STANDARDIZATION OF TECHNIQUES FOR CASHEW APPLE WINE PRODUCTION AND DEVELOPMENT OF WINE BASED PRODUCTS

By

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THESIS

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DECLARATION

I here by declare that the thesis entitled **"Standardization of techniques for cashew apple wine production and development of wine based products"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Introduction

Introduction

Cashew is one of the important plantation crops of India, which was introduced to the country in the sixteenth century by the Portuguese, mainly as a crop against soil erosion.

India is the largest producer, processor, consumer and exporter of cashew in the world, accounting for about 50 per cent of the world production. In India, cashew occupies an area of 0.683 million hectares with a production of 0.52 million tonnes and an average productivity of 865kg ha^{-1}. Cashew is mainly cultivated for its delicious and nutritious kernels obtained from the nut. This forms an important dollar earning crop whereby it stands as the third highest foreign exchange earner among the agricultural products. During the year 2000, an amount of 95,000 tonnes of kernels were exported from India, earning 2500 crore rupees (Rao and Nagaraja, 2000).

Kerala, being the largest cashew producing state in the country, cultivates cashew in an area of 1,21,600 hectares with a production of 1,30,000 MT and a high average productivity of 1100 kg/ha (Directorate of Cashewnut and Cocoa Development, 1998).

The cashew tree also produces cashew apples to the tune of eight to ten times the weight of the nuts. Cashew apple is enriched with sugars, minerals, fats, vitamins, proteins, etc. It also possesses innumerable medicinal properties. Despite being a highly nutritious fruit, it is estimated that majority of it is being wasted. Kerala alone produces approximately eight lakh tonnes of cashew apples annually, which are not utilized.

In India, Goa is the only state where cashew apples are used in the preparation of 'feni', a fermented cashew apple beverage (Bhakta, 1980). Some other products, which can be produced from cashew apple are jam, candy, syrup, vinegar, liquor and wine. However, the commercial production of these products is not being taken up due to the persisting astringent taste imparted by tannins in them. This necessitates clarification of cashew apple juice by precipitation of tannins and subsequent removal by filteration. The extent to which clarification can be achieved, depends on the efficiency of clarifying agents. In the present study, various clarifying agents were tried in order to screen out the most ideal one in clarification of cashew apple juice for preparation of wine.

Of the various products from cashew apple, a good quality wine will be a novel product. Wine is a low alcoholic beverage prepared by the fermentation of any fruit juice having sugars. The alcohol content of most fruit wines is about 12 per cent. However, in some cases fruit wines may be fortified by the addition of alcohol to achieve a higher alcohol content. Preparation of wines from neglected fruits proves to be highly remunerative. The fruit wines are not only liked by wine fanciers but also serve as good health drinks. (Bhajipale *et al.*, 1998).

Wine is unique among beverages in that it contains both alcohol and antioxidants. Antioxidants are substances that protect the body systems from harmful substances. Antioxidants are also involved in the prevention of many diseases such as diabetes, liver damage, cirrhosis and cancer.

Besides antioxidants, wines also contain all the nutritional constituents of the respective fruit juice and due to their low alcohol content, they do not cause severe intoxication. Instead, they help in the preservation of the otherwise perishable fruits by its low alcohol percentage. Thus, wines help to extend the availability of a particular seasonal fruit throughout the year in the form of its wine. In this context, methods for preparation of quality wine from cashew apple, a highly perishable commodity would help farmers to increase their income from cashew. Eventhough preparation of cashew apple wine has been tried by many workers earlier, a simple technique that can be adopted by farmers at house-hold level is not common.

In order to retain the good wine quality, like any other commodity, proper storage conditions are necessary. Hence, the effect of containers and environment on the storage stability of the wines was analysed. Storage helps in improving the bouquet of the wines.

Blending of wines is a technique that can be adopted to improve the quality and acceptability of the beverage. The major impediment in the acceptance of cashew apple wine being its poor taste and quality, attempts to blend it with other fruit wines and juices was taken up. 'Wine coolers' (prepared by mixing wine with fresh fruit juices) are nutritionally enriched beverages with low alcohol content. Hence, these may be popularised as a healthful beverage and can be served even to children. Development of such products based on cashew apple wine was attempted to.

The study was undertaken largely to promote the large-scale utilization of cashew apple with the following specific objectives:

- To standardise techniques for making wine from cashew apple juice.
- To identify suitable variety/varieties of cashew apple for wine making.
- To select appropriate containers, treatment and environment for storage stability of cashew apple wine.
- To develop healthy and acceptable beverages based on cashew apple wine by blending with other fruit wines or juices.

Review of Literature

Review of literature

The potential of cashew apple as a raw material for conversion into different kinds of fruit products such as jam, jelly, syrup, candies has been highlighted by many workers. The preparation of fermented and unfermented beverages, also has been reported. This section is the review of work done on the utilisation of cashew apple, its nutritional constituents, wines prepared from other fruits and the quality and storage aspects of wines.

2.1 Introduction and spread of cashew in India

Cashew (*Anacardium occidentale* Linn.), a native of Brazil was introduced to India in the sixteenth century by the Portuguese travelers on the West Coast of the country. It was initially planted as a soil conservation measure and has since been naturalized making India one of the leading cashew producers in the world (Natarajan, 1979).

Traditionally, cashew was grown in the states of Kerala, Karnataka, Goa, Tamil Nadu, Maharashtra and Andhra Pradesh. It has also spread to other non-traditional areas of Orissa, West Bengal, Tripura and Pondicherry (Natarajan, 1979; Bopaiah, 1982; Balasubramanian, 1987).

2.1.1 Importance of cashew

Augustin (1984) opined that due to regular occurrences of food shortage, countries like India cannot afford to waste such a valuable food material as the cashew apple. Besides the use of cashew apples could also provide extra income to the farmers.

Many scientists have reported the nutritional and medicinal benefits of cashew apple. Edassery (1987) referred to cashew apple as a natural nutrition capsule and stressed the importance of the utilisation of this fruit.

Cashew is mainly grown for its nuts, the raw material for processing out kernels. The by-product obtained from the shell called cashew nut shell liquid (CNSL), is an industrial raw material for the manufacture of paints, varnishes, brake linings, laminating and rubber compounding resins, etc. The testa covering the kernels is rich in tannin and has high value in leather industry (Balasubramanian, 1987).

In India, cashew nut trade is the third highest foreign exchange earner among the agriculture-based export market. India has earned an all time high export earnings of 2500 crores rupees during 2000 (Rao and Nagaraja, 2000).

2.2 Growth and development of cashew apple

The size and shape of the fruit can vary from almost round to elongated. The very young apple is green or purple, turning green later. When ripe, the apple becomes red or yellow or a mixture of the two. The ripe apple is juicy (85%), somewhat fibrous with a very thin skin (Ohler, 1979).

Pratt and Mendoza (1980) reported that cashew apple grew very slowly until the nut matured. It then grew very rapidly and ripened. Removal of nuts initiated rapid growth of cashew apple and also indicated early ripening. They also studied the ethylene production pattern and confirmed that cashew apple was non-climacteric.

Augustin and Unnithan (1982) found that the increase in dry weight in cashew apple was slow upto 36 days from fruit set and thereafter it was rapid. In the early stages, growth rate of cashew nut was much faster than the apple.

Chattopadhyay *et al.* (1983) stated that the growth patterns of cashew apple, pericarp and kernel were of different types. Initially the nuts grew faster than the apples but in later stages apple size increased much more rapidly and outgrew the nut.

Kumar *et al.* (1984) analysed the physical parameters of growth of fruit in cashew. They opined that optimum fruit development occurred 70 days after fruit set.

According to Naidu *et al.* (1998), fruits reached 'peanut' stage in about eight days and thereafter fruit growth was completed in another five weeks. Apple showed a slower increase in dry weight till the fourth week after 'peanut' stage followed by a sudden spurt in growth. Apple weight increased from 11.13mg per fruit at zero WPS (weeks after 'peanut' stage) to 4870.3mg per fruit at five WPS.

2.2.1 Changes in composition during development

The various physiological and biochemical aspects of fruit development were reviewed by Nitsch (1953). The development process of fruit is characterised by the changes that make it juicy, sweet and coloured.

Mudambi and Rajagopal (1977) reported that the vitamin C content increased with size and maturity till the half-ripe stage. It showed an increase by 100% until the full ripe stage and declined thereafter.

The changes in chemical composition during ripening were reported by Natarajan (1979). Acidity decreased while TSS, brix-acid ratio and ascorbic acid content increased. Tannin content, nitrogen and polyphenols were found to decrease on ripening.

The increase in soluble carbohydrates and ascorbic acid content upto the final stage of maturity in cashew apple was reported by Augustin and Unnithan (1982).

Chattopadhyay *et al.* (1983) found that total and reducing sugar contents increased with maturity of cashew apple.

The steady increase in the ascorbic acid content of cashew apple from 25 days to 55 days after fertilisation and decline towards the later stages of maturity was put forward by Champakam (1983).

2.2.2 Variability in cashew apple characters

Singh and Mathur (1953) studied the chemical composition of yellow and red fruits with regard to TSS, reducing sugars, total acidity, ascorbic acid and moisture in juice. They concluded that yellow fruits were distinctly superior to red ones.

Albuquerque *et al.* (1960) noticed wide variation in weight and size of cashew apples. They found that yellow apples were less astringent, heavier and softer than red apples.

Based on detailed studies of physico-chemical composition of cashew apple juice, Sondhi (1962) reported the range of variation in its constituents as TSS (7.2 to18.3), acidity w/w (0.1 to 0.7%), brix-acid ratio (14.2 to 104.3) and pH (3.7 to 4.6).

While reviewing the possibilities of cashew apple utilisation, Anon (1963) stated that its juice had a brix of 12 to 14% containing 10.5 to 12.5% reducing sugars, 35% acid as malic and 170 to 236mg ascorbic acid per 100ml.

Sastri and Chakraborty (1963) reported variation in chemical composition of different selections namely, Chrompet(63), Kutuparamba(40), Manjeri(38), Rio de Janeiro, Pattukotai(65), Madhuranthakan(64), Kanchangad(19), Ullal(5), Itchapur(69), Permannur(9), Udayarpalayam(59), Nileshwar(28), Derlakatta(7), Manjeri(37), Talapady(22), Wynad(43) and Guntur(67) with regard to the colour of apple, brix, acidity, ascorbic acid and tannin. They recorded variation in all these characters from selection to selection.

On reviewing the correlation studies between the apple characters, Aiyadurai (1966) stated that the heavier and longer the apple, the higher was the juice content.

Chandran and Damodaran (1985) opined that cashew apples showed a lot of variation in morphological and qualitative characters. Variability in terms of size of apple, colour, TSS, ascorbic acid, proteins and tannin were reported.

Kumar and Aravindakshan (1985) concluded that among the varieties examined, K-27-1, BLA-139-1, BLA-1 and Sawantwadi were suitable for processing. Cashew apples with acidity in the range of 0.39 to 0.42% were most desirable for processing.

Aravindakshan *et al.* (1986) conducted studies on some physico-chemical attributes of cashew apples of 13 selected types and found variation in weight, volume, juice content, TSS, reducing and non reducing sugars, acidity and brix-acid ratio.

Significant variation in terms of apple weight, size, specific gravity, juice recovery, TSS, acidity and reducing sugar content was also observed by Ghosh and Kundu (1989).

On comparing the apple characters of nine varieties of cashew, Sapkal *et al.* (1992) observed variation in TSS, acidity, ascorbic acid, reducing sugars and total amino acid content. The type 2/77 from Tuni, Andhra Pradesh and type 1/26 from Nileshwar, Kerala were found to be the best among the varieties studied.

Sena *et al.* (1995) described variation in apple colour, weight, specific gravity, juice recovery, acidity, TSS and total sugars in 17 cultivars of cashew.

Lenka *et al.* (1998) evaluated 13 varieties of cashew for apple characters and found variation in qualitative characters such as TSS, acidity, reducing sugars and ascorbic acid content of the cultivars.

2.3 Nutritional importance of cashew apple

Natarajan (1979) reported that the free amino acids present in the juice are o - (al-amine), proline, arginine and lysine. Cashew apple juice was also a good source of water-soluble vitamins viz., ascorbic acid, riboflavin and thiamin. Cashew apple also contains 8000 IU of vitamin A per 100g of fruit.

The nutritional constituents of an average sized cashew apple were analysed by Shahjahan (1980). According to him the apple contains 0.8% protein, 0.6% fats, 0.4% minerals, 0.9% fibre, 12% starch, 53 calories of sugars, 39 IU vitamin A, 0.02mg thiamin, 0.05mg riboflavin, 0.4mg nicotinic acid and 180 IU vitamin C. It can also be used as a curative against stomach ailments like diarrhoea, dysentry and as a tonic to mothers in confinement.

The medicinal properties of cashew apple were enumerated by Vijaya Kumar (1991) as a cure for scurvy, diarrhoea, uterine complaints and dropsy. It is also useful against neurologic pain and rheumatism. It is effective for preventing cholera and as a medicine for women after parturition.

The use of cashew 'feni', an alcoholic beverage prepared from cashew apple juice to cure various ailments of infants and aged as well, was stated by Augustin (1987).

2.4 Storage of cashew apple

Cashew apple, due to its tender skin gets easily bruised and is highly perishable. It should be processed shortly after collection of fruits, without microbial contamination.

Mandal *et al.* (1979) reported that cashew apple juice rapidly deteriorated unless sterilized by heat or treated with preservatives. But heat treatment affected flavour, imparted a cooked taste and juice stored with preservatives is not feasible for processing as fermented products (Vilasachandran and Gopikumar, 1983).

