this grouping was done. Physico chemical attributes of fruits based on their size were studied separately (Table 4a). The important processing attributes studied were physical characters such as weight of fruits, pulp content and biochemical characters *viz.*, TSS, acidity, sugar and ascorbic acid content. The variability observed in Malay apple with respect to size groups gave better opportunity to impose selection criteria for organized plantation. Selection of desirable plant types is no doubt the first essential step. It is also important to standardize the technique of vegetative propagation so that true to type plants may be produced for commercial plantation.

The size of fruits assumed significance only in Malay apple, since there was significant difference in quality attributes among the three size groups *viz*., big, medium and small. In general big sized fruits of Malay apple recorded highest recovery of pulp. The total sugar and ascorbic acid content was also significantly high in this fruit of particular group. As the acidity was low the sugar acid ratio of big fruits are comparatively high. Considering these aspects it can be concluded that big fruits of Malay apple are ideal for table purpose and preparation of value added products. Thus AC.1 was selected for preparation of various products.

Statistically significant variation could be noticed among the different types analyzed in terms of fruit weight (Fig.1) and titrable acidity (Fig. 2). In general the mean fruit weight recorded for Malay apple was higher compared to other two types. The pink and white watery rose apple did not record significant difference with respect to fruit weight. Watery rose apples are the common types grown in homesteads and quite often they are small fruit bearing types. The study pointed out the possibility of improving the fruit size of watery rose apple through planned breeding programmes and subsequent vegetative propagation to perpetuate the types.

Even though more quantity of pulp could be recovered from bigger fruits, there was no significant difference in percentage recovery of pulp among different types (Table 4). Palaniswamy and Muthukrishnan (1976) stated that the size of the mango fruits was a direct indication of pulp content. Mango varieties with bigger fruit size gave higher pulp yield than the varieties with smaller fruit size. This was true in watery rose apple and Malay apple types. In pink watery rose apple, pulp

Fig. 1 Variation in fruit weight

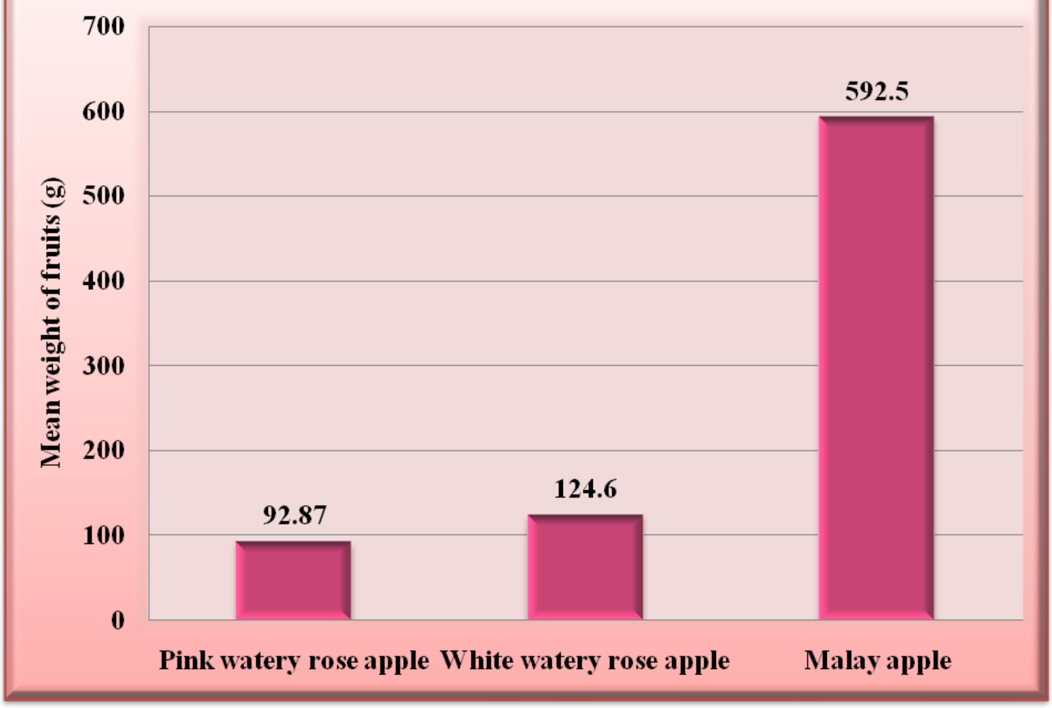
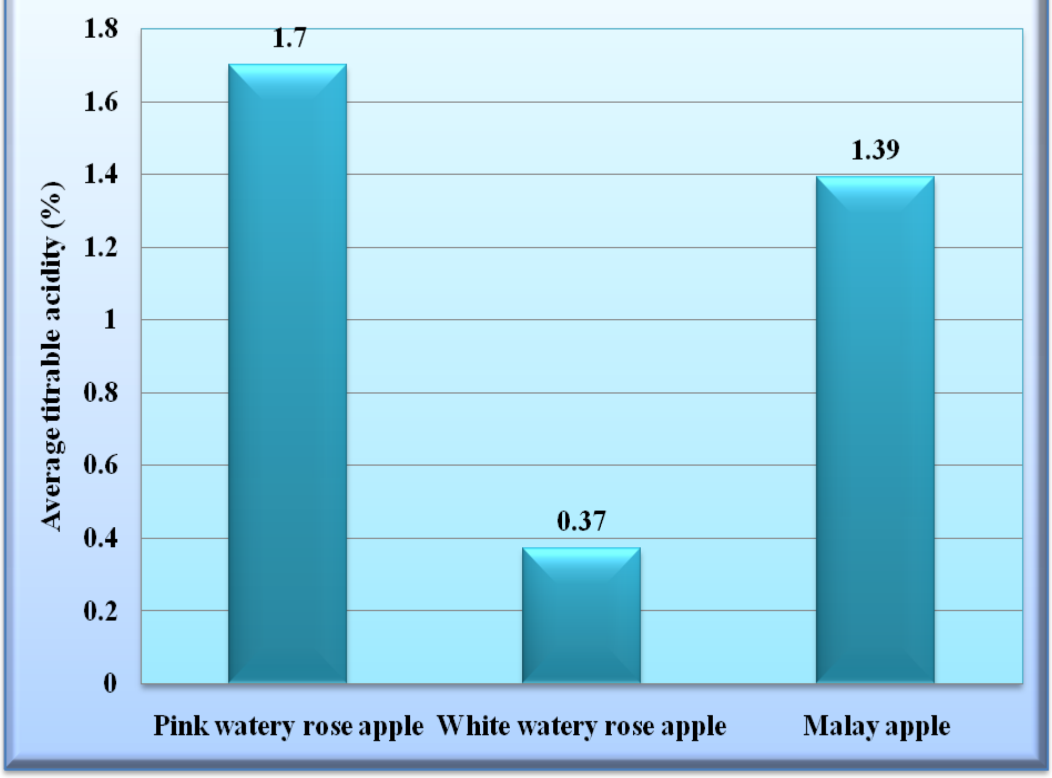


Fig. 2 Variation in acidity



recovery recorded ranged between 60 and 98.2 % that in white watery rose apple, 95.65 and 91.56 % and in Malay apple 85.4 and 92.56 %. The pulp recovery of watery rose apple was almost the same as that recorded for oblong types of jamun fruits. Oblong type jamun fruits exhibited a pulp recovery of 87 to 92 % (Singh *et al.*, 1999). The reports of scientific studies on processing attributes of minor fruits underline the emerging scope for their utilization in future.

The prime component of interest for the processors is the biochemical characters of fruits. According to the variation in biochemical characters, the fruits can be chosen for various purposes. The striking difference among the different types of fruits was noticed in the titrable acidity. The titrable acidity ranged between 0.37 and 1.7 % among the three types. All accessions of white watery rose apple recorded the lowest acidity while the pink accessions recorded the highest. Acidity is an important biochemical attribute that impart a sour taste to fruits. This has a governing role in determining the likeness of a fruit. Sour tastes are generally not accepted in their fresh form. But for preparation of products this is a significant character. Fruits which are sour in taste can be used for preparation of a variety of pickles. In the present study also accessions with more acidity were selected for pickling.

It has been reported that many underutilized fruits are good source of vitamins (Rathore, 2001 and Matsura *et al*., 2001). The present study also highlights the fact that watery rose apple and Malay apple are good source of vitamin C. The vitamin C content of watery rose apple ranged between 6.45 and 83.87 mg/100g whereas the range in Malay apple was 12.9 to 42.2 mg/100g. This was almost similar as that reported in jamun fruits which recorded a range of 30.3 to 40.7 mg/100g (Singh *et al.,* 1999). This is very important in the context where vitamin C deficiency causes scurvy (Woodruff, 1975). There should be a great concern that a major chunk of watery rose apple and Malay apple produced in the country were wasted due to want of scientific and sound processing technologies. Studies on processing in minor fruits are to be streamlined in such a way to retain their maximum vitamin resource. As wines are reported to be the health providing beverages that retain the phytonutrient and phytoceutical properties of fruits, accessions with high vitamin C content were selected for preparation of wine.

Variability with respect to sugar content in different types was very narrow. The mean total sugar content in pink and white watery rose apple ranged between 2.07 and 2.53 % while in Malay apple it was 2.45 %. However, considering the TSS and total sugar content it could be seen that pink watery rose apple was comparatively sweeter than the other two types. Jamun an underexploited fruit belonging to Myrtaceae family is reported to have TSS ranged between 9.00 and 11.00 (Singh *et al*, 1999). It is much higher than the watery rose apple. The fruit juice percentage recovery and well balanced sugar acid ratio of jamun fruit highlighted its feasibility in preparation of attractive beverages (Hema, 1997). This again stresses the need to increase the sugar acid ratio of watery rose apple and Malay apple so that it could be better utilized in the processing industry.

The analyses on biochemical characters of watery rose apple and Malay apple in the present study highlighted three facts- one is that the fruits can be put in to use for developing low calorie products as the sugar content in them is very low. Acceptable value added products can be prepared selecting ideal types from the existing variability. Types possessing ideal processing attributes with respect to product suitability can be developed through breeding programmes.

5.1.2. Accessions for preparation of value added products

The suitability of fruits for preparation of products depends upon their physico chemical attributes. Thus selecting fruit types according to their suitability for products will be highly useful. Such attempts had already been done in major fruit crops like mango, pineapple, banana *etc.* (Chadha *et al*., 1998). For preparation of beverages, sugar content and juice recovery are given prime consideration. However the beverage industry primarily depends upon the juice recovery considering the economics of raw material and labour involved.

In the present study variation among the different accessions within white watery rose apple and Malay apple types was negligible in pulp recovery and TSS. Only pink watery rose apple exhibited variation in pulp recovery. Hence accessions with high pulp recovery and comparatively high sugar content were selected for preparation of beverage. Similarly accessions with big fruits were selected for preparation of osmodehydrated products as they can be handled easily as whole or sliced form. As the small fruits had less use in fresh form they were selected for pickling. Big fruits with high sugar acid ratio were selected for table purpose and for preparing wine those accessions with high vitamin C and total sugars were considered.

The types suitable for different products were identified for further studies. In general pink watery rose apple which possesses attractive colour and comparatively high sugar and acidity is ideal for preparation of fruit beverage while white watery rose apple and Malay apple can be used for preparation of fermented products like wine, pickle and vinegar. In the present study products were prepared using the selected accessions (Fig. 3) under each type and their quality attributes were evaluated and compared. This helped to bring out the type suitability and ideal treatment to be adopted in standardization of products.

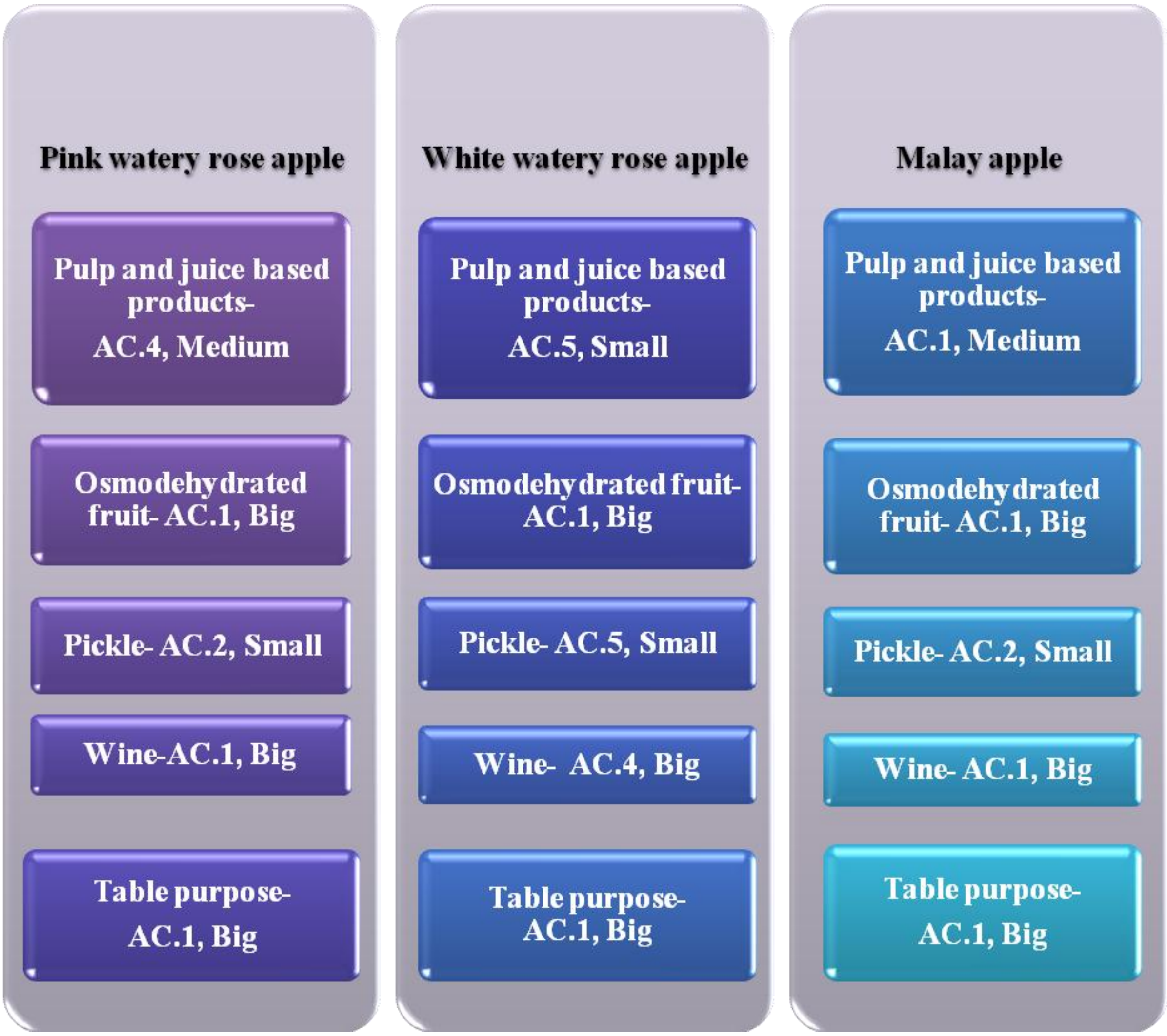
5.2. Production of quality pulp/juice

5.2.1. Blanching

Watery rose apple and Malay apple are mainly consumed in fresh form and rarely in the form of juice. Sound technology for preparation of pulp or extraction of juice is lacking in this fruit. Quality of pulp/juice should be given prime importance in formulating technology for their preparation as the same will reflect in the product. Hence in the present study emphasis was given to evolve ideal technology for extraction of quality pulp/juice. Quality of pulp/juice was determined on the basis of colour, taste, flavour, consistency and overall acceptability of the pulp/juice obtained through different treatments delineated.

In production of quality pulp/juice, blanching (hot water and steam) and osmoextraction were tried. It was found that the pulp and juice recovery from fruits subjected to hot water and steam blanching was higher than that in the control. Hot water and steam blanching gave better extraction of constituents like acidity and total soluble solids due to tissue softening in heat treatment. Sharma *et al.*, (1992) also opined the same in juice extracted from grapes grown under

Fig. 3 Product suitability of different accessions



temperate conditions. Shashikumar and Khurdiya (2002) reported that blanching of fruits at 100 °C for six minutes improved the juice recovery in aonla. Similar results have been reported by Saikia and Dutta (1995) in juice extracted from outenga (*Dillenia indica*) fruits. Slicing of fruits followed by blanching was found to increase the pulp/juice recovery. This might be due to the more exposure of surface area and penetration of heat enabling more cell collapse and oozing out of juice. However pure blanching was not recommended as an ideal method for extraction of pulp/juice as the pulp obtained through both hot water and steam blanching has not scored good organoleptically (Table 11). This could be due to the great instability of anthocyanin pigments and dissociation of solids upon heat treatment. As a result the appealing pink colour of the pulp was lost as well as the treatment could have imparted an off taste to the pulp/juice. The stability of anthocyanins and the rate of their degradation were significantly influenced by temperature (Hrazdina *et al.,* 1970). Even though the recovery of pulp and juice was more in blanched fruits, the fresh fruit pulp acquired the highest score in organoleptic evaluation.

5.2.2. Osmoextraction

A novel method tried for the extraction of pulp and juice from watery rose apple and Malay apple was osmoextraction. The same method was found to be superior in extracting juice from pummelo also (Nair, 2006). In this method fruits were crushed in a commercial mixer and equal quantity of sugar was added and kept overnight. Crushing the fruits in a mixer ruptured the cells which enhanced extraction of juice from the fruits. The rest of juice could be extracted from osmotically active cells by pressing. Mixing the crushed fruit pulp with sugar and keeping overnight gave a pulp yield of 96.94 % in pink watery rose apple, 81.02 % in white watery apple and 92.32 % in Malay apple. The juice yield was 79.95 % in pink watery rose apple, 62.98 % in white watery rose apple and 62.3 % in Malay apple.

Compared to blanching, the recovery of pulp/juice was less in osmoextraction. However, quality of pulp/juice is equally important to quantity.

When quality is considered blanching could not be recommended for production of quality pulp/juice. In comparison, fresh fruit pulp gained more score compared to blanched ones. Hence a judicious approach was taken to compare the quality and quantity of osmoextracted pulp and juice with that of fresh fruit pulp and juice.

Results have shown that quantity and quality of sweetened juice (due to addition of sugar) was not significantly different from that obtained from fresh fruits (Fig. 4). Hence the organoleptic characters of osmoextracted pulp were compared with that of fresh fruit pulp. The colour and taste of the osmoextracted pulp/juice was more, compared to that from fresh fruit pulp/juice (Fig. 5). As the syrup extracts the juice through osmosis, the anthocyanin pigments might have also been extracted giving an attractive colour to pulp/juice (Plate 7). Also citric acid added at the time of osmoextraction might have enhanced better extraction of colour. Spagna *et al*. (2003) successfully extracted anthocyanin pigment from grape waste using tartaric acid treatment. Attempts to add chemicals to stabilize natural colorants in foods were done by Maccarone and Rapisarda (1985). They opined that tartaric acid and glutathione had a protective effect on stability of anthocyanin by being mildly acidic and antioxidant in nature. The other organoleptic attributes of osmoextracted pulp did not differ much from that obtained from fresh fruit.