They also reported that cashew growers in Goa extracted juice in the cashew plantation itself and then transported it to the processing industries.

The decreasing trend of TSS, brix-acid ratio, sugar-acid ratio and increase in acidity, on storage of cashew apple juice was reported by Vilasachandran and Gopikumar (1983). Tannin content was also found to decrease.

Washing in water or dipping in solutions with low concentration of antibiotics was suggested to reduce spoilage of cashew apples (Bopaiah, 1983).

Nanjundaswamy *et al.* (1984) found that 65% of the fruits were spoiled within 24 hours of harvest and transportation from the field to the processing centre.

Antarkar *et al.* (1991) studied the influence of storage on physiological loss in weight (PLW) and chemical composition of cashew apple. They found that PLW increased till the end of storage period. Moisture content, TSS, total and reducing sugars, acidity, ascorbic acid and tannins decreased during storage. The storage life of all varieties studied were less than two days at ambient temperature conditions.

Vijaya Kumar (1991) reported that the cashew apple cannot be kept for more than a day after the nut is removed and hence, should be immediately processed.

The increase in PLW on storage, was reported by Attri and Singh (1999). They also found an increase in specific gravity and decrease in titrable acidity, brix-acid ratio and ascorbic acid content during storage.

2.5 Utilization of cashew apple

In India, the commercial utilization of cashew apple has been investigated mainly by Central Food Technological Research Institute, Mysore and Kerala Agricultural University. A number of products such as jam, jelly, candy, syrup have been developed and also reported by various research workers. But processing of the fruit is yet to be undertaken for processing on a commercial scale.

Jain *et al.* (1952) stressed the need of cashew apple utilization and described the methods of preparation of juice, syrup and canned fruits from cashew apple.

Cashew apple products, from Brazil, were discussed by Johnson (1976). They included preserves such as 'doce', 'doce em calda', 'caju cristalizado' and 'caju ameixa'. Some others were 'cajuina', 'cremel de caju', 'cajuvita' and 'caju aperativo'.

Shahjahan (1980) proposed that the products such as jam, syrup, candies could be easily prepared at house-hold level. This would reduce rural unemployment and avoid national loss by means of wastage. Besides we could also enjoy the privilege of tasting various preparations of cashew apple.

Products such as juice, syrup, jam, candy, chutney, pickle and canned cashew apple were evaluated by Augustin (1984). The procedure for the preparation of clarified cashew apple juice, blended juices, juice concentrate, vinegar, jam, preserve and candy, was given by him. He also suggested the use of cashew apple residue after juice extraction for the recovery of low methoxyl pectin or as cattle feed after drying.

Nanjundaswamy (1984) estimated the annual loss to horticultural wealth of the country by means of wastage of cashew apple as 240 million rupees. Hence, he suggested the need of utilization of the fruit and creation of commercial outlets for the products.

Since the Seventh Plan gave emphasis on 'waste utilisation', setting up of small units in major cashew growing areas for manufacture of cashew apple products was aimed at. This was to generate rural employment and provide additional income to the cashew growers (Cashew Export Promotion Council, 1987). The Council requested the Government of Kerala to amend the Akbari Act so that fermentation and distillation of cashew apple could be carried out at small holder level and the product sold to distilleries for further utilization.

Edassery (1987) highlighted the importance of using the cashew fruit as a dried raw material for its extensive utilization. He gave the process for the preparation of dry fruit, upgraded to the higher order of any other dry fruit.

Vijaya kumar (1991) opined that the cashew apple jam, juice, syrup, pickle and candy had a refreshing taste which offered a good scope for export. Hence, according to him, cashew products could expect a ready market in India and abroad.

2.6 Clarification and pre-treatment of cashew apple juice

Chakraborty *et al.* (1962) reported that steam treatment of fruits for ten minutes at ten pound pressure per square inch (0.64kg / square inch) reduced the residual oil content and the retention of tannin in the final product was only in traces.

To remove the astringent taste from the juice, the Central Technological Research Institute (CTRI), Mysore, recommended that after washing the apples, they should be pressure steamed at five to ten pound for five to ten minutes. The juice extracted should be strained through a muslin cloth and tannin precipitated with gelatin solution at 430mg of gelatin per litre of juice. The mixture should be stirred for 15 minutes and then strained again to obtain clarified juice (Ohler, 1979).

According to Augustin (1984), clarification of cashew juice can be achieved by straining the extracted juice through muslin cloth and adding 1.4g of PVP (Poly vinyl pyrrolidone) per litre of juice. The mixture should be stirred for two minutes and then strained again through muslin cloth.

Nanjundaswamy (1984) suggested various methods to remove astringent and acrid principles. These included, steaming the fruit for five minutes under the steam pressure of five pounds per square inch and subsequent washing of the fruits with cold water. Also, cooking the fruits for five minutes in boiling solution of common salt (2%) resulted in clarified cashew apple juice. Addition of 0.5% gelatin solution also removed the undesirable principles in the juice.

Bopaiah (1982) reported that steaming of cashew fruit or juice was the most efficient method in removing astringent and acrid principles from cashew juice. The steam pressure varied from two to six kg for a period of 5-15 minutes. Also, fresh juice treated with gelatin (0.25-0.4%) and pectin (0.35%) or gelatin alone (0.5%) could precipitate tannins in the juice.

2.7 Cashew apple – for production of alcoholic beverages

Anon. (1941) stated that the cashew apple was soft and juicy and also that it was edible and yielded a delicious beverage. A wine could be obtained on fermenting, which retained the flavour of the fresh fruit.

Johnson (1972) remarked that the utilization of cashew apples by the local people of Asia and Africa for making cashew wine dated back to 300 years. He stated that the introduction of cashew to India by the Portuguese in the sixteenth century seemed to be the potential value of cashew apple for its medicinal properties and also for its juice which could be fermented into good wine.

Natarajan (1979) stated that a tasty wine was obtained by fermentation of cashew apple juice but was of less commercial interest due to high cost of production.

Bhakta (1980) reported that Goa was the only place in India where cashew 'feni' was being distilled for the last four centuries or more. 'Feni' is an alcoholic beverage prepared from cashew apple juice, having a unique taste and medicinal properties.

Vilasachandran and Damodaran (1981) evaluated cashew apples of 16 high yielding types and opined that K-10-2, M 6/1, BLA-1 and Sawantwadi had higher TSS, specific gravity, percentage juice recovery and could be used for production of alcoholic beverages.

Bopaiah (1982) suggested that, cashew apples could be successfully utilized for the production of high quality alcoholic beverages having export potential on an industrial scale such as cashew wine, cashew apple brandy and cashew 'feni'.

Augustin (1986, 1987) reported techniques for the production of cashew wine, cashew liquor and cashew vinegar.

According to Balasubramanian (1987) the most economical and industrial use to which cashew apple can be subjected to is towards its fermented products. He also reported that when fermented, it forms a very good palatable alcoholic drink of high export value.

2.8 Fruit wines

The preparations of wines from various fruits have been reported by many workers.

Ali and Dirar (1980) prepared two wines 'sherbote' and 'nabit' from date syrup and another wine 'dakkai' from whole date fruits. Small amounts of spices and sorghum malt were added in the preparation of 'sherbote' and 'nabit'.

A method of preparation of wild apricot (chulli) wine was developed by Joshi *et al* (1990). The mineral composition was in a desirable range and the taste and aroma of the wine prepared from 1:2 dilution was comparatively better due to balanced acid/ alcohol/ sugar taste, appealing colour and flavour.

Kulkarni *et al.* (1980) screened ten varieties of mango to evaluate their suitability for wine making. They obtained alcohol content ranging from 7.6 to 13.0% and low tannins, which ranged from 0.007 to 0.0125g/100ml. They reported that wines from varieties 'Fazri', 'Langra' and 'Chausa' had best organoleptic scores.

A methodology for making wine from *jambal* was standardised by Shukla *et al.* (1991). They also screened three cultivars namely, 'Pharenda', 'Jamun' and 'Kathjamun' for evaluating their suitability in wine making and concluded that 'Jamun' gave the best wine.

Peach wine could be produced from peach puree as well as juice having 24% sugar. The wine was low in acid, so addition of 0.1% acid improved the sensory score. Sulphur dioxide, more than 250mg per litre maintained colour during storage (Ogino *et al.*, 1982).

Vecher *et al.* (1982) reported that aromatised apple wine contained small amounts of St. John'swort, holygrass, rose petals, linden flowers, burnet and long leaved mint in addition to the young apple wine.

Vyas and Joshi (1982) standardised a method for making wine from plums. Organoleptic evaluation of the wine showed that 1:1 diluted pulp produced an acceptable quality of wine though it was little more astringent.

Wzorek and Krugly (1982) described the procedure for manufacture of Malaga - type fruit wines from currants, plums and strawberries. The amount of caramelised product determined the quality of wine.

Kwasniewski and Drillean (1983) prepared cider from apple juice concentrate diluted to specific gravity of 1.048 and 1.033 and fermented at 11 °C and 20°C.

Rzedowski and Surdel (1983) reported the limited use of plums for wine making as they were cloudy due to the presence of waxes and gums. Clarification with bentonite was found to partially eliminate turbidity.

Method of preparing fruit wine of improved quality was suggested by Skrypnik (1983). He said that the juice of low acid apples or pears should be blended with high acid black currant or gooseberry pulp. The juice was then extracted and fermented.

Vermouth is an alcoholic beverage prepared from fruit wines by adding extracts of spices and herbs (Ethiraj and Suresh, 1990).

Onkarayya (1985) developed mango vermouth by mixing herb mixtures of 14 herbs in different proportions (forming four formulae) to improve the aroma and taste of mildly flavoured mango wine prepared using dilute pulp.

Tamarind vermouth – a new alcoholic beverage from tamarind was reported by Lingappa *et al.* (1993). Four formulae with increasing concentrations of the constituents were tried of which one was found of commercial acceptability.

Teotia *et al.* (1991) suggested the preparation of beverage from fermented muskmelon juice. The fermented juice had 6.5% w/v alcohol and very good sensory quality. This was then fortified with sucrose to raise TSS and to prepare a RTS beverage.

Wine from custard apple was reported by Kotecha *et al.* (1995). The organoleptic evaluation revealed that the wine was comparable to that of grape in terms of body and taste. However, it scored less for colour and appearance, flavour and overall acceptability than grape wine. The wine was reported to have an alcohol content of 7.92%.

Singh *et al.* (1998) conducted studies on the suitability of kinnow fruits for wine production. *Saccharomyces cerevisiae* MTCC 178 was used for production of alcohol from kinnow juice.

Karonda fruits of different ripening stages were chemically analysed and used for wine making by Bhajipale *et al.* (1998). Over ripe fruits produced tasty, cherry red coloured wine with 8.26% alcohol and 438 ml/kg wine yield.

Gautam and Chundawat (1998) standardized the technology of making wine from sapota. The wine prepared from clarified juice was preferred to that made from non-clarified juice or to that from pulp.

2.9 Yeast for wine making

Rosi and Rosini (1981) found that, for the proper growth of the selected strain of *Saccharomyces cerevisiae* for wine making, the most suitable concentration was 30g glucose and 0.5g yeast per litre. The optimum temperature of 30°C and pH of 4.0 was the best.

Giudici and Guerzoni (1982) suggested that the sterol content may be considered as a character for selecting yeast strains in enology, as a significant positive correlation was found between the two.

Arcay-Ledezma and Slaughter (1984) demonstrated that at an excess pressure of two atmospheres of carbon dioxide throughout fermentation by *Saccharomyces cerevisiae*, the fermentation rate, yeast growth decreased, while the final pH increased.

Kish *et al.* (1983) described a medium for the differential enumeration of *Saccharomyces* for the quantitative assessment of wine yeast's during various stages of fermentation of fruit juices. ESY medium containing 150ml/l bisulphite and 12% ethanol by volume completely suppressed the growth of apiculate yeasts, enabling enumeration of the wine yeast.

Vartanyan *et al.* (1983) reported the use of antiseptics like nistatin, formic and boric acids to prevent the spoilage of wine yeast sediment during storage.

Minarik (1984) opined that both mixed and combined cultures of *Saccharomyces rosei* and *Saccharomyces oviformis* induced more complete fermentation of must at lower concentration of volatile acid than pure cultures of the two yeast's. Best results were obtained at a 9:1 ratio, using 5% starter in terms of must volume.

2.10 Quality of wines

Schaeffer (1981) suggested that young wines or musts should be clarified and centrifugation gave best quality retention of wine and development of good sensory properties.

Shklyaruk *et al.* (1982) improved the stability of wines using enzyme systems from coagulated yeast cells. The resultant young wines contained fewer phenols, proteins and polysaccharides, which affect the stability. The organoleptic properties of the wine were improved.

Spedding and Raut (1982) studied the influence of dimethyl sulphide (DMS) on the bouquet of wines. They found that 0.22 micro litres of DMS per litre of wine had a beneficial effect on the wine quality.

Castino (1983) discussed the colloidal substances in wines such as proteins, glucides and polyphenols. Methods to reduce their effect included addition of pectolytic enzyme preparations to facilitate clarification of musts and use of clarifying agents (tannins or silica sol with gelatin) to facilitate precipitation of insoluble colloids.

Pavlenko *et al.* (1983) studied the influence of storage time on physico – chemical and sensory characteristics of wines and concluded that quality is not linked to age alone but also good storage conditions are important.

Plessis (1983) reported that high pre-fermentation temperature would lead to excessive absorption of phenolic compounds and thus reduce shelf life of wine. Higher alcohol and increased content of tannins and leucoanthocyanins, but a decrease in esters of fatty acid was observed with increase in temperature. All these factors affected wine quality.

Ringland and Eschenbruch (1983) reported the ability of gelatin to complex and selectively remove phenolics from wines and juices. Most wines and juices require fining rates of 2 - 25g/hl.

Wucherpfenning and Dietrich (1983) showed that enzymic degradation of colloids improved the filterability of wines. Samples of 18 Rheingan and Palatinate wines treated with glucanase preparation at 1g/hour caused improvement in filterability after four to five days.

The use of gelatin and bentonite for clarification in wine making was reported by Zinchenko *et al.* (1983). For gelatin treatment, an aqueous tartarate solution (10g/l) less than 24 hour old was recommended.

Baccioni (1984) described methods for stabilization of wine as, removal of cations responsible for crystallization, inhibition of crystallization and artificial acceleration of crystal formation by refrigeration techniques.

Bardini (1984) reported that limpidity of white musts and control of fermentation temperature are indispensable factors for improving wine quality. The optimum temperature for fermentation was established as 18-20°C.

Gortges (1984) suggested the possible methods for de-acidification of must and wine as the use of calcium carbonate, double salt method, use of potassium bicarbonate, potassiun tartarate and double salt of tartaric acid. Microbial de-acidification also can be done.

Guettes *et al.* (1984) developed a procedure for the selective and intensive de-acidification of wine based on filtration at 25°C through a filter coated with a mixture of hydrated cellulose, magnesium oxide, aluminium oxide and bentonite.

Vialatte (1984) carried out de-acidification by adding calcium carbonate, potassium bicarbonate, calciun tartarate and calcium double salts of tartaric and malic acids to cause precipitation of the desired crystals.

Villettaz (1984) and Anon. (1985) reported the use of enzymes in wine making. The use of proteases to control protein haze and use of glucanases to improve filterability and clarification were discussed.

2.11 Storage of wines

2.11.1 Storage containers

Bach and Hess (1984) conducted a comparison of wine stored in cartons, bag in box packs and cans with glass bottles. Decrease in ascorbic acid, total and free sulphur dioxide was highest in bag in box packs and least in glass bottles while increase in colour intensity was highest in bag in box packs. Sensory quality was inferior in bag in box packs.

In a survey conducted by Botta (1984), the criteria for selecting a particular type of bulk container was given. Concrete and lined steel containers were suggested for wine.

Caprio (1983) found two stainless steel type containers, AISI 304 and AISI 316 suitable for wine. These two were incorporated with chromium and nickel and chromium, nickel and molybdenum respectively along with normal or low carbon content.

Colagrande (1983) reported containers for wine made from wood, lined concrete, lined steel, stainless steel and fibreglass reinforced polyester resin (9%).

A detailed and illustrated survey on the use of wooden large barrels to store wine was conducted by Garbellotto (1984).

The use of stainless steel vessels in wine making for hygienic control of foods and beverages and selling of wine in containers of plastic, metal or plastic film lined with carton or aluminium foil was published by Ministro dell' Agricoltura e delle Foreste, Italy (1982).

2.11.2 Changes in wine on storage

Cortes (1981) described oxidation, temperature and effects of enzymes as the major causes of colour changes in wine and suggested methods for prevention as use of fining agents, use of sulphur dioxide and prevention of access of air.

Cela *et al.* (1982) demonstrated the effects of wine making conditions on the changes in tannins and colour of sherry wines. When held at 55°C for 30 days, the polyphenol content initially decreased and then remained constant. Tannins initially decreased, then gradually increased. Colour intensity increased with increasing suspended solid content and time.

Simpson (1982) reported that the factors affecting oxidative browning of white wine were the contents of total phenolics, catechins and procyanidins.

Lemperle and Kerner (1983) conducted storage studies on red French table wine packaged in 1-1 tetrabrik packs. They found that total and free sulphur dioxide concentration decreased during storage affecting the sensory quality.

The presence of acetic acid bacteria at all stages of wine making was reported by Joyeux *et al.* (1984). On short exposure of the wine to air, there was rapid proliferation and thereby increase in concentration of acetic acid. High temperature of wine storage and high wine pH favoured their development.

According to Postnaya and Tkach (1984), hydrogen sulphide, mercaptan, methyl thioacrylate and other bivalent sulphur compounds formed in wine by the action of yeast enzymes caused odours in wine. However, proper clarification of must and proper fermentation, timely separation of yeast, treatment with inert gas and limited must sulphitation could eliminate these defects.

Toniolo (1984) reported techniques of bottling and corking wines to prevent oxidation of bottled wines. The Bertolaso and Cobert winery developed a method involving isobaric depression type fillers and pre-filling of bottles with carbon dioxide and nitrogen.

2.12 Health benefits of wine

There is no doubt that wine is a healthful beverage. It has been consumed through the ages as food and as a food adjunct. It may indeed be considered as the world's oldest medicine. Modern scientists believe that wine is one of the most complex beverages containing many substances that are important to health. As a dietary liquid, it is second only to that of milk (Blevins and Morris, 1997).

The beneficial aspects of wine can be attributed to the presence of antioxidants in wine. These protect the body systems from endogenous as well as exogenous harmful substances (Muller and Fugelsang, 1994).

Wine antioxidants might help prevent diabetes and associated visual loss (Halliwell and Gutteridge 1985a, 1985b). They also combat painful inflammation of arthritic tissues (Kanner *et al.*, 1986; Esterbauer *et al.*, 1991). Antioxidants may also help to prevent certain forms of liver damage, including cirrhosis and cancer (Kennedy and Tipton, 1990; Poli *et al.*, 1993).

An important antioxidant in wine, salicylic acid, is effective against some viral and bacterial infections in humans. Recently salicylic acid and wine has been shown to be protective against the common cold (Cohen *et al.*, 1993).

According to Holmgren (1993), a study conducted showed that women who were moderate drinkers suffered fewer heart attacks and ischemic strokes. In yet another study conducted, data showed that moderate wine drinkers had the lowest vascular death rates (Doll *et al.*, 1994).

Brennan (1995) reported that the non-alcoholic ingredients in wine could reduce the risk of heart disease. The polyphenol antioxidants in wine also prevented atherosclerosis and kept the blood vessels relaxed. They could also be responsible for the anticoagulant effect of wine.

Materials and Methods

Materials and methods

The present investigation on the 'Standardization of techniques for cashew apple wine production and development of wine based products' was undertaken in the Department of Processing Technology, College of Horticulture, Vellanikkara, during 1999 – 2001.

Cashew serves as an important cash crop in Kerala's economy. Only the nut is utilized while the cashew apple is wasted, despite the fact that it has innumerable nutritional as well as medicinal properties. The study, hence, aimed at preventing the loss of this valuable fruit by preparing cashew apple wine. Wine not only helps in easy preservation of the product but also serves as a health drink due to its low alcohol content.

The research programme was undertaken under the following four experiments:

- Standardization of techniques for cashew apple wine making and identifying promising strains for wine making.
- Effect of treatments on the yield and quality of cashew apple wine.
- Comparison of containers and storage environment in relation to shelf life of cashew apple wine.
- Development of cashew apple wine based products.

Collection of cashew apples and extraction of juice

Fully ripe cashew apples were harvested from the trees maintained at the Cashew Research Station, Madakkathara, under the Kerala Agricultural University. Nuts were separated immediately and sorting of the cashew apples was done to remove the damaged and undesirable ones. The selected cashew apples were then carefully transported to the analytical laboratory of the Department of Processing Technology in clean plastic buckets having lids. They

Plate 1. Fresh cashew apple

were then thoroughly washed in clean water followed by washing in 0.2% potassium-metabisulphite (KMS) solution in order to avoid microbial contamination and to get rid of field heat. Juice was extracted from the cashew apples using a basket press without any delay. The fresh juice obtained as such was used for the different experiments under the study.

3.1 Experiment 1. Standardization of techniques for cashew apple wine making and identifying promising strains for wine making.

The experiment was aimed to standardise techniques for the preparation of cashew apple wine and to evaluate the suitability of three different strains of wine yeast, *Saccharomyces cerevisiae*, viz., MTCC 172, MTCC 174 and MTCC 180. They were obtained from the Institute of Microbial Technology (IMTECH), Chandigarh, Punjab. The institute is marketing these strains as ideal strains for making wine.

3.1.1 Clarification of cashew apple juice

Fresh cashew apple juice was kept for clarification overnight (12 hours) by adding rice gruel at the rate of 150ml per litre of juice. In the preparation of the rice gruel half kilogram of parboiled rice was thoroughly washed and added to about double the quantity of water. The gruel was strained and used. The clarified juice was used for the preparation of the wine.

3.1.2 Preparation of starter culture

Freeze dried cultures in vacuum-sealed glass ampoules were obtained from IMTECH, Chandigarh. The cultures were received and subcultured in a growth medium of the following composition:

Yeast extract	3.0g
Peptone	10.0g

Dextrose	20.0g
Agar	15.0g
Distilled water	1.0 litre

The media was sterilized and then dispensed in petri-plates. Single colonies of the culture were uniformly suspended in sterile water. A loopful of the suspension was streaked on petri-plates. The procedure was done aseptically in a laminar airflow chamber. Later the petri-plates were incubated in a B.O.D. incubator at 37°C for a period of two days.

3.1.2.1 Subculturing the yeast

To prevent contamination of the yeast colonies by other microorganisms, subculturing was done at bimonthly intervals. Here a single colony of yeast was taken in a sterile loop and streaked on petri-plates with fresh media. Only single colonies of yeast were used for inoculation in the cashew apple juice.

3.1.2.2 Standardisation of inoculum concentration

For the production of wine of generally accepted taste and quality, the fruit juice should be inoculated with populations of yeast of 10^6 or 10^7 cfu (colony forming units) per ml of juice (Battock and Azam-Ali, 1998). The period taken by the yeast cells to attain the desired cfu, from the time of inoculation into liquid growth media was noted. Single colonies were inoculated in 10ml of the medium and incubated in B.O.D. incubator at 37°C. Population was enumerated at 24 hour interval by serial dilution plating on the specified medium contained in petri-plates. The plates were incubated for 48 hours, number of colonies were counted and expressed as cfu/ml.

3.1.2.3 Multiplication of the yeast

A colony of yeast cells was inoculated in each of 5ml and 10ml liquid media tubes to get starter cultures of the two desired strengths. The yeast cells were allowed to multiply by keeping the tubes on a shaker rotating at 100 rpm for the standardised period of time.

The starter cultures of the three different strains were prepared and inoculated into fresh clarified juice. In the following treatments rice gruel was used for clarification. Different additives namely, cane sugar and jaggery were added to the juice and for each strain, two concentrations of the cultures were used as detailed below.

T_1 - cashew apple juice + starter culture (5ml) + anaerobic condition + ambient environment.

T_2 - cashew apple juice + starter culture (5ml) + cane sugar to raise brix to 20^0 + anaerobic condition + ambient environment.

T_3 - cashew apple juice + starter culture (5ml) + jaggery to raise brix to 20^0 + anaerobic condition + ambient environment.

T_4 - cashew apple juice + starter culture (10ml) + anaerobic condition + ambient environment.

T_5 - cashew apple juice + starter culture (10ml) + cane sugar to raise brix to 20^0 + anaerobic condition + ambient environment.

T_6 - cashew apple juice + starter culture (10ml) + jaggery to raise brix to 20^0 + anaerobic condition + ambient environment.

T_7 - cashew apple juice + starter culture (10ml) + fermentation in china clay jar.

T_8 - cashew apple juice + starter culture (10ml) + cane sugar to raise brix to 20^0 + fermentation in china clay jar.

T_9 - cashew apple juice + starter culture (10ml) + jaggery to raise brix to 20^0 + fermentation in china clay jar.

The fermentation was carried out in a Buchner's flask and anaerobic condition was provided by water lock mechanism.

Replications : 3

Design : CRD

3.1.3 Observations were made on physico-chemical attributes of cashew apple juice and wine

3.1.3.1 Weight of cashew apple and percentage juice recovery

Fresh, ripe cashew apples were washed in 0.2% KMS solution and weight was noted in grams. Juice was extracted using a basket press and weight expressed in terms of percentage.

$$\text{Percentage juice recovery} = \frac{\text{weight of cashew apple juice}}{\text{weight of cashew apple}} \times 100$$

3.1.3.2 Clarified juice recovery

The cashew juice was clarified using rice gruel at 150 ml per litre of juice and kept overnight. The juice obtained after clarification was strained using a muslin cloth and expressed as a percentage of the initial weight of cashew juice.

$$\text{Clarified juice recovery} = \frac{\text{wt. of clarified juice}}{\text{initial wt. of cashew apple juice- qnty. of rice gruel}} \times 100$$

3.1.3.3 pH of cashew apple juice

The pH of the fresh as well as clarified juice was recorded using standard pH meter (Digital pH meter PH 5652 A of Electronics Corporations of India).

3.1.3.4 Total soluble solids (TSS) of juice

The TSS content in the fresh as well as clarified juice was measured using the Erma hand refractometer (range 0-32^0 brix) and expressed as degree brix.

3.1.3.5 Microbial population

The population of the yeast in the fermenting cashew apple juice was estimated daily by the serial dilution plate counting method. One ml of the juice was pipetted out and diluted serially to concentrations ranging from 10^{-2} to 10^{-5}. Then 0.1 ml of the dilution was spread on a petri-plate containing yeast extract peptone dextrose agar media. After 48 hours of incubation in B.O.D. at 37°C, the yeast colonies developed and were counted. It was then expressed as colony forming units per ml.