Quality is the ultimate criterion of the desirability of any food product. Sensory evaluation plays a significant role in determining quality of foods (Kapse *et al.*, 1985). The osmoextracted pulp and juice have an added benefit of good storability as well as direct use for product preparation of sweetened beverages. Another advantage of osmoextraction over blanching is that, as no heat treatment was involved in the extraction of pulp/juice, vitamins, especially vitamin C and minerals were retained in the pulp. Shashikumar and Khurdiya (2002) reported that vitamin C content in aonla was reduced to 12 % through blanching of fruits. Manay and Shadaksharaswamy (1998) also got the same result in kiwi fruit. This method could be easy and low cost compared to mechanical juice extraction from fresh fruits when power and labour is considered. Hence osmoextraction was selected for the preparation of value added products from watery rose apple and Malay apple fruits.

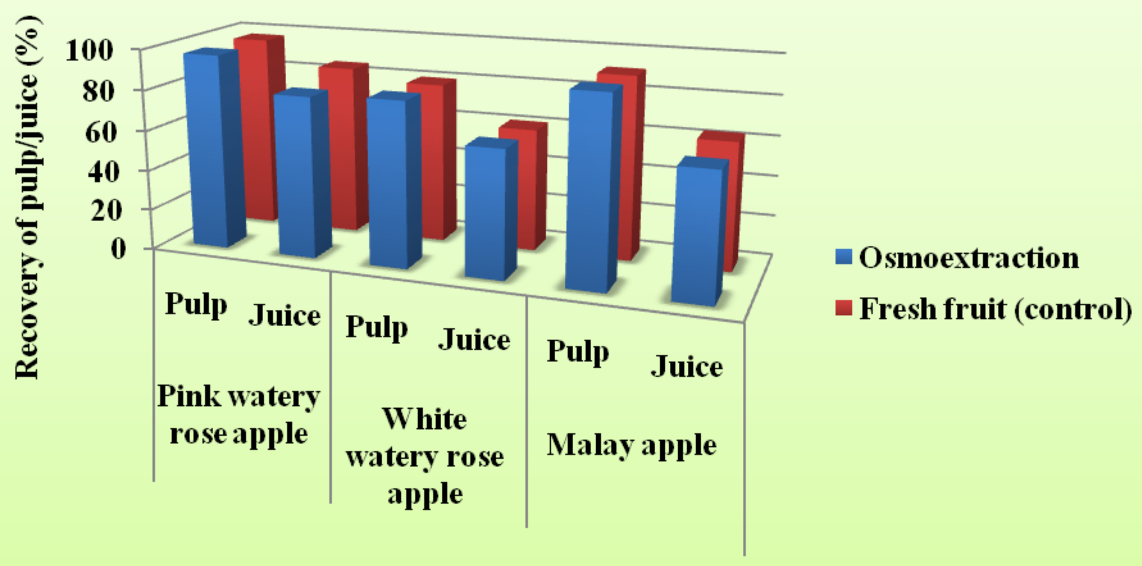
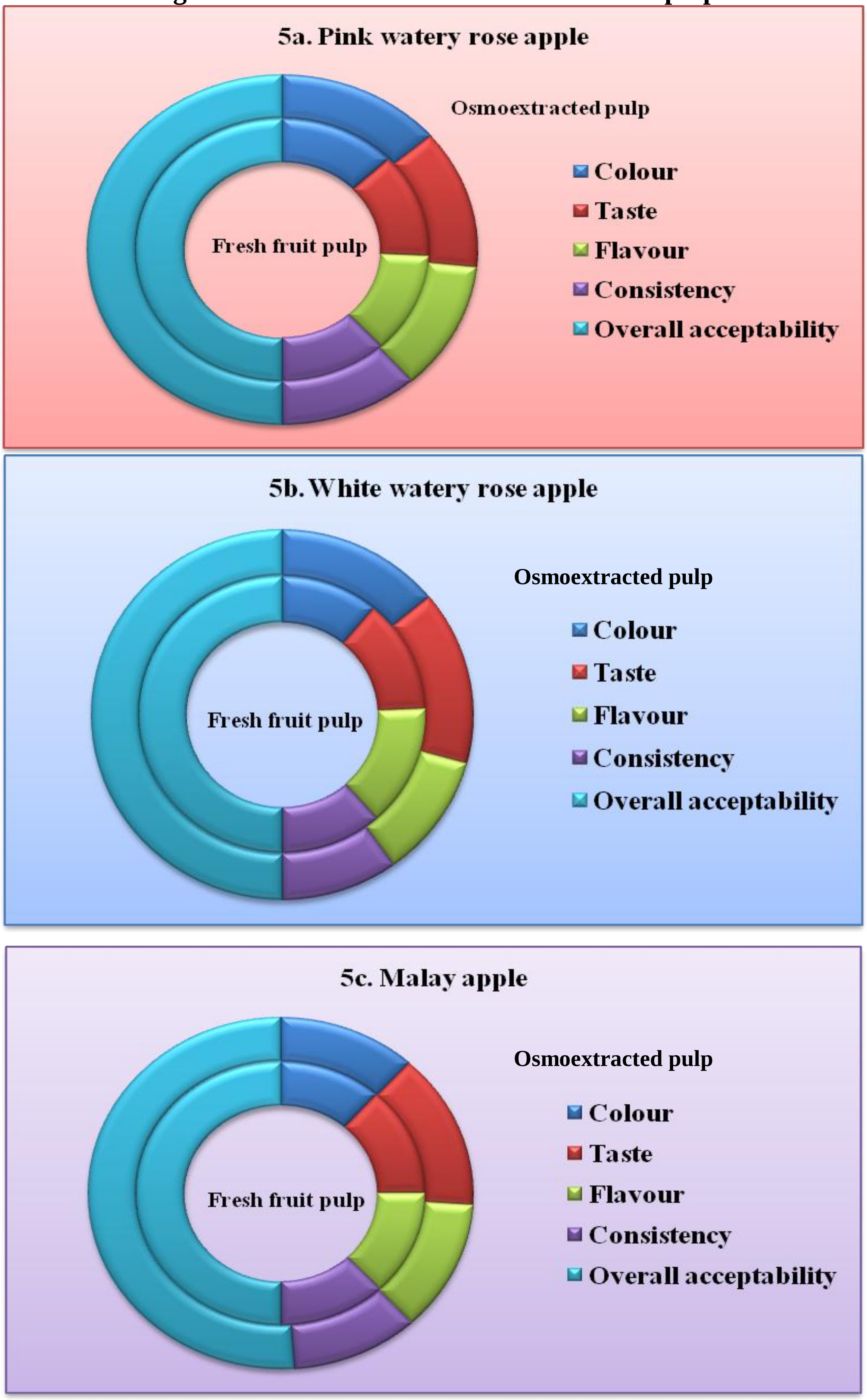


Fig. 4 Comparison of percentage recovery of pulp and juice in osmoextraction and control

Fig. 5 Mean score values for osmoextracted pulp



5.3. Value added products

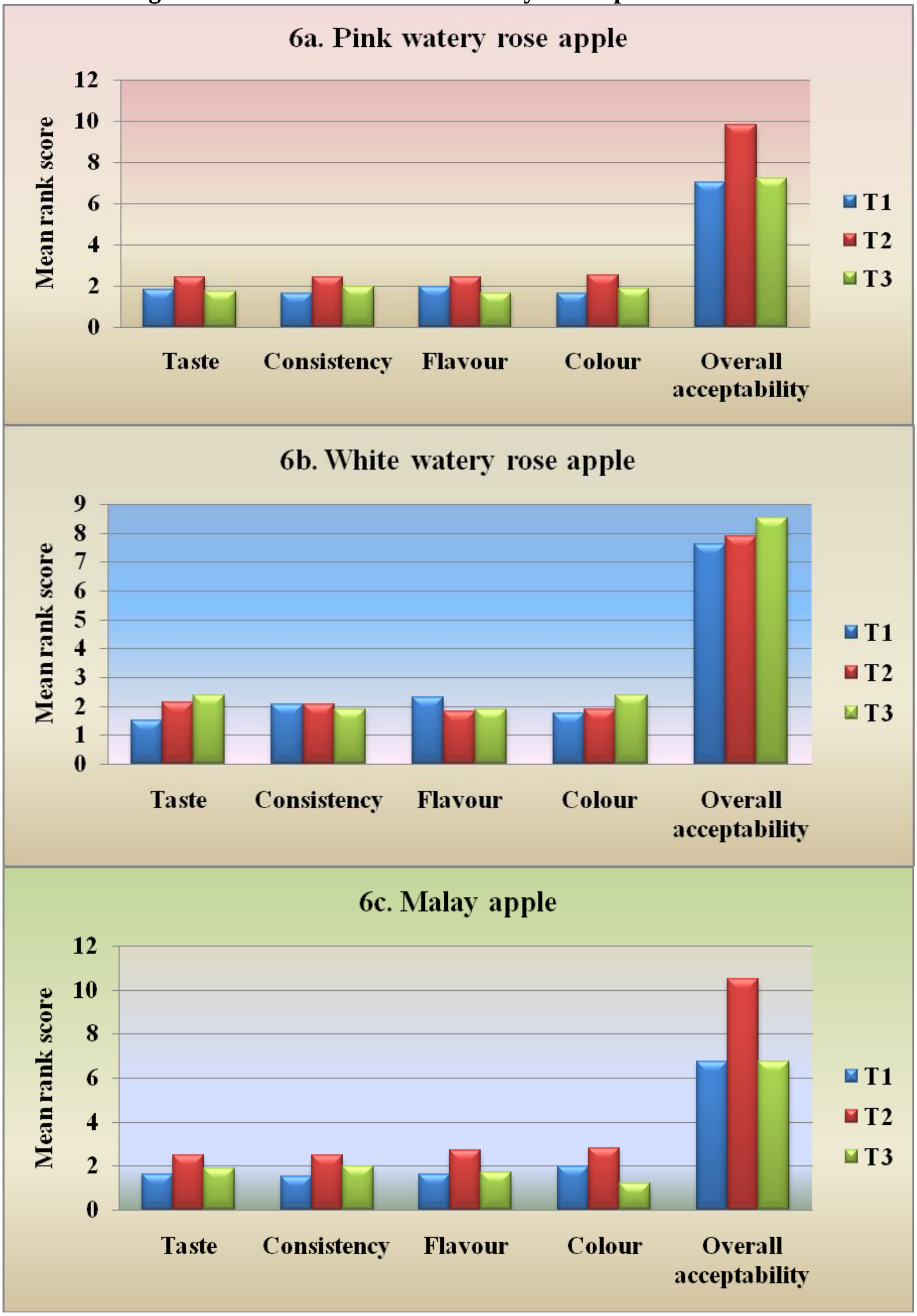
5.3.1. Osmodehydrated products

Osmodehydration is a simpler preservation technique, which will not require much sophisticated and expensive equipments. Chaudhari *et al*. (1993) stated that this technique could be adopted for preparation of dehydrated products of a variety of fruits. Even at rural areas without much investment, the growers can adopt this technique and convert the excess production into stable dehydrated forms. The quality of the end product depends to a larger extent on the concentration of sugar syrup used for osmosis and subsequent drying temperature and moisture content in the end product (Rashmi *et al.*, 2005). Moreover this osmodehydrated fruit had various uses as explained by Martinez *et al*. (2002). It can be used in preparation of jams, marmalades, cakes and dry fruit blends. As the processing time is reduced, the quality of the product will be better in terms of colour, flavour and aroma (Rahman, 1992). Therefore research was carried out to prepare osmodehydrated product using watery rose apple and Malay apple optimizing the sugar concentration.

In osmodehydration technique moisture removal was fast and a significant reduction in the TSS of the sugar syrup used for the osmosis was observed during the first three hours of osmosis and thereafter moisture removal was reduced (Tiwari, 2005). In the present study significant reduction in weight of samples was not recorded due to osmosis in all the concentrations of sugar syrup tried. After 24 hours of osmosis, the fruit pieces showed a reduction of only 25 g from its original weight and reduction in TSS by 8 to 10 %. This shows that moisture removal due to osmosis from the fruit pieces was very less and so also intrusion of sugar molecules to the fruit was negligible. Maya (1999) reported that rate of water loss on osmotic dehydration was maximum at early hours of osmosis which tends to decline on attaining a peak.

However the sliced fruits dipped in 50, 60 and 70 °Brix were scored as acceptable. Overall acceptability was maximum for the product under 60 °Brix for pink and Malay apple (Fig. 6a and 6c). In a study conducted by Oommen (1995)

Fig. 6 Mean rank scores for osmodehydrated products



suitability for applying osmotic drying technique for product development in jack fruit concluded that samples treated with 60 °Brix retained better appearance, colour and texture. Rashmi *et al*. (2005) also reported that the physico chemical composition and sensory quality of osmodehydrated pineapple fruits was better in 60 °Brix. Similarly papaya slices osmodehydrated by overnight soaking in a 60 °Brix sucrose solution containing 0.1 % citric acid and 0.1 % potassium sorbate was organoleptically good according to Ahmed and Choudhary (1995).

In white watery rose apple, fruit slices under 70 °Brix scored the highest overall acceptability (Fig. 6b). This may be due to the increase in the total sugars and a higher sugar acid ratio of syrup compared to other treatment. Kalsi and Dhawan (2001) prepared guava powder by osmotic dehydration. Guava slices were blanched in boiling water for two minutes and immersed in 70 °Brix sugar syrup overnight followed by cabinet drying at 65 °C. For consistency and flavour, there was strong disagreement among the judges so that the asymmetric significance arrived was 87.8 and 43.8 % respectively. The slices dipped in 70 °Brix lost almost all the flavour. This may be due to leaching out of principal compounds responsible for flavour to the strong syrup. In sliced fruit better penetration of sugar syrup might have happened as they were organoleptically acceptable

Osmodehydrated product prepared with whole fruit was not acceptable. This might be due to the failure of sugar syrup to penetrate into the cells or tissues of the fruit in sufficient quantities. The moisture loss was also less from the fruits. Deformation of fruits due to cell collapse in high concentration of sugar syrup was also observed. Instead of a slow release of water from the cells, rupture of delicate cell wall happened due to osmosis. This was very clear from the previous experiment on osmoextraction technique for preparation of pulp and juice.

The results of the organoleptic evaluation of osmodehydrated whole fruit and sliced fruit were different. Whole fruit dehydrated at low concentration of sugar syrup (50 °Brix) was not acceptable. At higher concentration the product cannot be served to the panel as they got deformed. Nair (2006) reported that extraction of juice after mixing the juice vesicles of pummelo with 30 % sugar yielded good quality juice. But increasing the sugar beyond 30 % was not advantageous as it caused sudden rupture of cells. According to Raoult (1994) structural collapse of fruits could happen in terminal drying if proper solute uptake has not taken place.

The osmodehydrated products obtained by dry blending of sugar were not found acceptable. The sugar crystals were not wet even after 24 hours of osmosis which showed that plasmolysis has not occurred in the cells of the fruit. However, reports are there which highlight the importance of dry blending of sugar for osmodehydration of fruits. Habeeba (2005) prepared osmodehydrated fig by dry blending with sugar in the ratio 1:1 containing 375 ppm SO_2 and 0.03 % citric acid as preservative for 20 hours. Maya (1999) also prepared osmodehydrated sapota slices using dry sugar containing 1500 ppm SO_2 and 0.3 % citric acid in the ratio of 1:1 for eight hours followed by oven drying for eight hours. This was not possible in watery rose apple and Malay apple fruits as they are more watery in nature with less solids.

An advantage obtained through osmodehydration was developing an acceptable sweetened juice (Plate 7). Dipping of fruits in higher concentration of sugar syrup (70 °Brix), a considerable quantity of colour and solids of pulp leach out to the syrup and this syrup could be recommended to use directly as sweetened juice. Leaching of anthocyanin pigments into the osmotic syrup was observed in cranberries as reported by Gir bowsk *et al*. (2002). Levi *et al*. (1985) also reported that osmosis caused significant discolouration and heavy losses of ascorbic acid in osmodehydrated papaya slices. Bolin *et al.* (1983) revealed that syrup remaining after osmotic dehydration can be recycled as table syrup, concentrated beverage, wines and jellies. This highlighted the possibility of recycling the osmotic syrup which is usually wasted.

Removal of moisture happens during second phase *i.e.* drying. The initial moisture content of 88 % was reduced to 18 % during the drying phase. To attain

This moisture, drying for 48 hours in vacuum oen was required. Usually ten hours

Plate 7 Osmoextracted pulp and juice (Pink watery rose apple)

Pulp

Juice

Sweetened juice

of drying is reported to be sufficient if proper dehydration has taken place in osmosis (Amitabh *et al.*, 2000). According to Kim and Toledo (1987) the drying time was directly related to the moisture content in the fruit. So osmotic dehydration would reduce the processing time in blueberry according to Angela *et al.* (1987). As the moisture content in the watery rose apple and Malay apple are very high, more time was taken to get a dehydrated product. Also moisture removal due to osmosis was negligible.

5.3.1.1. Shelf life of osmotically dehydrated product

The most important factor which determines the extend of deterioration in dried products during storage is the moisture content of the final product. In the present study the product stored was having a moisture content of 18 %. According to Bera *et al*. (2001) the growth of fungi and bacteria in the food samples are influenced by moisture content, high or low relative humidity, temperature of storage and type of samples. In the osmodehydrated product bacterial and fungal count increased gradually. But there were no traces of yeast throughout the storage period in the present study. Saima (2002) reported that candy, preserve, jelly and tuti fruity stored under ambient and refrigerated storage were found to be free from fungi and bacteria up to six months. Habeeba (2005) in her studies on osmotic dehydration and storage studies of fig also reported that there were no traces of yeast in fig up to four months. In the present study, the product could be stored up to two months safely and after two months the microbes started to appear in the product. After three months of storage, the microbial load in the product enhanced to a considerable level. The increase in the bacterial and fungal count can be correlated with the increased level of moisture in the product. The moisture content recorded for safe storage of semi moisture foods is 10 to 12 %.