3.1.3.6 Wine yield

At the end of fermentation, the wine was decanted leaving the dead yeast cells and other residue at the bottom of the fermenting vat. The wine yield was expressed as a percentage of its weight.

$$\text{Wine yield} = \frac{\text{final weight of wine obtained}}{\text{initial weight of cashew apple juice}} \quad X\ 100$$

3.1.3.7 Alcohol strength of the wine

The alcohol strength of the wine was estimated by adopting the dichromate oxidation, procedure using Micro Kjeldahl apparatus (A.O.A.C., 1980). Water was boiled in a steam generator. One ml of the wine sample was pipetted and drained into the still along with a small amount of water. 25 ml of potassium dichromate solution was placed under the condensor with the tip immersed in the solution. Steam was allowed to pass through the still for 30 minutes. The alcohol collected in the potassium dichromate solution was titrated with ferrous ammonium sulphate using ferroin as the indicator till a brown end point. The percentage of alcohol was then calculated.

3.1.3.8 pH of the wine

The pH of the wine at the end of fermentation was recorded using standard pH meter (Digital pH meter PH 5652 A of Electronics Corporations of India).

3.1.3.9 Titrable acidity

Titrable acidity was estimated as per A.O.A.C. (1980). 25g of the wine sample was made up to a known volume with distilled water. An aliquot of the solution was titrated against 0.1N Sodium hydroxide (NaOH) solution using phenolphthalein as indicator. The acidity was expressed as percentage of malic acid.

3.1.3.10 TSS of wine

The TSS content of the wine was estimated using the Erma hand refractometer (range 0 –32^0 brix).

3.1.3.11 Brix-acid ratio

The ratio was determined by dividing the degree brix of the sample by the percentage of titrable acidity of the same. It was expressed nearest to the second decimal place (Ranganna, 1986).

3.1.3.12 Reducing sugars

The content of reducing sugars was estimated by adopting the method given by Lane and Eynon (Ranganna, 1986). To 25g of the wine sample, an amount of distilled water was added and then clarified with neutral lead acetate. The excess lead acetate was removed by adding potassium oxalate. The volume was then made up to 250ml. An aliquot of this solution was titrated against a mixture of Fehling's Solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

3.1.3.13 Total sugars

The total sugar content was determined using the method given by Lane and Eynon (Ranganna, 1986). 25ml of the clarified solution was boiled gently after adding citric acid and water. It was later neutralized with NaOH and the volume made up to 250ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B. The total sugar content was expressed as percentage.

3.1.4 Sensory evaluation

Sensory evaluation of fresh wine samples as well as wines after storage was conducted to assess the colour and appearance, aroma, taste, flavour, astringency, sugar-acid blend, alcohol content and overall acceptability. A panel of ten experienced judges evaluated the wines using a five point hedonic scale (Ranganna, 1986).

For the parameters, colour and appearance, aroma, taste, flavour and overall acceptability, the ratings were:

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

In the case of astringency, which refers to the drying, mouth puckering taste of the wine caused due to tannin and other related compounds, the ratings were:

Not detectable	5
Slightly detectable	4
Moderately detectable	3
Detectable	2
Strongly detectable	1

For evaluating the sugar-acid blend of the wine, the ratings were:

Optimum	5
Satisfactory	4
Sweet	3
Neither sweet nor acid	2
Acidic / Sour	1

For the alcohol content presence, the ratings were:

High	4
Medium	3
Low	2
Very low	1

3.2 Experiment 2. Effect of treatments on the yield and quality of cashew apple wine.

In this experiment, the yield and quality of wine prepared from cashew apples subjected to various pre-treatments and cashew apple juice clarified using various clarifying agents was worked out. In all the treatments, the TSS of the juice was increased to 20^0 brix by adding cane sugar before the addition of starter culture.

T_1 - Ripe cashew apples washed in 200 ppm KMS solution before juice extraction and clarified using rice gruel (control).

T_2 - Soaking cashew apples in hot water 60°C for five minutes before juice extraction and clarified using rice gruel.

T_3 - Treating juice clarified using rice gruel with 200mg of KMS per litre before adding starter culture.

T_4 - Cashew apple juice clarified with gelatin (1.0%).

T_5 - Soaking cashew apples in hot lye (0.2% sodium bicarbonate solution) for three minutes before juice extraction and clarified using rice gruel.

T_6 - Cashew apple juice clarified with pectin (0.5%).

T_7 - Cashew apple juice clarified with 0.4% PVP and later treated with 200mg KMS per litre of juice.

Replications - 3

Design - CRD

3.2.1 Preparation of starter culture

Starter culture was prepared using commercial Baker's yeast, *Saccharomyces cerevisiae*. Sugar was dissolved in luke warm water at the rate of 20g per 100ml of water. Baker's yeast was then added at five grams per 100ml of the sugar solution. The culture was kept as such for 30 to 60 minutes for vigorous frothing and then added to the cashew apple juice.

3.2.2 Preparation of cashew apple juice

The clarified cashew apple juice obtained after the pre-treatments as well as clarification was used for production of cashew apple wine. The TSS of the juice was raised to 20°brix by the addition of cane sugar. This was then subjected to fermentation.

The fermentation was carried out under anaerobic conditions and ambient environment in a Buchner's flask provided with a water lock mechanism.

3.2.3 Physico-chemical attributes of cashew apple juice

The attributes were determined as in 3.1.3

3.2.4 Physico-chemical properties of cashew apple wine

The physico-chemical properties namely, wine yield, alcohol strength, pH, titrable acidity, TSS, brix-acid ratio, reducing and total sugars were determined as in 3.1.3

3.2.5 Sensory evaluation

The sensory evaluation was conducted as in 3.1.4

3.2.6 **Varietal suitability for cashew apple wine making**

To identify the most suitable variety for making wine, seven varieties of cashew apple, namely, Madakkathara-1, Madakkathara-2, Dhana, Kanaka, Dharasree, Priyanka, and Amrutha were utilized in the preparation of cashew apple wine.

3.2.6.1 Preparation of starter culture

Starter culture was prepared as described in 3.2.1

3.2.6.2 Preparation of cashew apple juice

Cashew apple juice after clarification using rice gruel was used for wine making. Cane sugar was added to raise the TSS content to 20° brix. This was then subjected to fermentation carried out under anaerobic conditions and ambient environment in a Buchner's flask, provided with a water lock mechanism.

Observations on the physico-chemical as well as sensory evaluation were conducted as given in 3.1.3 and 3.1.4 respectively.

3.3 Experiment 3. Comparison of containers and storage environment with respect to quality of cashew apple wine.

In this experiment wines were evaluated with respect to their quality after storage in eight types of containers kept in three different environments namely, open room storage, storage in refrigerator and storage in dark condition as detailed below.

T_1 - Glass bottle- plain
T_2 - Glass bottle- amber cloured
T_3 - Pet jar- plain
T_4 - Pet jar- amber coloured
T_5 - Bamboo containers
T_6 - Stainless steel containers
T_7 - China clay jars
T_8 - Clay pots

Total treatments	- 8 X 3
Replications	- 2
Design	-CRD

The storage containers were washed in 0.2% KMS and sterilized before storing the wine. Fresh wine was analysed for its sensory quality and pasteurized before storage. Wine samples were assessed for their biochemical and sensory quality after six months of storage.

3.3.1 Physio-chemical characters of wine

The alcohol strength, pH, TSS content, titrable acidity, brix-acid ratio, reducing and total sugar content were estimated as in 3.1.3

3.3.2 Sensory evaluation

Sensory evaluation of the wines stored in different containers and kept under the three environments was conducted at bimonthly intervals as described in 3.1.4

3.4 Experiment 4. Development of cashew apple wine based products.

This experiment aimed at improving the consumer acceptability of the wine by development of two types of beverages viz., cashew apple wine blended with other fruit wines and cashew apple wine mixed with fruit juices.

A. Blended wines

For the preparation of blended wines, wines were prepared from various fruits, namely mango (variety Muvandan), pineapple, jackfruit "koozha' type, grapes, gooseberry and banana (variety Palayankodan). The fruits were pulped separately and double the quantity of water was added. The TSS was raised to 30^0 brix by the addition of cane sugar. Fermentation was done in a Buchner's flask having water lock mechanism. Starter culture was prepared as in 3.2.1 and added to each of the fruit juices for fermentation. The fruit wines were kept for a period of aging of six months and later used for blending with cashew apple wine, which was also aged for six months. The fruit wines were blended with cashew apple wine as detailed below.

T_1 - Cashew apple wine 50% + Mango wine (variety Muvandan) 50%.

T_2 - Cashew apple wine 50% + Pineapple wine 50%.

T_3 - Cashew apple wine 50% + Jackfruit 'koozha' type wine 50%.

T_4 - Cashew apple wine 50% + Wine (home made) 50%.

T_5 - Cashew apple wine 50% + Gooseberry wine 50%.

T_6 - Cashew apple wine 50% + Banana (Palayankodan) wine 50%.

T_7 - Cashew apple wine alone (control).

Replications - 3
Design -CRD

B. Wine coolers

Wine coolers were prepared by mixing fresh fruit juices with cashew apple wine. Fresh fruits, namely, mango, pineapple, grape, orange and tomato were obtained from the local market. They were thoroughly washed using 0.2% KMS solution. In the case of mango, pineapple and orange, the fruits were peeled. The pulp was used for juice extraction, which was done in a mixer. The TSS of all juices was maintained at a constant of 20^0 brix by the addition of cane sugar. The fresh juices were then used for the preparation of wine coolers by mixing in an equal quantity of cashew apple wine. Fresh tender coconuts and toddy were also procured for the same. The fresh fruit juices were then mixed with the cashew apple wine, aged for a period of six months, as given below.

T_1 - Cashew apple wine 50% + clarified cashew apple juice 50%.
T_2 - Cashew apple wine 50% + mango juice 50%.
T_3 - Cashew apple wine 50% + tender coconut water 50%.
T_4 - Cashew apple wine 50% + fresh toddy 50%.
T_5 - Cashew apple wine 50% + pineapple juice 50%.
T_6 - Cashew apple wine 50% + tomato juice 50%.
T_7 - Cashew apple wine 50% + grape juice 50%.
T_8 - Cashew apple wine 50% + orange juice 50%.
T_9 - Cashew apple wine alone (control).

3.4.1 Sensory evaluation of blended wines and wine coolers

The blended wines as well as wine coolers prepared were given to a panel of ten judges for sensory evaluation with respect to the quality attributes as explained in 3.1.4

3.5 Statistical analysis

The observations recorded were tabulated and analysed statistically using Completely Randomized Design (CRD) as prepared by Panse and Sukatme (1985). In Experiments I and III, the data was analysed statistically using factorial CRD. The significant difference between the treatments was assessed using the critical difference (CD) at 5% level.

The scores of organoleptic evaluation were analysed by Kruskal Wallace Analysis of Variance.

Results

Results

The results of the study on the 'Standardization of techniques for cashew apple wine production and development of wine based products', conducted in the Department of Processing Technology, College of Horticulture, Vellanikkara during 1999 – 2001 are presented in this chapter under the following heads:

4.1 Standardization of techniques for cashew apple wine making and identifying promising strains for wine making.
4.2 Effect of treatments on the yield and quality of cashew apple wine.
4.3 Comparison of containers and storage environment with respect to quality of cashew apple wine.
4.4 Development of products based on cashew apple wine.

4.1 Standardization of techniques for cashew apple wine making and identifying promising strains for wine making.

Techniques for the preparation of cashew apple wine using three strains of wine yeast, *Saccharomyces cerevisiae*, namely MTCC 172, MTCC 174 and MTCC 180 were studied. Observations on physical and biochemical attributes as well as sensory evaluation were recorded and are presented below.

4.1.1 Physio-chemical attributes of cashew apple juice

4.1.1.1 Weight of cashew apple and juice recovery percentage

The cashew apples were weighed and the percentage of juice recovery obtained was found to range from 49.09 to 67.27 per cent in different samples with a mean juice recovery of 58.18 per cent.

4.1.1.2 Clarified juice recovery

The recovery of the juice after clarification was recorded and found to range from 73.78 to 94.78 with a mean clarified juice recovery of 84.28 per cent.

4.1.1.3 pH

There was no change in the pH of the cashew apple juice after clarification. It remained the same as that of the fresh juice and ranged from 4.10 to 4.40 with a mean of 4.25.

4.1.1.4 TSS

The TSS of the fresh cashew apple juice ranged between 11.0^0 brix and 14.0^0 brix and that of the clarified juice ranged from 9.0^0 brix to 11.0^0 brix.

The wines prepared from the three strains using nine treatments were analysed for their physio-chemical as well as sensory attributes to identify the most suitable strain for wine making.

4.1.2 Physio-chemical attributes of cashew apple wine

4.1.2.1 Microbial population in the fermenting must

The population of yeast in the fermenting musts of all the treatments using the three strains was found to be highly variable. However, an increase in the population for first few days followed by a decreasing trend was observed in most of the samples till the end of fermentation.

4.1.2.2 Wine yield

There was no significant difference in the wine yield obtained from the nine treatments using the three strains. The yield ranged from 83.89 to 97.50 per cent with a mean of 90.70 per cent as indicated in Table 1.

Table 1. Effect of strains of wine yeast on wine yield and alcohol strength of cashew apple wine.