5.3.2. Pickle

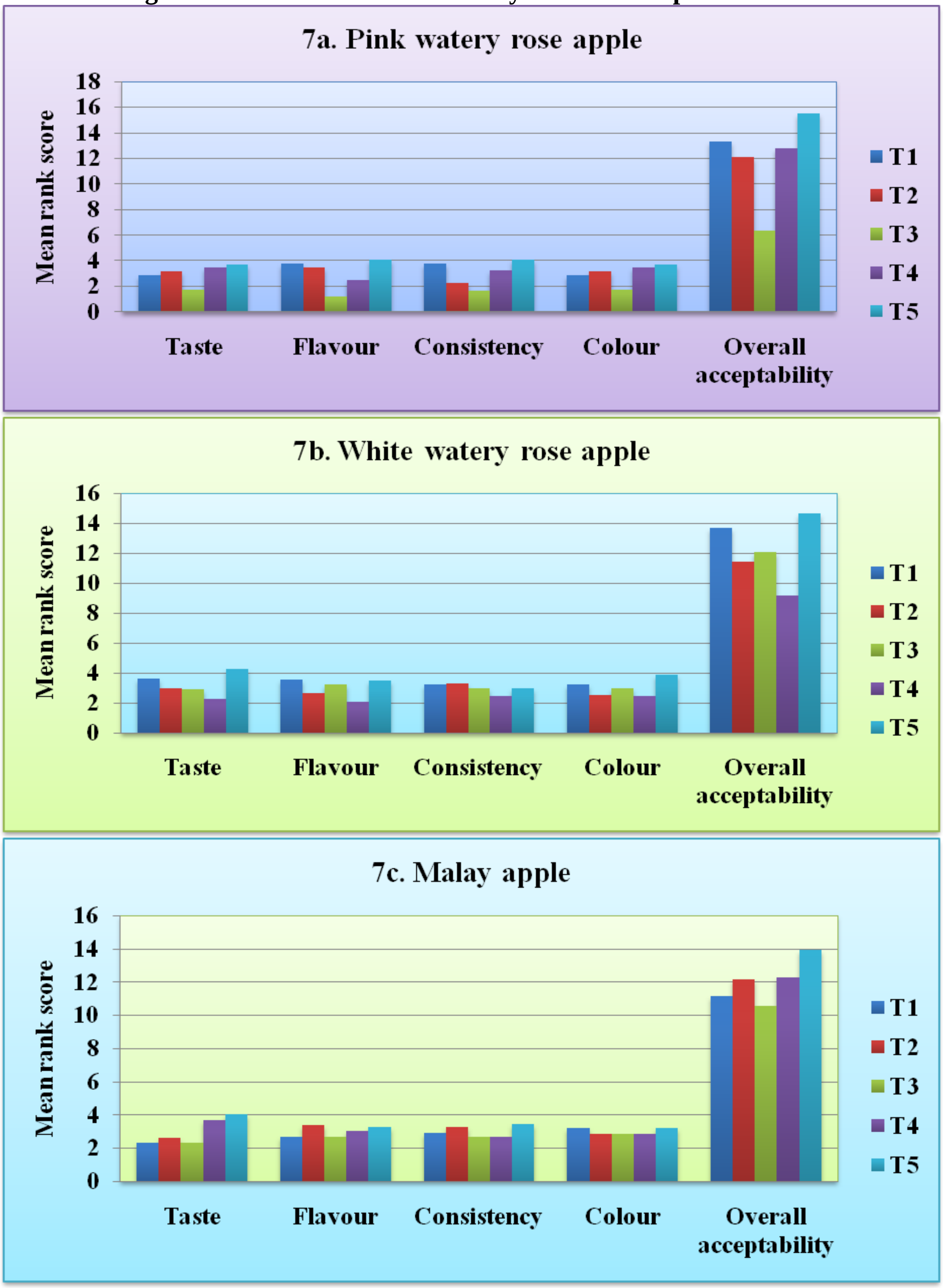
Pickling is one of the oldest method of preserving fruits or vegetables in common salt, oil, vinegar and juice. The fruits of AC. 2 in pink watery rose apple and Malay apple and AC. 5 in white watery rose apple with small size and relatively high titrable acidity were used for pickling in the present study adopting different treatments. It can be seen from the results that the pickle made from the fresh fruit slices scored the highest in sensory evaluation in all the types of fruits (Fig. 7). When the fruits were subjected to blanching or salting as pretreatments, the crunchiness of the fruits was lost which was not relished by most of the judges. Pickle made from fresh fruits of pink watery rose apple scored the highest value for overall acceptability. There was a disagreement among the judges regarding the consistency of the pickle. This was because of the outflow of water from the fruit to the gravy during storage. As a result the consistency became watery. Also with regard to flavour in white rose apple pickle, the divergence of opinion among judges could be attributed to the browning reaction. Shukla *et al*. (1991) also opined that browning reaction could affect the development of flavour in foods. In pulp/juice extraction also heat treatment to the fruits resulted in loss of acceptability of product. The benefit cost ratio of pickle is given in Appendix V(a).

5.3.3. Wine

Fermented beverages have been known to mankind from time immemorial. Wine is a natural, nontoxic, healthful, fermented alcoholic product rich in calcium, vitamins and minerals (Adsule *et al*., 1992).

For preparing the fruits for wine making, slicing and crushing were adopted. Crushing of fruits was not found advantageous especially in the context of reducing the clarity of wine. Hence slicing of fruits was sufficient to obtain good quality wine. But a judicious combination of sugar and water is to be there in the cuvee for production of quality wine (Anderson and Badrie, 2005). T_3 which was imposed with half water and sugar as that of fruit was scored as not good even if sliced fruits were subjected to wine preparation. This could be attributed to stuck wine fermentation. Maynard (1999) described several causes for this, like, insufficient substrate, ethanol toxicity and high temperature. Here insufficient substrate (sugar) could be the reason for stuck wine fermentation.

Fig. 7 Mean rank scores for sensory attributes of pickle

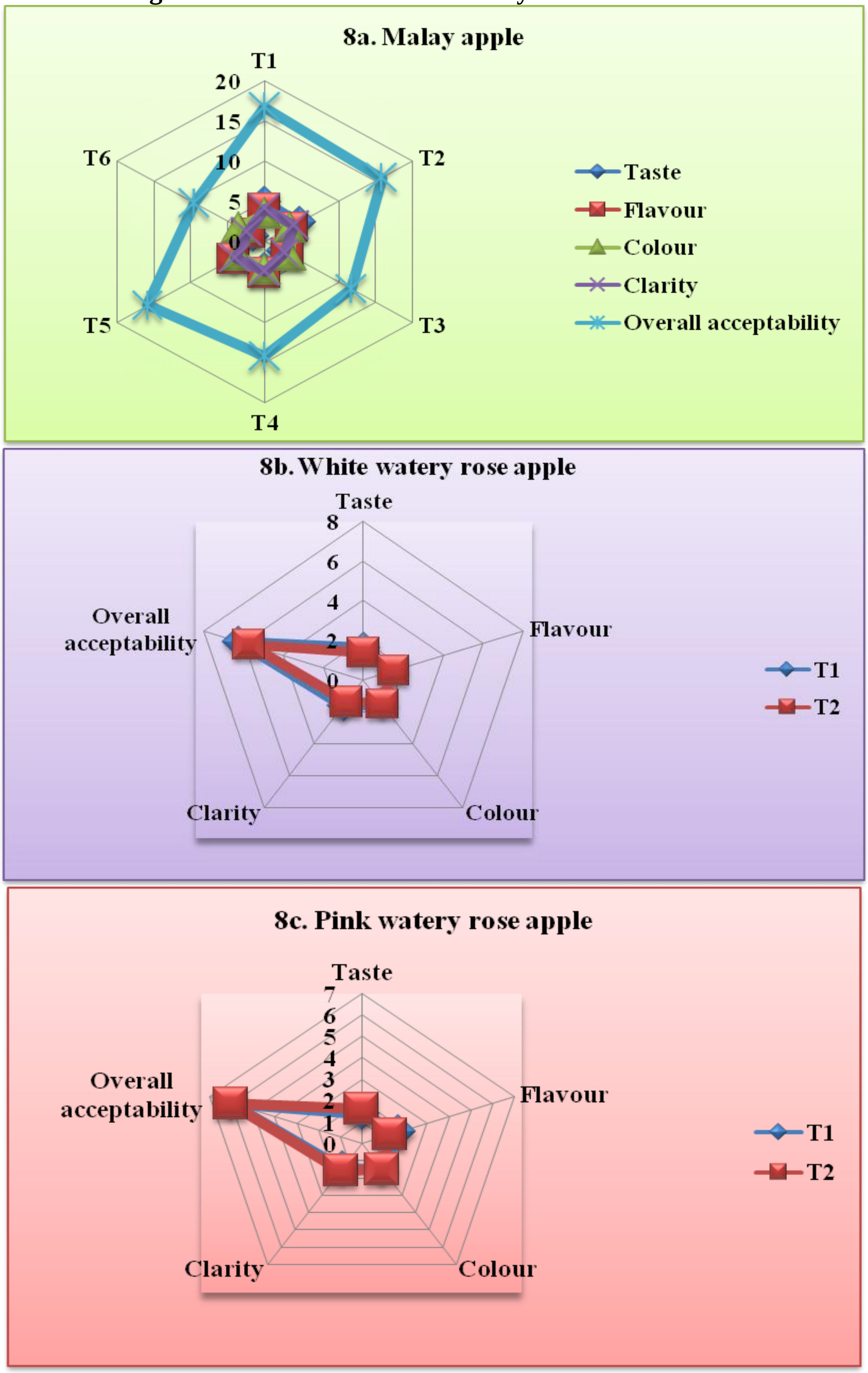


Thus cuvee in T_1 and T_2 which contain equal amount of sugar as that of fruits were found good for wine. In these cases either half quantity of water as that of fruits can be added as in T_1 or equal quantity of water as that of fruits can be added as in T_2. The first case produced sweeter wine which acquired highest acceptability (Fig. 8) and in second case a wine with less sweetness, thus acquiring less score for organoleptic characters. Considering the merits and demerits of different treatments imposed for preparation of wine with Malay apple, T_1 and T_2 were selected for preparing wine using pink and white watery rose apples.

Comparative evaluation of T_1 and T_2 in pink and white watery rose apples revealed the superiority of T_1 over T_2 in white watery rose apple. In pink watery rose apple T_1 and T_2 were on the par with respect to quality of wine. It can be seen from the results that there was strong agreement among the judges regarding the quality of these wines with respect to all the characters. According to Singleton and Ough (1962) appearance is the important feature of wine and the colour along with its clarity is a good indicator of past, present and future quality. Malay apple and pink watery rose apple wine had an appealing pink colour. However colour of white wine was also equally acceptable. Regarding clarity, the wine prepared from white watery rose apple and Malay apple adopting T_1 (sliced fruit, sugar and water in 1:1:0.5) scored the maximum. In pink watery rose apple wine the disagreement of judges regarding clarity was high so that either T_1 or T_2 could not be selected for clarity. This may be because the suspended fruit particles gave a cloudy look to the wine which was not an appealing characteristic. Clarity attribute would be improved during storage (Amerine, 1972). Wine prepared from pink watery rose apple using sliced fruits, sugar and water in the ratio of 1:1:1 (T_2) scored the highest for taste in sensory evaluation. This is in conformation with the results obtained in standardization of plum fruit wine by Vyas and Joshi (1982).

The strength of the wine depends on the alcohol percentage. According to the FPO standards, the alcohol content of the wine ranges from 7 to 18 %. Watery rose apple and Malay apple was subjected to active fermentation only for a duration of 10 days as against 21 days in grape wine. Same duration was standardized for jamun wine also by Hema (1997). The alcohol content in jamun wine was recorded as 8.63 % by this time of fermentation.

fig. 8 Mean rank scores for sensory attributes of wine



From the results it could be presumed that equal quantity of sugar as that of fruits is required for production of quality wine. In sensory evaluation irrespective of type of fruits, adding half quantity of water as that of fruit was found ideal. In pink watery rose apple equal quantity of water as that of fruit can also be added for wine preparation.

5.3.4. Pulp and juice based products

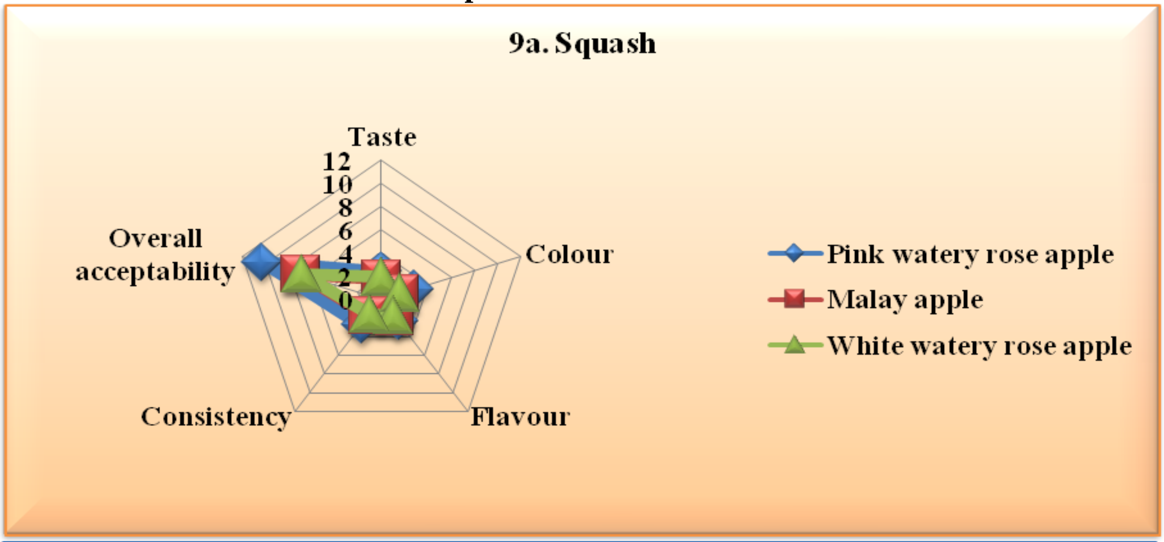
5.3.4.1. Squash

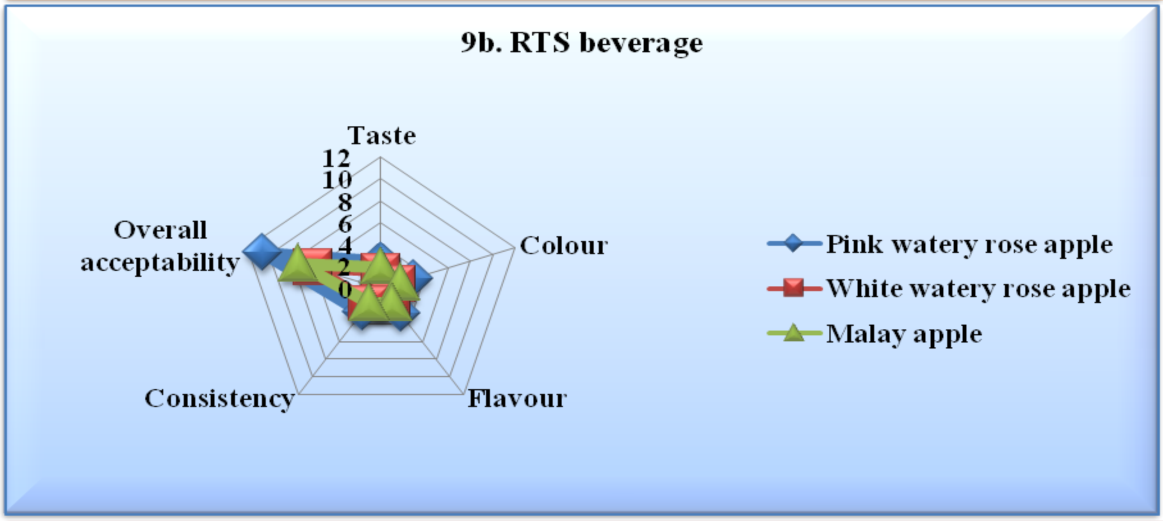
Prior to preparation of squash using osmoextracted juice of watery rose apple and Malay apple, an earnest attempt was made to standardize the sugar and water to be added to the extracted juice to scale it up to the standard of squash. This enabled preparation of squash as per FPO standards (Table 27).

From the table, it can be seen that the percentage of TSS, percentage of fruit juice and the amount of preservative in prepared squash conforms to FPO standards. Squash prepared from pink watery rose apple was highly acceptable (Fig. 9a). It has a pleasing colour and flavour. The osmoextracted juice was having a pink colour and the same was imparted to the product. The titrable acidity (0.3 %) was almost similar to that for ber squash (0.48 %) reported by Jain *et al*. (1984). Joy (2003) prepared rose apple squash which contained an acidity of 3.06 % and vitamin C content of 10.13 mg/100g.

The method of extracting juice from watery rose apple and Malay apple through osmoextraction by adding equal quantity of sugar to that of pulp and developing squash by subsequent dilution with required quantity of water which is calculated by noting the Brix and weight of osmoextracted juice is a novel technique evolved in the present study. In the organoleptic test, the significance level for flavour was higher which showed the divergence of opinion among the judges. This can be due to the browning reaction which is responsible for loss of flavour of beverages. According to Shukla *et al.* (1991) browning reaction can affect the development of flavour in the fruit products. Thakur and Barwal (1998) also stated that there was loss in flavour and taste in kiwi fruit squash due to loss of volatile aromatic substances.

Fig. 9 Mean rank scores for sensory attributes of pulp and juice based products





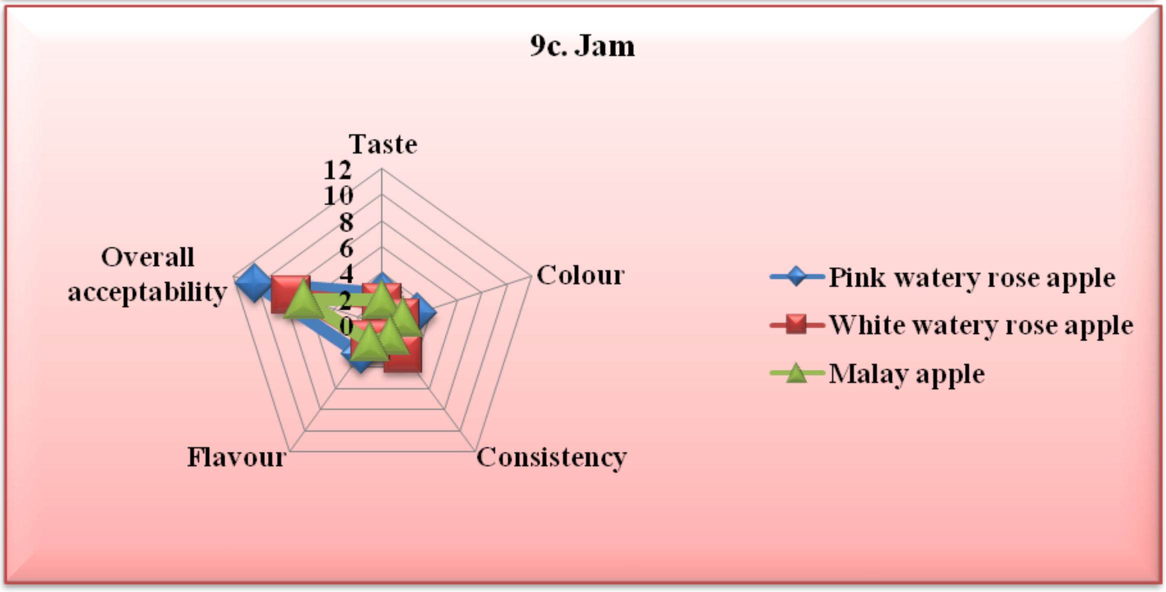


Table 27 Conformation of rose apple and Malay apple squash with FPO standards

	Rose apple squash (pink)			Rose apple squash (white)			Malay apple squash		
Particulars	% of TSS	% of fruit juice	Amount of preservative (ppm)	% of TSS	% of fruit juice	Amount of preservative (ppm)	% of TSS	% of fruit juice	Amount of preservative (ppm)
FPO value	40	25	750	40	25	750	40	25	750
Analyzed value	39	25	750	40	25	750	38	25	750

The colour of the squash faded gradually on storage. This may be due to the accelerated rate of decomposition of anthocyanins at varying pH and storage under atmospheric temperature. Wasker and Khurdiya (1987) reported similar trends in the degradation of anthocyanins in phalsa juice. The colour stability could be improved by storing under cool conditions. Hema (1997) stated that decrease in colour of jamun squash might be due to colour bleaching by light rays that has passed through the colourless glass containers. Similar decrease in colour was observed for rose apple squash by Joy (2003). The benefit cost ratio of squash is given in Appendix V(b).