Composition of cuvee	Strains of wine yeast							
	Wine yield(%)				Alcohol strength(%)			
	M-172	M-174	M-180	Mean	M-172	M-174	M-180	Mean
T_1	95.83	89.17	93.67	92.89	2.94	1.47	1.20	1.87
T_2	94.17	88.33	90.00	90.83	8.72	7.24	9.01	8.33
T_3	87.83	87.08	95.83	90.25	5.63	5.45	9.28	6.78
T_4	87.50	92.22	95.00	91.57	2.83	3.87	5.42	4.04
T_5	95.00	95.00	89.33	93.11	6.56	8.31	8.95	7.94
T_6	97.50	89.00	94.72	93.74	9.34	9.93	10.04	9.77
T_7	83.89	85.00	86.67	85.19	0.82	0.93	2.34	1.36
T_8	94.30	88.89	86.67	90.02	7.34	8.56	9.84	8.58
T_9	90.00	88.33	92.50	90.28	8.22	5.11	10.20	7.85
Mean	91.80	89.23	91.60	90.88	5.82	5.65	7.36	6.28

Wine yield
CD (P=0.05) for comparison of strains – NS
CD (P=0.05) for comparison of treatments – NS
CD (P=0.05) for comparison of treatments within strains –NS

Alcohol strength
CD (P=0.05) for comparison of strains – 0.54
CD (P=0.05) for comparison of treatments – 0.94
CD (P=0.05) for comparison of treatments within strains – 1.62

T_1 - cashew apple juice + starter culture (5%) + anaerobic condition + ambient environment.
T_2 - cashew apple juice + starter culture (5%) + cane sugar to raise TSS to 20^0 brix + anaerobic condition + ambient environment.
T_3 - cashew apple juice + starter culture (5%) + jaggery to raise TSS to 20^0 brix + anaerobic condition + ambient environment.
T_4 - cashew apple juice + starter culture (10%) + anaerobic condition + ambient environment.
T_5 - cashew apple juice + starter culture (10%) + cane sugar to raise TSS to 20^0 brix + anaerobic condition + ambient environment.
T_6 - cashew apple juice + starter culture (10%) + jaggery to raise TSS to 20^0 brix + anaerobic condition + ambient environment.
T_7 - cashew apple juice + starter culture (10%) + fermentation in china clay jar.
T_8 - cashew apple juice + starter culture (10%) + cane sugar to raise TSS to 20^0 brix + fermentation in china clay jar.
T_9 - cashew apple juice + starter culture (10%) + jaggery to raise TSS to 20^0 brix + fermentation in china clay jar.

4.1.2.3 Alcohol strength

The alcohol contents in the nine treatments, using the three strains ranged from 0.82 to 10.20 per cent as indicated in Table 1.

The wine yeast strains as well as the treatments differed significantly from each other with respect to the alcohol strength. The wine yeast strain, MTCC 180 was superior to the other two strains in production of alcohol in case of all the treatments. Production of highest alcohol by the strain, (10.20 per cent) was obtained from T_9 and the treatments T_3, T_6 and T_8 were on par with it.

With regard to alcohol production, the strains, MTCC 172 and MTCC 174 did not differ significantly from each other. Between the treatments both these strains produced maximum alcohol in T_6. The least alcohol of 0.82 per cent and 0.93 per cent was recorded by strains MTCC 172 and MTCC 174 respectively from T_7. The treatments, T_2, T_5 and T_8 had alcohol content on par with each other in case of all the three strains, but the alcohol content in these was significantly less than that produced from T_6. In all three strains, the minimum alcohol production was from treatments T_1, T_4 and T_7.

4.1.2.4 pH

Between treatments, the pH of the wines differed significantly, while that between strains showed no significant difference. The highest pH of 4.23 was recorded for T_3. The pH of the wines from T_1, T_2, T_4, T_5, T_6, T_8 and T_9 were on par with each other and ranged from 3.51 to 3.70 as indicated in Table 2. However, the wine from T_7 recorded the least pH of 3.21.

4.1.2.5 Titrable acidity

The results of the titrable acidity obtained in the wines are presented in Table 2.

Table 2. Effect of strains of wine yeast on pH and acidity of cashew apple wine.

Composition of cuvee	Strains of wine yeast							
	pH				Acidity(%)			
	M-172	M-174	M-180	Mean	M-172	M-174	M-180	Mean
T_1	3.83	3.70	3.47	3.67	0.24	0.31	0.33	0.29
T_2	3.53	3.30	3.90	3.58	0.93	1.02	0.27	0.74
T_3	4.37	4.10	4.23	4.23	0.28	0.25	0.35	0.29
T_4	3.47	3.83	3.80	3.70	0.54	0.43	0.37	0.45
T_5	3.63	3.70	3.67	3.67	0.64	0.44	0.33	0.47
T_6	3.80	3.73	3.43	6.66	0.47	0.55	0.37	0.46
T_7	3.03	3.17	3.43	3.21	0.39	1.73	1.45	1.85
T_8	3.63	3.63	3.77	3.38	0.57	0.50	0.44	0.50
T_9	3.40	3.63	3.50	3.51	1.55	0.91	0.75	1.07
Mean	3.63	3.64	3.69	3.67	0.85	0.68	0.52	0.68

pH

CD (P=0.05) for comparison of strains – NS
CD (P=0.05) for comparison of treatments – 0.20
CD (P=0.05) for comparison of treatments within strains – 0.35

Titrable acidity

CD (P=0.05) for comparison of strains – 0.14
CD (P=0.05) for comparison of treatments – 0.24
CD (P=0.05) for comparison of treatments within strains – 0.41

Significant difference with respect to strains, composition of cuvee and their interaction was recorded with regard to acidity of cashew apple wine. Strain, MTCC 172 recorded the highest mean acidity of 0.85 per cent and the least by MTCC 180 (0.52 per cent).

Among treatments, T_7 recorded the highest mean acidity of 1.85 per cent, while the least was in case of T_1 which was found to be on par with T_3, T_4, T_5, T_6 and T_8.

All three strains recorded the highest acidity in T_7. The least acidity in case of MTCC 172 was noted from T_1, which was found to be on par with T_3 and T_6. The strain, MTCC 174 recorded the least acidity in T_3 and was on par with T_1, T_4 and T_5. Wines produced using MTCC180 showed low acidity in treatments T_1, T_2, T_3, T_4, T_5, T_6 and T_8 and were on par with each other.

4.1.2.6 TSS

The TSS content of the cashew apple wine differed significantly between strains, treatments and also between treatments within strains as indicated in Table 3. The highest mean TSS of 7.78^0 brix, between strains was noted in case of MTCC 172, while the least of 5.38^0 brix in MTCC180.

Between treatments, T_3 recorded the highest mean acidity of 9.67^0 brix, which was on par with T_9. The least TSS was in T_1, which did not differ significantly from T_4.

For strain MTCC 180, treatments T_2, T_3, T_5, T_6, T_8 and T_9 were on par with each other having high TSS. The treatments T_1, T_4 and T_7 recorded a comparatively lower TSS.

Similarly, strain MTCC 172 showed high TSS content in wines where nutrient supplements were given to the cashew juice, except in case of T_8, where a

Table 3. Effect of strains of wine yeast on TSS and brix-acid ratio of cashew apple wine.

Composition of cuvee	Strains of wine yeast							
	TSS(^{0} brix)				Brix-acid ratio			
	M-172	M-174	M-180	Mean	M-172	M-174	M-180	Mean
T_1	3.13	3.47	2.40	3.00	12.95	11.18	7.29	10.47
T_2	9.17	9.13	5.87	8.06	9.92	9.13	23.61	14.22
T_3	11.73	10.33	6.93	9.67	4.45	42.89	19.89	34.74
T_4	3.20	3.33	3.10	3.21	5.95	7.71	9.88	7.85
T_5	9.57	7.60	6.87	8.01	15.42	15.39	21.04	17.28
T_6	10.47	6.07	6.40	7.64	24.39	13.19	17.56	18.38
T_7	6.00	4.53	4.00	4.84	2.55	3.04	2.76	2.78
T_8	5.87	8.07	6.00	6.64	10.36	16.17	13.82	13.45
T_9	10.87	10.00	6.87	9.24	7.03	10.99	9.24	9.09
Mean	7.78	6.95	5.38	6.70	14.45	14.41	13.90	14.25

TSS

CD (P=0.05) for comparison of strains – 0.40
CD (P=0.05) for comparison of treatments – 0.70
CD (P=0.05) for comparison of treatments within strains – 1.21

Brix-acid ratio

CD (P=0.05) for comparison of strains – NS
CD (P=0.05) for comparison of treatments – 3.78
CD (P=0.05) for comparison of treatments within strains – 6.54

comparative low TSS of 5.87^0 brix was recorded. T_1 and T_4 recorded a low TSS, but T_7 showed a comparative higher TSS of 6.00^0 brix.

For strain MTCC 174, T_1, T_4 and T_7 showed least TSS content in wine ranging from 3.33 to 4.53^{0}brix, while the highest was in T_3 (10.33^0 brix), being on par with T_2 and T_9.

4.1.2.7 Brix-acid ratio

The brix-acid ratio of the cashew apple wine varied significantly between treatments as well as between treatments within strains (Table 3). However, between strains no difference was observed statistically.

Among treatments, T_3 was the best with the highest ratio of 34.74. T_5 and T_6 were the next best with ratios of 17.28 and 18.38 respectively and they were on par with each other. T_7 had the least ratio of 2.78.

On comparing treatments within strains, wine prepared using MTCC 174 in T_3 recorded the highest ratio and was on par with that of T_3 using MTCC 172. In this treatment, MTCC 180 produced wine of low brix-acid ratio of 19.89. In case of T_2, MTCC 180 was superior with ratio of 23.61 compared to the other two strains. The other treatments did not show a marked difference within the three strains.

4.1.2.8 Reducing sugars

As observed in Table 4, the reducing sugar content did not differ significantly between the strains and also between treatments within strains. However, between treatments alone, there was a significant difference.

Treatments T_2 and T_9 were on par with each other and showed higher reducing sugar content of 3.68 and 3.20 per cent respectively. The treatments T_3,

Table 4. Effect of strains of wine yeast on reducing and total sugar content of cashew apple wine.

Composition of cuvee	Strains of wine yeast							
	Reducing sugars(%)				Total sugars(%)			
	M-172	M-174	M-180	Mean	M-172	M-174	M-180	Mean
T_1	1.05	1.07	1.23	1.11	2.69	3.25	3.28	3.07
T_2	3.74	3.53	3.79	3.68	11.39	7.98	6.33	8.57
T_3	1.27	2.78	1.42	1.83	8.35	9.99	8.26	8.86
T_4	1.83	1.36	1.15	1.45	2.84	3.24	1.90	2.66
T_5	2.13	2.99	1.75	2.29	4.10	6.45	6.92	5.82
T_6	2.54	1.92	2.21	2.23	12.48	7.93	8.94	9.79
T_7	2.77	1.36	1.14	1.76	8.72	2.81	3.72	5.08
T_8	2.57	3.29	1.38	2.41	6.22	8.44	5.25	6.64
T_9	4.98	1.94	2.68	3.20	14.52	10.17	10.29	11.66
Mean	2.54	2.25	1.86	2.22	7.92	6.70	6.10	6.91

Reducing sugars

CD (P=0.05) for comparison of strains – NS
CD (P=0.05) for comparison of treatments – 0.97
CD (P=0.05) for comparison of treatments within strains - NS

Total sugars

CD (P=0.05) for comparison of strains – 1.39
CD (P=0.05) for comparison of treatments – 2.40
CD (P=0.05) for comparison of treatments within strains – NS

T_4, T_5, T_6, T_7 and T_8 were on par with each other and were better than T_1, which recorded the least reducing content of 1.11 per cent.

4.1.2.9 Total sugars

The total sugar content differed significantly between the strains as well as treatments, but the treatments within strains showed no significant difference as indicated in Table 4. Between strains, the highest content of total sugars (7.92 per cent) was from wine obtained using MTCC 172 and least was from MTCC 180. MTCC 174 was on par with MTCC 172 in this regard.

Between treatments T_9 recorded a high content of 11.66 per cent and was on par with T_6, both of which had jaggery supplemented. The treatments T_2, T_3 and T_8 were on par with each other and were superior to T_1, T_4 and T_7, which recorded low total sugars as no nutrient was added in the latter three.

4.1.3 Sensory evaluation

There was no significant difference between the three strains in most of the sensory attributes of the cashew apple wine, in case of all the three treatments evaluated, except in case of aroma and overall acceptability of the wine (Table 5).

Wine obtained from treatment, T_3 (using jaggery as ameliorant) and strain, MTCC 172 had better aroma than the wines of the other two strains and recorded the highest score, while that prepared using MTCC 174 recorded the least.

For the overall acceptability, a significant difference was noted in case of T_2 (using sugar as an ameliorant), where the wine from MTCC 172 was superior to the other two, both of which recorded the same score.

Hence, with regard to sensory quality as pursued by the panelists, the strain MTCC 172 was observed to be superior to strains MTCC 174 and MTCC

Table 5. Effect of strains of wine yeast on sensory quality of cashew apple wine.