5.3.4.2. RTS beverage

As done for squash attempts were made to standardize the water to be added to the osmoextracted juice for preparation of RTS beverage. This helped to prepare an acceptable RTS beverage, which conforms to FPO standards (Table 28).

RTS beverage prepared from pink watery rose apple scored the highest value for overall acceptability (Fig. 9b). In the case of RTS beverage, there was high agreement among the judges. Organoleptic evaluation of jamun RTS beverage standardized by Hema (1997) have shown that the colour, taste, appearance, flavour and overall acceptability were more when the beverage was prepared from 25 % juice. The RTS beverage prepared from watery rose apple and Malay apple contains only 16 % juice as per the FPO standards. The RTS beverage can be made better with respect to sensory evaluation by increasing the juice percentage. The RTS beverage prepared from pink watery rose apple and white watery rose apple contained an acidity of 0.1 % and 0.05 % respectively.

Malay apple RTS retained the maximum vitamin C content of 17.78 mg/100g. This was almost the same as that recorded with fresh fruit RTS beverage prepared with 10 % ber juice, 15 % TSS and 0.25 % acidity (Kadam *et al*. 1991).

The benefit cost ratio of RTS beverage is given in Appendix V(c).

Table 28 Conformation of rose apple and Malay apple RTS beverage with FPO standards

	Rose apple RTS (pink)			White apple RTS (white)			Malay apple RTS		
Particulars	Juice %	TSS °Brix	Acidity	Juice %	TSS °Brix	Acidity	Juice %	TSS °Brix	Acidity
FPO	15	15	0.3	15	15	0.3	15	15	0.3
Analyzed value	16	12	0.1	16	15	0.05	16	12	0.05

5.3.4.3. Jam

Prior to preparation of jam attempts were made to standardize the sugar to be added to the pulp to get the final Brix of jam as per FPO standards (Table 29). Thus the jam prepared recorded 65 % Brix and 50 % pulp in the final product.

Organoleptic evaluation had shown that the jam was acceptable and there was high agreement among the judges about its acceptability. Jam prepared using pink watery rose apple scored the highest value for overall acceptability compared to white and Malay apple jam (Fig. 9c). The fruit contains no pectin. So pectin was added at a level of two per cent in order to get the desired consistency. In white apple browning of the jam was an undesirable character. According to Ana and Aderina (1991) high solid jam from less used tropical fruits are composed of fruits (43 to 45 %), soluble solids (68 to 68.9 %) and reducing sugar (35.6 to 40.6 %). The acidity was found to be high in watery rose apple jam (0.5 %). Vitamin C content in jam prepared from pink rose apple and Malay apple was 17.78 mg/100g. It can be seen that the retention of vitamin C was highest in Malay apple products. It can be concluded that the products of Malay apple are healthy and nutritious. This needs special consideration in the context where Malay apples are not commonly grown types in the state. The benefit cost ratio of jam is given in Appendix V(d).

5.3.5. Extraction and utilization of natural colour

Colour is an extremely important sensory attribute of food. Though the use of natural colours is an ancient practice, it is gaining importance now a days. Synthetic colours may have some side effects and extraction and processing of natural colours are ecofriendly and nonhazardous process. Consumer pressure, sociological changes and technological advances in the food processing industry have increased the natural colour market (Chaudhuri *et al*., 2004).

Several works have been conducted on the extraction of anthocyanin pigments using different solvents. Spagna *et al*. (2003) used tartaric and citric acid solutions to extract anthocyanin pigments from fresh grape skin. Also a comparative trial was conducted using sulphur dioxide and acidified ethanol as solvents.

Table 29 Conformation of rose apple and Malay apple jam with FPO standards

Particulars	% of TSS in the final product	% of fresh fruit in the final product
FPO value	68%	50%
Analyzed value	65%	50%

They concluded that 0.75 % tartaric acid was more efficient than other solvents. Longo *et al*. (2007) extracted anthocyanin from the berries of *Pistacia lentiscus* L. and *Rubia peregrina* L. using 0.1 % methanolic HCl as the solvent. Heidari *et al.* (2006) studied the influence of storage temperature, pH, light and varieties of grape on the stability of anthocyanin extracted using absolute ethanol containing 0.1 % HCl as the solvent. Absolute ethanol was used to facilitate further concentration steps. Extraction and purification was done by acidified ethanol as solvent. Anthocyanin pigment was extracted from three different berries (*Morus nigra*, *Morus alba var nigar* and *Fragaria* L.) using the soaking and wetting in ethanol which was one per cent acidified (Nikkah *et al*., 2007).

In the present study, methanolic HCl and citric acid were used for the extraction of anthocyanin pigments. The total anthocyanin extracted from the flowers of Malay apple using 0.1 % methanolic HCl was 0.33 mg/g of the sample. Ghosh *et al*. (2002) extracted and identified the anthocyanin pigments from grape pomace. Grape pomace contains 30 to 150 mg/100g of the pomace. The flowers of Malay apple which possess attractive crimson pink colour are subjected to heavy shedding (Plate 4). They can be effectively utilized to extract colour naturally and this colour extract can be added to foods for imparting an appealing colour. This would increase the acceptability of the product. Besides, the anthocyanin pigments contribute to a variety of health related benefits like antibacterial, antiviral, anti-inflammatory, antiallergenic and above all they act as an antioxidant. Flower pigment analysis of *Melastoma malabathricum* was carried out by Janna *et al.* (2000) with the objective of analyzing the colour pigment anthocyanin and their stability in extracted form.

From the flowers of Malay apple, better extraction of anthocyanin was obtained using citric acid 4 % for an incubation period of 12 hours. The anthocyanin pigment is highly susceptible to pH changes. In the present study colour intensity was best expressed under acidic condition or at a low pH. There was a gradual colour change from red to dull yellow as the pH increases. Both colour intensity and colour stability of anthocyanin in berberies and cranberries were being best at pH 1 to 3.5 (Laleh *et al*., 2006; Gross, 1987; Jackman and Smith, 1996). So the extraction was done under acidified conditions.

Extraction using citric acid is easy and economical to practice. Also the absorbance was found to be higher using higher concentration of citric acid. As citric acid can be safely recommended in foods, the colour extract need not be purified further.

The highest recovery of anthocyanin pigment from pink watery rose apple fruit was obtained from citric acid at 5 % concentration incubated for six hours. As the fruits are more hardy compared to flowers a higher concentration of citric acid might become necessary for the extraction of anthocyanin pigment. This colour extract was added to foods provided it does not impart an undesirable taste to the product. Such levels were identified in this study. The colour of the products developed with anthocyanin extract was found to be highly unstable. Anthocyanins exhibit their most intense colour under acidic conditions below pH 3.5 (Newsome, 1990). So these pigments are suitable for colouring acidic foods.

5.3.5.1. Anthocyanin in food products

Squash and wine were coloured with the anthocyanin extract prepared in citric acid. Both the products added with the colour extract exhibited an attractive pink colour. However the colour faded during storage which was evident from the absorbance value one month after storage. The value of absorbancedecreased in due course of storage. The colour instability can be attributed to the effect of change in pH and photo oxidation. In solution many binding and releasing reactions will take place during storage resulting in change of pH (Ranganna, 1986). Similarly the oxidative reactions which take place in the presence of light also might have accelerated the fading of colour. Khurdiya and Anand (1982) opined that low pH exerted a protective influence on the pigment stability of anthocyanin in phalsa juice. Also increased loss of pigments occurred with increasing temperature of processing. This phenomenon was seen in blueberries (Virachnee *et al.*, 2004). In phalsa juice, Khurdiya and Anand (1982) reported that sugar and light had little effect on the decomposition of anthocyanin.

As against to this report, in pink rose apple squash, the degradation of anthocyanin pigment was found faster when stored in transparent glass containers. Colour retention was more when the squash was stored in amber coloured bottles. Janna *et al*. (2000) also got the same result. He reported that ideal storage conditions for coloured anthocyanin pigments are low pH, dark and low temperature (4 °C).

For better colour stability of anthocyanin in food products, modified pH, storage atmosphere and suitable colour stabilizers are to be tried.

Summary

6. SUMMARY

The project entitled "Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara.

Evaluation of watery rose apple and Malay apple for physico chemical attributes revealed the variation among the three types of fruits (pink watery rose apple, white watery rose apple and Malay apple) as well as among accessions within types.

Variation among the colour groups studied within each type was negligible. However variability among different size groups was significant in Malay apple (Table 4a). The different size groups registered significance with respect to recovery of pulp, titrable acidity, ascorbic acid content, total and non reducing sugar. Variability among accessions within types was obvious. In pink watery rose apple the accessions differed significantly with respect to all the biochemical attributes studied except for TSS and total sugars. The accessions of white watery rose apple and Malay apple differed with respect to fruit weight, acidity, ascorbic acid content and sugar content.

Suitability of fruits for preparation of various products were selected based on recovery of pulp/juice, acidity, sugar content, TSS and vitamin C content of fruits. In this way, AC 4, 5, and 1 were selected from pink, white and Malay apples respectively for the preparation of pulp and juice based products. AC.1 from all the three types was used for preparing osmodehydrated product and as table purpose. For pickle making, AC. 2 from pink and Malay apple and AC.5 from white watery rose apple was selected. For preparation of wine, AC.1 from pink and Malay apple and AC.4 from white watery rose apple was selected.

Among the different treatments tried *viz.*, blanching (hot water and steam) and osmoextraction, for preparation of quality pulp/juice osmoextraction was identified as superior. The osmoextracted pulp had good storability due to high sugar content and could be directly used for product preparation.