Sensory attributes	Strains of wine yeast											
	T_1				T_2				T_3			
	M-172	M-174	M-180	H-st.	M-172	M-174	M-180	H-st.	M-172	M-174	M-180	H-st.
Colour	32.5	46.5	41.0	0.98	41.5	51.5	27.0	3.04	42.5	42.5	35.0	0.38
Aroma	27.5	50.0	42.5	2.63	44.5	46.0	31.0	2.57	49.5	33.5	46.0	8.89*
Taste	42.5	42.5	35.0	0.38	39.0	42.0	39.0	0.06	35.5	35.5	40.0	0.01
Flavour	37.5	45.0	37.5	0.38	45.5	24.5	50.0	3.71	32.0	43.0	45.0	0.98
Astringency	34.5	46.0	39.5	0.67	42.5	37.5	40.0	0.13	42.5	38.0	39.5	0.11
Sugar-acid	40.5	40.3	40.5	1.05	39.5	32.5	48.0	1.21	42.0	42.0	36.0	0.24
Alcohol	43.0	38.5	38.5	0.14	45.0	40.5	33.0	0.01	41.5	37.0	41.5	0.14
Overall acceptability	45.5	45.5	29.0	1.82	56.0	35.0	35.0	7.86*	44.5	41.0	34.5	0.52

* - significant at 5% level

H-st – Kruskal Wallace H-statistic value

T_1 - cashew apple wine prepared without any ameliorant added to the juice
T_2 - cashew apple wine prepared by addition of cane sugar to the juice
T_3 - cashew apple wine prepared by addition of jaggery to the juice

Plate 2.

A – cashew apple juice + 5ml starter culture
B – cashew apple juice + cane sugar + 5ml starter culture
C - cashew apple juice + jaggery + 5ml starter culture
D - cashew apple juice + 10ml starter culture
E - cashew apple juice + cane sugar + 10ml starter culture
F - cashew apple juice + jaggery + 10ml starter culture
G - cashew apple juice + 10ml starter culture + fermentation in china clay jar
H - cashew apple juice + cane sugar + 10ml starter culture + fermentation in china clay jar
I - cashew apple juice + jaggery + 10ml starter culture + fermentation in china clay jar

Plate 2. Wines prepared using yeast strain MTCC 180, as influenced by ameliorants and strength of starter culture.

180 in cashew apple wine making. On the other hand, the biochemical analysis revealed that strain MTCC 180 was more effective in wine preparation.

4.2 Effect of treatments on the yield and quality of cashew apple wine.

The results of the physical, biochemical and sensory evaluation are presented in Table 6 and 7.

4.2.1 Physio-chemical properties of cashew apple juice

4.2.1.1 Weight of cashew apples and juice recovery percentage

The weight of cashew apples and recovery of juice after the seven pre-treatments expressed as a percentage are presented in Table 6. The treatments did not differ significantly in their juice recovery, which ranged from 54.72 to 56.75 per cent. However, the highest recovery was from T_5 (soaking cashew apples in hot lye before juice extraction).

4.2.1.2 Clarified juice recovery percentage

A significant difference in the juice recovery percentage obtained after clarification was recorded between the treatments. The highest yield of 87.06 per cent was obtained in T_6, while the least recovery of clarified juice (70.88 per cent) was recorded from T_7. All the treatments T_2, T_3, T_4 and T_5 were on par with T_6 and the control (Table 6).

4.2.1.3 TSS of fresh juice

The TSS of the fresh juice did not show a significant difference between any of the treatments and they were on par with each other. The TSS ranged from 12.40^0 brix to 13.67^0 brix. (Table 6).

Plate 3.

1 – Control (no clarifying agent)
2 – Rice gruel
3 – Pectin
4 – Gelatin
5 – Poly vinyl pyrrolidone (PVP)

Plate 4.

A – ripe cashew apple washed in 200ppm KMS solution before juice extraction and clarified using rice gruel.
B – soaking cashew apples in hot water 60^0C for five minutes before juice extraction and clarified using rice gruel.
C – treating juice clarified with rice gruel with 200mg of KMS per litre before adding starter culture.
D – cashew apple juice clarified with gelatin.
E – soaking cashew apples in hot lye (0.2% sodium bicarbonate solution) for three minutes before juice extraction and clarified using rice gruel.
F – cashew apple juice clarified with pectin.
G – cashew apple juice clarified with 0.4% PVP and later treated with 200mg KMS per litre of juice.

Plate 5.

A – Kanaka
B – Dhana
C – Dharasree
D – Priyanka
E – Amrutha
F – Madakkathara-1
G – Madakkathara-2

Plate 3. Effect of clarifying agents on clarification of cashew apple juice.

Plate 4. Effect of pre-treatments and clarifying agents on cashew apple wine.

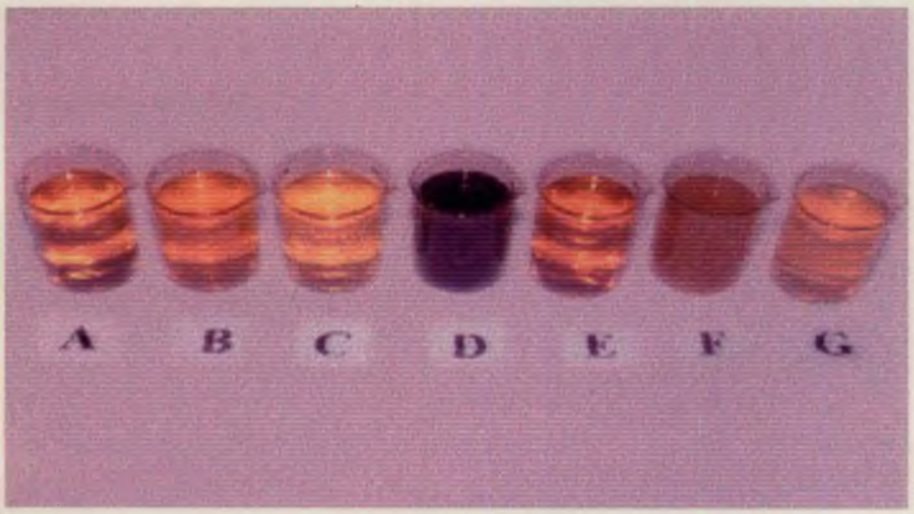


Plate 5. Cashew apple wine prepared from different varieties.

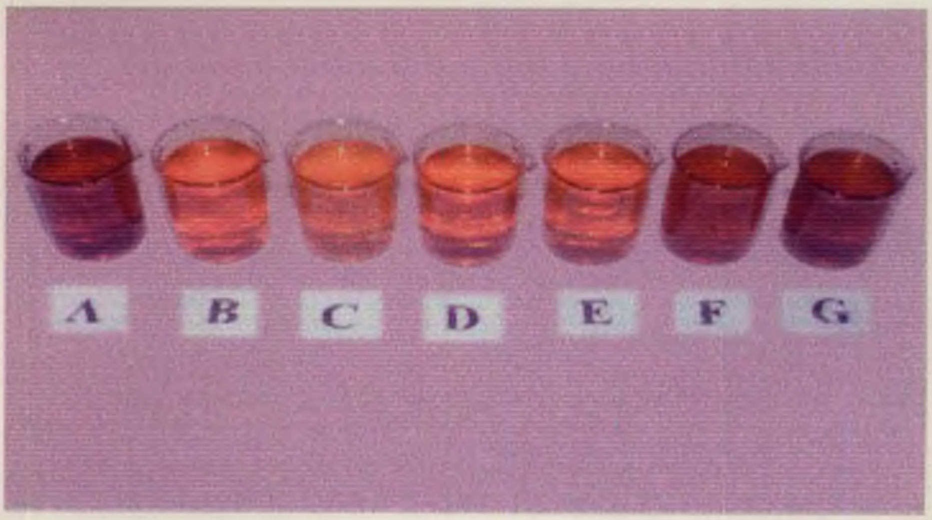


Table 6. Effect of pre-treatments on recovery percentage and TSS of fresh and clarified juice.

Treatments	Juice recovery(%)		TSS(° brix)		
	Fresh	Clarified	Fresh	Clarified	TSS decr.
T_1	54.72	82.95	13.20	11.67	1.53
T_2	55.28	85.90	13.67	11.80	1.87
T_3	55.97	82.64	13.47	11.20	2.27
T_4	56.39	81.86	13.47	12.40	1.07
T_5	56.75	83.37	13.53	11.53	2.00
T_6	55.33	87.06	12.40	1193.	0.47
T_7	55.33	70.68	13.07	11.67	1.40
Mean	55.68	82.07	13.26	11.74	1.51
CD (p=0.05)	NS	7.60	NS	NS	0.88

NS – not significant at 5% level

T_1 - Ripe cashew apples washed in 200 ppm KMS solution before juice extraction and clarified using rice gruel (control).

T_2 - Soaking cashew apples in hot water 600C for five minutes before juice extraction and clarified using rice gruel.

T_3 - Treating juice clarified using rice gruel with 200mg of KMS per litre before adding starter culture.

T_4 - Cashew apple juice clarified with gelatin (1.0%).

T_5 - Soaking cashew apples in hot lye (0.2% sodium bicarbonate solution) for three minutes before juice extraction and clarified using rice gruel.

T_6 - Cashew apple juice clarified with pectin (0.5%).

T_7 - Cashew apple juice clarified with 0.4% PVP and later treated with 200mg KMS per litre of juice.

4.2.1.4 TSS of clarified juice

There was a significant difference in the decrease in TSS of clarified juice as compared to that of the fresh juice (Table 6). The maximum reduction in TSS of 2.27^0 brix was observed in T_3 (using rice gruel for clarification) and was on par with T_1, T_2, T_5 and T_7 of which the three treatments except T_7 were clarified using rice gruel. T_7 was juice clarified using PVP. T_6 (pectin clarified juice) recorded a low decrease in TSS of only 0.47^0 brix. This treatment was found to be on par with T_4 (gelatin clarified juice).

4.2.1.5 pH

The pH of the clarified juice was found to remain unchanged from that of the fresh juice even after clarification. The pH ranged from 4.1 to 4.4.

4.2.2 Physio-chemical attributes of cashew apple wine

The results of the physio-chemical parameters of the wines prepared using the seven treatments are presented in Table 7.

4.2.2.1 Wine yield

The quantity of wine obtained on adopting the seven treatments did not differ significantly.

4.2.2.2 Alcohol strength

All the wines differed significantly with regard to their alcohol strength (Table 7). The highest alcohol content of 10.95 per cent was obtained from T_7. The treatments T_3, T_4 and T_5 were on par with T_7. T_2 had the least alcohol strength of 8.40 per cent.

Table 7. Effect of pre-treatments on physio-chemical attributes of cashew apple wine.

Treat-ments	Wine yield (%)	Alcohol Strength (%)	pH	TSS (^{0}brix)	Titrable acidity (%)	Brix-acid ratio	Reducing sugar (%)	Total sugar (%)
T_1	92.43	9.11	3.73	6.60	0.54	12.15	0.24	0.48
T_2	89.20	8.40	3.83	6.13	0.43	14.18	0.26	0.50
T_3	90.53	10.91	3.67	6.13	0.44	13.96	0.21	0.40
T_4	86.13	10.31	3.83	6.27	0.55	13.30	0.22	0.41
T_5	93.63	10.34	3.63	6.27	0.47	13.24	0.21	0.45
T_6	86.20	9.51	3.53	7.00	0.63	11.22	0.27	0.49
T_7	90.53	10.95	3.73	6.80	0.47	14.37	0.22	0.43
Mean	89.81	9.93	3.71	6.60	0.51	13.20	0.23	0.45
CD (p=0.05)	NS	0.76	0.12	0.46	0.06	1.34	NS	NS

NS – not significant at 5% level

Table 8. Effect of pre-treatments on sensory quality of cashew apple wine.

Treat-ments	Sensory attributes (mean score value)							
	Colour	Aroma	Taste	Flavour	Astrin-gency	Sugar -acid	Alcohol strength	Overall accept.
T_1	29.70	36.65	45.42	43.30	42.75	34.65	38.30	43.45
T_2	38.20	37.60	37.38	36.90	19.45	29.75	36.80	35.95
T_3	40.40	36.65	34.56	46.10	38.75	36.90	35.50	44.60
T_4	61.50	51.80	50.10	52.50	46.35	44.05	40.70	52.20
T_5	40.45	31.75	32.91	26.20	30.65	34.65	33.10	36.95
T_6	11.80	14.25	12.75	14.90	34.75	25.25	31.20	10.25
T_7	26.45	38.15	31.38	28.60	42.75	25.25	32.90	25.10
H-st. value	*139.89	*112.96	*70.30	*126.56	*126.07	*58.23	*93.62	*131.74

* - significant at 5% level

H-st. value – Kruskal Wallace H-statistic value

4.2.2.3 pH

The pH of the wines differed significantly between the treatments (Table 7). The wines prepared from T_2, T_3, T_4, T_7 and control did not differ significantly among themselves and recorded higher pH. The least pH of 3.53 was recorded from T_6.

4.2.2.4 TSS

The TSS content of the wines differed significantly between the treatments (Table 7). T_4 (gelatin clarified juice) resulted in the highest TSS content in the wine (7.27^0 brix). T_6 and T_7 were on par with T_4. The treatments T_2, T_3 and T_5 were on par with the control and the TSS in these ranged from 6.13 to 6.60^0 brix.

4.2.2.5 Titrable acidity

A significant difference in the titrable acidity content between the treatments was observed (Table 7). The highest acidity was in the wine prepared fromT_6, while the least was in case of T_2. The acidity ranged from 0.43 to 0.63%. T_4 had the second highest acidity and was on par with the control. The treatments T_2, T_3, T_5 and T_7 were on par with each other and had comparatively lesser acidity.

4.2.2.6 Brix-acid ratio

The wines differed significantly in their brix-acid ratio (Table 7). T_7 had the highest ratio of 14.37 and T_2, T_3, T_4 and T_5 were found to be on par with it. The least brix-acid ratio was recorded in T_6, which was on par with the control.

4.2.2.7 Reducing sugars

The wines did not vary significantly in their reducing sugar content between treatments (Table 7).

4.2.2.8 Total sugars

No significant difference in total sugars of the wines from the seven treatments was noted. The total sugars ranged from 0.40 to 0.49% (Table 7).

4.2.3 Sensory evaluation

The wines were evaluated with respect to colour and appearance, aroma, taste, flavour, astringency, sugar acid blend, alcohol content and their overall acceptability by a panel of ten experienced judges. The mean rank scores obtained by the wines and Kruskal Wallace H-statistic of each treatment is presented in Table 8.

The wines differed significantly between the treatments with respect to all the sensory qualities. The wine prepared from T_4 (gelatin clarified juice), obtained the highest scores for all the parameters, while that from T_6 (pectin clarified juice), had least scores for colour and appearance, aroma, taste, flavour, sugar acid blend, alcohol content and overall acceptability.

A high score for astringency secured by T_4 indicated that it was the least astringent wine. However the highest astringency was recorded from T_2.

For the overall acceptability, T_4 obtained a high score of 52.20, while the least acceptable was the wine from T_6 with a low score of 10.25.

The colour and appearance as well as aroma of T_4 recorded scores of 61.50 and 51.80 respectively. This wine was superior to all other wines obtained through various treatments, in this regard. The treatment T_6 obtained a very poor score of 11.80 for its colour and appearance and 14.25 for aroma.

The taste of wine from T_4 was appreciated the most compared to the other wines. The scores ranged from 12.75 to 50.10. T_6 yielded wines of the poorest taste and secured a score of 12.75.

The highest score of 52.50 for flavour was attained by T_4, while the wine from T_6 had poor flavour and a low score of 14.90.

The sugar acid blend was best in T_4 having a score of 44.05. T_6 and T_7 produced wines that scored the least for sugar acid blend with 25.25.

The highest score of 40.70 for alcohol content was recorded by T_4, but T_6 had a low alcohol content and secured a score of 31.20.

Hence, from the results it was found that T_4 was superior to all other treatments, while T_6 produced wines of very poor sensory quality.

4.2.4 Varietal suitability for wine making

The results of the physio-chemical properties of the cashew apple wines prepared using seven varieties viz., Madakkathara-1, Madakkathara-2, Dharasree, Priyanka, Dhana, Kanaka and Amrutha are presented in Table 9.

4.2.4.1 Physio-chemical parameters of cashew apple wine.

4.2.4.1.1 Wine yield

The wine yield from the seven varieties tried, did not differ significantly and their yield ranged from 92.45 to 96.24 per cent.

4.2.4.1.2 Alcohol strength

Significant difference in the alcohol strength of the wines from different varieties was noted. Madakkathara-1 recorded the highest alcohol of 12.54 per cent. The varieties Madakkathara-2, Dharasree, Dhana and Kanaka had alcohol contents on par with each other and were the next best. Priyanka produced wine of poorest alcohol strength (8.33 per cent).

4.2.4.1.3 pH

With regard to the pH of the wines, there was a significant difference between the varieties used. The highest pH of 3.90 was recorded in the variety, Amrutha, while the least pH was noted in the variety, Kanaka, i.e. 3.43. The pH of Dharasree was on par with Amrutha. The pH of Madakkathara-2, Priyanka and Dhana were on par with each other and ranged from 3.67 to 3.73.

4.2.4.1.4 Titrable acidity

A significant difference in the acidity of wines prepared from seven varieties was recorded. The highest acidity of 0.65 per cent was observed for wine from Kanaka, while the least acidity (0.47 per cent) was for that from Priyanka.

4.2.4.1.5 TSS

The TSS content of the wines varied significantly between the varieties. The TSS retained in wine prepared from Madakkathara-1 was the highest (7.67^0 brix). The TSS of wines from Madakkathara-2, Dhana and Amrutha were on par with each other and had values of 6.93, 7.07 and 7.13^0 brix respectively. The TSS of wine from Kanaka was the least with 6.07^0 brix.

4.2.4.1.6 Brix-acid ratio

Dhana recorded the highest brix-acid ratio of 15.15 and was superior to the other varieties in this regard. This character in the case of Dharasree, Madakkathara-1, and Priyanka were the next best ranging from 13.06 to 13.52. The wine from Amrutha, however, had a poor brix-acid ratio of 10.92 and was found to be on par with Kanaka, having a ratio of 11.30.

4.2.4.1.7 Reducing sugars

The reducing sugars of the varieties ranged from 0.20 to 0.35 per cent. The varieties Dhana and Dharasree showed a comparative high content of 0.35 per

Table 9. Effect of varieties on the physico-chemical properties of cashew apple wine.

Varieties	Physico-chemical attributes							
	Wine yield (%)	Alcohol Strength (%)	pH	TSS (^{0}brix)	Titrable acidity (%)	Brix-acid ratio	Reducing sugar (%)	Total sugar (%)
MDKA-1	93.94	12.54	3.63	7.67	0.58	13.23	0.27	0.44
MDKA-2	92.45	11.38	3.67	6.93	0.56	12.32	0.20	0.35
Dharasree	92.48	10.54	3.87	6.40	0.54	13.52	0.35	0.48
Priyanka	96.25	8.66	3.73	6.27	0.47	13.06	0.21	0.39
Dhana	95.59	11.07	3.70	7.07	0.47	15.15	0.35	0.49
Kanaka	95.09	10.46	3.43	6.07	0.65	11.30	0.21	0.32
Amrutha	94.98	10.24	3.90	7.13	0.48	10.92	0.20	0.39
Mean	94.40	10.70	3.70	6.79	0.54	12.79	0.26	0.41
CD (p=0.05)	NS	0.97	0.09	0.27	0.03	0.76	0.03	NS

NS – not significant at 5% level
MDKA-1 – Madakkathara-1
MDKA-2 – Madakkathara-2

Table 10. Effect of varieties on quality of cashew apple wine.

Varieties	Sensory attributes (mean score value)							
	Colour	Aroma	Taste	Flav-our	Astrin-gency	Sugar acid	Alcohol strength	Overall accept.
MDKA-1	34.45	31.55	36.75	39.40	37.25	38.40	35.27	43.30
MDKA-2	27.60	22.25	40.65	26.82	31.40	38.40	37.66	41.35
Dharasree	30.25	43.40	33.45	37.18	30.25	34.00	32.36	25.90
Priyanka	39.30	35.60	43.15	36.21	33.25	38.30	32.17	35.90
Dhana	29.45	40.25	36.90	39.29	49.30	39.20	35.46	36.35
Kanaka	54.00	39.45	26.10	30.57	31.15	29.20	37.47	34.80
Amrutha	33.45	29.20	26.10	28.92	35.86	31.00	33.07	30.90
H-st. value	*108.14	*86.06	*87.36	*72.58	*100.22	*94.75	*80.28	*98.52

* - significant at 5% level

H-st. value – Kruskal Wallace H-statistic value cent. The varieties Madakkathara-2, Priyanka, Kanaka and Amrutha had lower contents and did not differ significantly from each other.

4.2.4.1.8 Total sugars

There was no significant difference in the total sugar content of the wines from different varieties.

4.2.4.2 Sensory Evaluation

The varieties differed significantly in quality of wines as per sensory evaluation. However, no variety was found superior to the others, when considering all the parameters (Table 10).

For the overall acceptability of the wine, Madakkathara-1 scored the highest with 43.30. The variety Dharasree gave wine of poor acceptability and scored the least, with a mean of 25.90.

The scores for colour and appearance of wine ranged from 27.60 to 54.00. Kanaka scored the highest and was superior to the other varieties, while Madakkathara-2 scored the least in this aspect.

The scores for the aroma of the varieties ranged from 22.25 to 43.40. The aroma of Dharasree was found to have scored better than the other varieties while Madakkathara-2 was least acceptable and the score was only 22.25.

The scores for taste ranged from 26.10 to 43.15. Wine from Priyanka was superior to the others with regard to its taste. Kanaka and Amrutha obtained the same score of 26.10 for their taste, which was the least.

The variety, Madakkathara-1 produced wine of better flavour compared to the other varieties tried and acquired a score of 33.40. Flavour of Madakkathara-2 had the least score (28.92).

Dhana had the least astringency with a mean score of 49.30, while Dharasree produced the most astringent wine, having a low mean score of 30.25. The mean scores of the other varieties ranged from 31.15 to 37.25.

Kanaka had the least score for sugar- acid blend i.e. 29.20, while Dhana obtained the highest score of 39.20. The other varieties obtained scores in between this range.

The scores for alcohol content ranged from 32.17 to 37.66. Madakkathara scored the highest, while Priyanka scored the least.

4.3 Comparison of containers and storage environment with respect to quality of cashew apple wine.

Based on biochemical and sensory evaluation, three promising wines from Experiment I were selected and used for further studies. The wines selected were, that obtained using jaggery as ameliorant with 5ml starter culture (ST_1), cane sugar with 10ml starter culture (ST_2) and wine using jaggery with 10ml starter culture (ST_3).

The fresh wines were clarified, pasteurized and then kept for storage in the mentioned containers. During storage, the wines in clay pots showed spoilage symptoms within a week of storage. Similarly, wooden containers (bamboo) also showed microbial growth on the outside of the container after about a month of storage. The wines from these became flat and turbid. Hence both these treatments were discarded and the experiment was preceded with, using six containers.

The results of the comparison of wines kept in six storage containers and three environments with respect to their biochemical characters are presented below.

Plate 6. Containers for storage of cashew apple wine.

4.3.1 Biochemical characters

4.3.1.1 Alcohol strength

The alcohol content of all the wines stored in the various containers and kept in three environments did not show any significant difference as indicated in Table 11. The alcohol contents ranged from 8.06 to 8.75%.

4.3.1.2 pH

The pH of the wines differed significantly with respect to storage containers and environments (Table 11). The wines stored in glass bottles, both coloured and plain as well as that in coloured pet jar and steel container were on par with each other and had a higher pH ranging from 3.77 to 3.86. The pH recorded from china clay jar was the least with a value of 3.58.

Between environments the pH of wines stored under refrigeration were higher and were on par with those kept in open. However, wines kept in dark recorded a lower pH of 3.70.

The comparison of containers within environments also showed significant difference between each other. The highest pH was noted in wine kept in china clay jar in the fridge. This was on par with both types of glass bottles kept in the three environments and also both types of pet jars kept in dark. However, wines kept in pet jars in open storage and under refrigeration had lower pH ranging from 3.70 to 3.73. The pH of wine kept in steel vessel in fridge and dark was on par with the highest pH, while that in the open had a pH of 3.70. The least pH of 3.13 was recorded from china clay jar, kept in dark.

4.3.1.3 TSS

The TSS content of wines between the containers showed significant difference, while a non-significant difference in the storage environments was

Table 11. Effect of storage containers and environments on pH and alcohol strength of cashew apple wine.

Storage Containers	Storage environments							
	pH				Alcohol strength (%)			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	3.87	3.83	3.87	3.86	8.54	8.53	8.49	8.52
SC_2	3.77	3.87	3.83	3.32	8.84	8.63	8.40	8.62
SC_3	3.70	3.73	3.77	3.73	8.63	8.62	8.33	8.53
SC_4	3.73	3.73	3.83	3.77	8.64	8.69	8.43	8.58
SC_5	3.70	3.90	3.13	3.58	8.54	8.44	8.06	8.34
SC_6	3.73	3.87	3.77	3.79	8.75	8.72	8.61	8.69
Mean	3.75	3.82	3.70	3.76	8.66	8.60	8.38	8.55

pH

CD for comparison of storage environment – 0.07
CD for comparison of storage container – 0.09
CD for comparison of storage container within environment – 0.15

Alcohol strength

CD for comparison of storage environment – NS
CD for comparison of storage container – NS
CD for comparison of storage container within environment – NS

SC_1 – glass bottle plain
SC_2 – g lass bottle coloured
SC_3 – pet jar plain
SC_4 – pet jar coloured
SC_5 – China clay jar
SC_6 – Steel container

Table 12. Effect of storage containers and environments on TSS, acidity and brix-acid ratio of cashew apple wine.

Storage Containers	Storage environments											
	TSS (^{0}brix)				Acidity (%)				Brix-acid ratio			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	9.03	9.10	9.03	9.06	0.32	0.34	0.32	0.33	27.95	27.05	28.54	27.84
SC_2	9.13	9.20	9.03	9.12	0.24	0.27	0.23	0.24	38.38	34.56	40.08	37.67
SC_3	9.20	9.17	9.13	9.17	0.27	0.31	0.31	0.29	36.47	31.46	30.65	32.86
SC_4	9.33	9.30	9.37	9.33	0.27	0.28	0.2	0.28	34.15	34.10	33.09	33.78
SC_5	9.03	9.07	9.00	9.03	0.30	0.30	0.30	0.29	30.13	32.94	30.43	31.17
SC_6	9.17	9.20	9.27	9.21	0.34	0.34	0.34	0.32	26.49	33.28	27.27	29.01
Mean	9.15	9.17	9.14	9.15	0.29	0.29	0.30	0.29	32.26	32.23	31.68	32.06

TSS

CD for comparison of storage environment – NS
CD for comparison of storage container – 0.12
CD for comparison of storage container within environment – NS

Titrable acidity

CD for comparison of storage environment – NS
CD for comparison of storage container – 0.03
CD for comparison of storage container within environment – NS

Brix-acid ratio

CD for comparison of storage environment – NS
CD for comparison of storage container – 3.32
CD for comparison of storage container within environment – NS

observed (Table 12). Wines stored in coloured pet jars and steel vessels were on par with each other and possessed higher TSS content. The least TSS was in wine stored in china clay jar with a value of 9.03^0 brix.