Dipping of sliced fruits in 60 °Brix overnight followed by drying at 50 °C were superior in sensory evaluation in pink and Malay apple. In white apple sliced fruits dipped in 70 °Brix were found to be superior. The microbial load in the osmodehydrated sample (60 °Brix) stored in glass bottle and plastic bottle increased with increase in storage period. Up to one month, no microbial load was observed in any of the samples. By third month of storage, bacterial and fungal colony increased.

Pickle made from fresh fruit slices without any pre-treatment was found to be the best in pink, white and Malay apple. The ideal fruit: sugar: water ratio for preparation of quality wine was identified. For all the types the maximum score for taste and overall acceptability was recorded for fruit: sugar: water in the ratio of 1:1:0.5. But for preparation of wine using pink apple, a ratio of fruit: sugar: water in the ratio 1:1:1 was also found good.

Methodology for preparation of squash, RTS beverage and jam using osmoextracted pulp and juice was developed. The prepared products exhibited the pulp content, sugar and acidity in conformation with FPO standards. Among the three types of fruits, squash, RTS beverage and jam prepared with pink watery rose apple gained more in sensory evaluation. The products prepared from Malay apple retained the maximum vitamin C content.

Natural colour anthocyanin was extracted from the flowers of Malay apple and fruits of watery rose apple using methanolic HCl and citric acid as solvents. Maximum anthocyanin (0.4 mg/g) obtained from Malay apple flowers were by incubation in citric acid 4 % for twelve hours. For extraction of anthocyanin from fruits of pink watery rose apple incubation in citric acid 5 % for six hours was the best. The colour extracted using citric acid was used for colouring foods. Fading of colour of products during storage was the crucial problem noticed which is to be addressed in the future studies.

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*Originals not seen

Appendices

APPENDIX I

Score card for assessing quality of products

Name of the Scorer:

Product:

Please score the given products using the following 5 point Hedonic scale.

Score	Inference
5	Like very much
4	Like
3	Neither like nor dislike
2	Dislike
1	Dislike very much

Product code	Color	Taste	Flavour	Consistency/Clarity

Remarks:
(Please write which flavour is dominating, whether you find the color appealing.)

Signature:

APPENDIX II

Media composition

(Ingredients per litre)

I. ROSE BENGAL CHLORAMPHENICOL AGAR

Dextrose	: 10.0 g
Peptone	: 5.0 g
KH_2PO_4	: 1.0 g
$MgSO_4.7H_2O$	: 0.5 g
Agar	: 15.5 g
Rose Bengal	: 0.05 g
Chloramphenicol	: 0.1 g
pH	: 7.2

II. NUTRIENT AGAR MEDIUM

Peptone	: 5.0 g
Beef extract	: 3.0 g
Agar	: 15.0 g
pH	: 6.5 to 7.5

III. SABOURAUD DEXTROSE AGAR

Mycological peptone	: 10.0 g
Dextrose	: 40.0 g
Agar	: 15.0 g
pH	: 5.6

APPENDIX III

Recipe for pickle

Ingredients for preparing 1 kg of pickle

Fruit	: 720 g
Salt	: 180 g
Chilli powder	: 80 g
Mustard seeds	: 5 g
Fenugreek	: 15 g
Asafoetida	: 10 g
Garlic	: 5 g
Mustard seed powder	: 5 g
Sesame oil	: 150 ml
Curry leaves	: 15 no.s
Sodium benzoate	: 250 ppm

APPENDIX IV

Reagents used in solvent extraction

A. H_2O_2 (30 %)

B. Methanolic HCl (0.5 N HCl in 80 to 85 % methanol)

Prepare 0.5 N HCl in aqueous methanol by taking 1.54 ml of concentrated HCl in 100 ml of 80 to 85 % methanol.

C. Methanolic HCl (5:1 N HCl in 80 to 85 % methanol: 3 N HCl)

Prepare 3 N HCl by taking 4.62 ml of concentrated HCl in 50 ml of distilled water

APPENDIX V

Benefit Cost Ratio of a few value added products

a. Benefit Cost Ratio of Pickle

Total cost of production

Ingredient	Quantity (g)	Rate	Amount (Rs.)
Fruit	720	Rs. 5/kg	3.6
Salt	180	Rs. 2.5/500g	1.0
Chilli powder	80	Rs. 7/100g	5.6
Mustard	10	Rs. 9/100g	1.0
Fenugreek	15	Rs. 6/100g	1.0
Asafoetida	10	Rs. 40/100g	4.0
Garlic	5	Rs. 9/100g	0.45
Oil	150 ml	Rs. 10/100ml	15.0
Sodium benzoate	250 ppm	Rs.40/100g	1.0
Total cost			32.65

Quantity of pickle that can be prepared = 1170 g
Number of bottles (400 g each) that can be filled = 1170/400 = 3 (approximately)
Cost of one bottle of pickle = Rs.50/-
Cost of 3 bottles of pickle = Rs.150/-
B/C ratio = 150/32.65 = 4.6
Net returns = 150 – 32.65 = Rs.117.35/-

b. Benefit Cost Ratio of Squash

Total cost of production

Ingredients	Quantity	Rate	Amount (Rs.)
Fruit	1kg	Rs.5/kg	Rs.5
Sugar	900g*	Rs.20/kg	Rs.18
Citric acid	1g	Rs.120/kg	Rs.0.12
Total cost			23.12

Quantity of squash that can be prepared with 800 ml juice = 2 litres
Number of bottles of squash (700 ml) that can be filled = 3 (approximately)
Cost of one bottle of squash = Rs.40/-
Cost of three bottles of squash = Rs.120/-
B/C ratio = 120/23.12 = 5.19
Net returns = 120 – 23.12 = Rs.96.88/-
* Recovery of pulp- 90%
Recovery of juice- 80%

c. Benefit Cost Ratio of RTS beverage

Total cost of production

Ingredients	Quantity	Rate	Amount (Rs.)
Fruit	1kg	Rs.5/kg	Rs.5
Sugar	900g	Rs.20/kg	Rs.18
Citric acid	1g	Rs.120/kg	Rs.0.12
Total cost			23.12

Quantity of RTS beverage that can be prepared with 800 ml juice = 2.2 litres
Number of bottles of RTS beverage (150 ml)
that can be filled = 15 (approximately)

Cost of one bottle of RTS beverage = Rs.10/-

Cost of 15 bottles of RTS beverage = Rs.150/-

B/C ratio = 150/23.12 = 6.5
Net returns = 150 – 23.12 = Rs.126.88/-

d. Benefit Cost Ratio of Jam

Total cost of production

Ingredients	Quantity	Rate	Amount (Rs.)
Fruit	1kg	Rs.5/kg	Rs.5
Sugar	900g	Rs.20/kg	Rs.18
Citric acid	1g	Rs.120/kg	Rs.0.12
Total cost			23.12

Quantity of jam that can be prepared with 900 g of pulp = 1250 g
Number of bottles of jam (500 g) that can be filled = 2.5
Cost of one bottle of jam = Rs.50/-
Cost of 2.5 bottles of jam = Rs.125/-
B/C ratio = 125/23.12 = 5.41
Net returns = 125 – 23.12 = Rs.101.88/-

Evaluation and value addition of watery rose apple (*Syzygium aqueum* (Burm) Alston) and Malay apple (*Syzygium malaccense* (L.) Mernil and Perry)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Watery rose apple and Malay apple belong to the family of Myrtaceae. The fruits are rich in vitamin C and have many medicinal properties. A major chunk of production of this crop is being wasted due to the lack of scientific handling and processing technologies. In this context, the present investigation "Evaluation and value addition of watery rose apple and Malay apple" was taken up to standardize technologies for processing and value addition of these fruits.

The fruits were primarily classified into different groups based on their colour. The physico chemical attributes in relation to colour was not apparent. Difference was significant in quality attributes with respect to size of fruits in Malay apple. Big fruits possessed most of the desirable attributes for product development. Among the three different types weight of fruits and titrable acidity differed significantly. Accessions within each type recorded significant variation in most of the quality attributes studied. Based on this suitability of accessions for preparation of different value added products were fixed.

Osmoextraction was selected as the ideal method for production of quality pulp/juice. A simple method for preparation of beverages and jam using osmoextracted pulp/juice was developed. The pulp and juice extracted through this method exhibited good storability and served as the basic material directly for the preparation of different beverages. Osmodehydrated product prepared by dipping fruit slices of pink watery rose apple and Malay apple in 60 °Brix solution followed by vacuum drying at 50 °C for 48 hours was found acceptable. In white watery rose apple dipping the fruit slices in 70 °Brix was found superior. The osmodehydrated product exhibited a shelf life of two months without any microbial contamination in both glass and plastic containers.

The pickle prepared using fresh fruit slices in all the three types of fruits acquired highest score. When heat treatment was adopted for preparation of fruits for pickling, the material became very soft and consistency of the product was lost. Wine prepared using fruit slices, sugar and water in the ratio of 1:1:0.5 scored the maximum value in organoleptic evaluation. Crushing the fruits was not good for production of quality wine as it caused loss of clarity.

Pulp and juice based products *viz.*, squash, RTS beverage and jam prepared using the osmoextracted pulp/juice in conformation with FPO standards were scored good by the judges. Products prepared using pink watery rose apple was found to be the best compared to other types as it possessed attractive pink colour.

Method for extracting the natural colour anthocyanin present in Malay apple flowers was standardized. The best treatment identified for extracting anthocyanin from Malay apple flowers was incubation in citric acid 4 % for twelve hours. For the fruits of pink watery rose apple, incubation in citric acid 5 % for six hours yielded maximum anthocyanin. The quantity of anthocyanin extract required to colour the various products were standardized. The retention of colour in the products during storage was very less.