4.3.1.4 Titrable acidity

Acidity of wines in the containers differed significantly from each other. But no significant difference in the three environments was observed (Table 12). High acidity was recorded in plain glass bottle (0.33 per cent) and it was on par with wine from steel container. Wines kept in both types of pet jars and china clay jar did not differ significantly from each other. But the wine in coloured glass bottle had a comparatively lower acidity of 0.24 per cent. No significant difference on comparing containers within the environments was recorded.

4.3.1.5 Brix-acid ratio

The brix-acid ratio of wines stored in the three environments showed no significant difference (Table 12). But between the containers, the brix-acid ratio of wines differed significantly. Wine in coloured glass bottle was the best for its brix-acid ratio, while the wines from both types of pet jars and china clay jar were on par with each other and were found to be the next best containers. The least ratio was obtained in plain glass bottle and was on par with the wine stored in steel container.

4.3.1.6 Reducing sugars

All wines had similar content of reducing sugars ranging from 1.90 to 1.98 per cent (Table 13) and did not differ significantly either due to storage in different containers or environments.

Table 13. Effect of storage containers and environments on reducing and total sugars of cashew apple wine.

Storage Containers	**Storage environments**							
	Reducing sugars (%)				**Total sugars (%)**			
	Open	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**
SC_1	1.92	1.95	1.92	1.93	9.49	9.46	9.46	9.47
SC_2	1.90	1.95	1.95	1.93	9.45	9.48	9.46	9.46
SC_3	1.91	1.95	1.94	1.93	9.48	9.44	9.50	9.47
SC_4	1.90	1.95	1.96	1.94	9.53	9.47	9.49	9.50
SC_5	1.95	1.91	1.97	1.94	9.44	9.45	9.44	9.45
SC_6	1.90	1.95	1.98	1.94	9.40	9.52	9.45	9.45
Mean	1.92	1.94	1.95	194	9.47	9.47	9.47	9.47

Reducing and total sugars

CD for comparison of storage environment – NS
CD for comparison of storage container – NS
CD for comparison of storage container within environment – NS

4.3.1.7 Total sugars

Non significant difference in the total sugars of the wines from different containers and kept in three environments was recorded. The amount of total sugars in the wines ranged from 9.40 to 9.53 per cent as in Table 13.

4.3.2 Sensory evaluation

The results of the sensory evaluation carried out by ten experienced judges are given in Tables 14 to 21.

4.3.2.1 Colour and appearance

The fresh wines were compared with those stored under dark, open and refrigerated conditions using T-test (Table 14). A significant difference between the fresh wine and that stored in dark condition for a period of six months, in terms of colour and appearance was noticed. However, storing wines in open and under refrigeration showed no difference from that of the fresh wine.

Comparison of wines stored in different storage containers or environments showed no significant difference among themselves, with respect to their colour and appearance. This was observed in the wines of all the three treatments selected for the storage study.

4.3.2.2 Aroma

The mean scores for aroma obtained by the wines are presented in Table 15. A significant difference between the aroma of fresh wine and that of the wine stored under refrigeration was noticed in case of all three wines studied. However, in ST_2, an improvement in aroma was also indicated from wine stored in dark over the fresh wine.

Table 14. Effect of storage containers and environments on colour and appearance of cashew apple wine in case of three treatments.

Storage Containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	3.78	3.25	4.10	3.71	3.67	3.20	3.78	3.55	3.42	4.40	3.60	3.81
SC_2	3.00	3.25	4.30	3.52	4.67	3.80	4.33	4.27	3.67	3.80	3.00	3.49
SC_3	4.00	2.75	2.70	3.15	1.89	2.20	4.22	2.77	3.25	2.40	3.50	3.05
SC_4	2.78	2.50	3.50	2.93	3.89	3.00	4.00	3.63	3.50	2.60	3.50	3.20
SC_5	3.00	3.33	4.00	3.44	3.56	4.00	3.10	3.55	3.67	4.00	4.40	4.02
SC_6	3.67	3.67	4.30	3.88	3.89	4.30	3.90	4.03	4.00	4.33	3.70	4.01
Mean	3.37	3.13	3.82	3.44	3.60	3.42	3.89	3.63	3.59	3.59	3.62	3.60
Fresh wine				2.89				2.93				2.95
t-value	2.29	1.41	3.72		1.76	1.53	5.33		5.81	1.78	3.53	

t-value – for comparison of fresh and stored wines

T1, T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

Table 15. Effect of storage containers and environments on aroma of cashew apple wine in case of three treatments.

Storage containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**
SC_1	3.44	3.75	3.40	3.53	3.00	3.00	3.22	3.07	3.80	3.00	1.70	2.83
SC_2	2.56	3.25	3.80	3.20	2.89	3.40	3.67	3.32	3.67	3.60	2.90	3.39
SC_3	3.33	3.00	2.50	2.94	2.78	3.20	3.22	3.07	3.25	2.80	3.00	3.02
SC_4	2.89	3.50	3.00	3.13	2.89	3.00	3.33	3.07	2.75	2.60	3.70	3.02
SC_5	3.00	3.67	3.20	3.29	3.38	3.67	2.90	3.32	3.00	2.67	2.90	2.86
SC_6	3.67	3.33	4.00	3.67	3.75	3.00	3.10	3.28	3.67	3.00	3.10	3.26
Mean	3.15	3.42	3.32	3.29	3.12	3.21	3.24	3.19	3.36	3.95	2.88	3.06
Fresh wine				2.79				2.90				2.97
t-value	2.12	*5.72	2.40		1.47	*2.81	*3.09		2.29	*6.53	0.33	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1, T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

On comparing the wines stored in different containers as well as environments, no significant difference with regard to the aroma of wines was observed.

4.3.2.3 Taste

No significant difference in taste of wines between the fresh and those kept under six months storage, except in case of one wine prepared using cane sugar as ameliorant (Table 16). A significant improvement was observed on storing this wine in fridge for a period of six months. In general, a slight increase in the scores was, however, noticed.

The wines prepared using cane sugar as well as jaggery with 10ml starter culture did not differ significantly from each other when kept in the six containers and three environments. However, the wine from ST_1, showed a significant difference in taste between the environments, while no difference with respect to the containers was observed. The taste of this wine when kept in the fridge and dark condition was on par with each other and was also found to be superior to the wine stored in open room. The highest mean score (3.20) was obtained by wine from steel container kept in dark and the least by steel as well as china clay jar kept in open (2.00).

4.3.2.4 Flavour

The flavour of wines did not show any difference between the fresh wines and those under storage as indicated by T-test. A general increment in scores was, however, indicated (Table 17).

The comparison of the containers and environments indicated a significant difference in the flavour of the wine from treatment ST_1, when kept in the three environments, but no difference between containers was noted.

Table 16. Effect of storage containers and environments on taste of cashew apple wine in case of three treatments.

Storage containers	**Storage environments**											
	ST_1				**ST_2**				**ST_3**			
	Open	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**
SC_1	2.78	2.75	3.10	2.88	3.67	2.60	3.78	3.35	3.25	2.40	1.60	2.42
SC_2	2.33	2.75	2.90	2.66	2.11	3.67	2.89	2.89	2.75	1.80	2.40	2.32
SC_3	2.33	3.00	2.00	2.44	2.33	2.80	3.00	2.71	3.00	1.60	2.60	2.40
SC_4	2.33	2.75	2.60	2.56	1.89	2.20	3.83	2.64	2.75	1.40	2.30	2.15
SC_5	1.67	2.67	2.60	2.31	2.25	2.67	1.93	2.28	1.67	2.67	1.93	2.09
SC_6	1.67	2.57	3.20	2.48	2.63	3.33	2.10	2.69	3.00	3.17	2.10	2.76
Mean	2.19	2.75	2.73	2.56	2.48	2.88	2.92	2.76	2.74	2.17	2.16	2.36
Fresh wine				2.48				2.45				2.36
t-value	1.61	*4.50	1.39		0.12	1.95	1.42		1.65	0.68	1.33	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1

CD for comparison of storage environment – 0.49
CD for comparison of storage container – NS

T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

Table 17. Effect of storage containers and environments on flavour of cashew apple wine in case of three treatments.

Storage Containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	2.75	2.50	2.80	2.68	3.11	2.40	3.33	2.95	2.50	2.40	1.80	2.23
SC_2	2.25	2.50	2.90	2.55	2.33	3.20	2.89	2.81	2.75	2.60	3.50	2.95
SC_3	2.00	2.25	2.20	2.15	2.67	2.40	2.67	2.58	2.25	2.00	3.70	2.65
SC_4	2.25	2.25	2.70	2.40	2.00	2.40	3.33	2.58	2.25	1.80	3.50	2.52
SC_5	2.00	2.67	2.60	2.42	2.50	2.67	2.23	2.47	2.33	2.33	2.23	2.30
SC_6	2.00	2.67	3.20	2.62	2.50	3.33	2.40	2.74	2.67	2.57	2.40	2.58
Mean	2.21	2.47	2.73	2.47	2.52	2.73	2.81	2.69	2.46	2.30	2.86	2.54
Fresh wine				2.41				2.43				2.48
t-value	1.67	0.75	2.28		0.60	1.76	2.00		0.22	1.38	1.15	

t-value – for comparison of fresh and stored wines

T1

CD for comparison of storage environment – 0.32
CD for comparison of storage container – NS

T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

For treatment ST_1, the wines stored in dark had highest mean score of 2.73 but were on par with those in refrigerated condition. However, flavour of those stored in open obtained the least mean score of 2.21. Wine from steel container kept in dark scored the highest with a mean of 3.20, whereas the least mean score of 2.00 was secured by wines from plain pet jar, china clay jar and steel container kept in open condition.

The wines from treatments ST_2 and ST_3 showed no significant difference between themselves when stored in different containers and environments.

4.3.2.5 Astringency

There was a reduction in the astringency in case of two wines (ST_1 and ST_2) stored in open condition and in wine from ST_1 stored in fridge over the fresh wines (Table 18). No significant difference between those stored in dark and that of the fresh wines in terms of astringency was noticed.

The astringency of wines stored in containers as well as environments showed no significant difference between each other, for all the three treatments.

4.3.2.6 Sugar-acid blend

The mean scores for the sugar-acid blend obtained by the wines are presented in Table 19.

In wine from treatment ST_1, there was a significant improvement in the sugar-acid blend in all three environments over the fresh wine. The treatment with cane sugar added (ST_2), showed no significant improvement over the fresh wine. In case ST_3, wines stored in fridge were significantly better that the fresh wines.

The wines did not differ significantly in their sugar-acid blend between those stored for six months in the different containers and environments, in case of all three treatments evaluated.

Table 18. Effect of storage containers and environments on astringency of cashew apple wine in case of three treatments.

Storage containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	3.56	4.50	3.20	3.75	4.11	4.00	3.78	3.96	3.33	3.40	4.20	3.64
SC_2	3.33	4.00	3.30	3.54	3.56	4.00	3.22	3.59	3.67	3.00	3.50	3.39
SC_3	3.22	3.75	3.10	3.36	3.44	3.20	3.67	3.44	3.87	2.80	3.70	3.46
SC_4	4.22	4.00	3.80	4.01	3.75	3.20	4.11	3.69	3.67	2.80	3.50	3.32
SC_5	3.90	3.33	3.60	3.61	4.13	3.33	3.10	3.52	3.00	3.87	3.50	3.46
SC_6	3.50	3.87	3.70	3.69	3.38	3.87	2.60	3.28	3.33	3.33	3.30	3.32
Mean	3.62	3.91	3.45	3.66	3.73	3.60	3.41	3.58	3.48	3.20	3.62	3.43
Fresh wine				3.25				3.32				3.35
t-value	*2.47	*4.13	1.67		*3.15	1.75	0.41		1.00	0.88	2.08	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1, T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

Table 19. Effect of storage containers and environments on sugar-acid blend of cashew apple wine in case of three treatments.

Storage containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**
SC_1	1.78	1.75	2.50	2.01	2.89	3.20	3.11	3.07	3.67	2.00	1.80	2.49
SC_2	1.58	2.50	2.40	2.16	1.56	2.40	1.78	1.91	1.67	1.80	1.90	1.79
SC_3	1.89	2.00	1.90	1.93	1.89	1.60	2.56	2.02	1.87	1.80	2.00	1.89
SC_4	2.00	2.25	2.10	2.12	1.67	2.00	3.33	2.33	1.87	1.80	2.10	1.92
SC_5	1.60	2.67	2.20	2.16	1.67	2.67	1.10	1.81	2.33	2.00	1.00	1.78
SC_6	2.10	2.00	2.50	2.20	1.56	1.67	1.50	1.58	2.67	2.00	2.10	2.26
Mean	1.83	2.20	2.27	2.10	1.87	2.26	2.23	2.12	2.35	1.90	1.82	2.02
Fresh wine				1.53				1.61				1.72
t-value	*3.33	*4.79	*7.40		1.24	*2.60	1.89		2.10	*3.60	0.59	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1, T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

4.3.2.7 Alcohol strength

An improvement in alcohol strength was reported by judges in the stored wines over the fresh ones (Table 20). A significant improvement was observed in wine from ST_1, in case of open and dark storage.

The wines of ST_1 differed significantly from each other between the environments, while non-significant difference in case of containers was observed. The wines in dark were superior to those in refrigerated as well as open storage. The wines in these two environments were on par with each other, irrespective of the containers. In ST_1, the score for highest alcohol was secured by wine from china clay jar kept in dark, while the least mean score of 1.67 was from wines in plain pet jar kept in open as well as steel kept in refrigerated storage.

The wines of ST_2 also showed significant difference between the storage environments. The wines stored in dark were superior to both the other environments irrespective of the container, but the wines in open had a low mean score of 1.98. The highest mean score for alcohol strength of 3.22 in case of ST_2 was recorded in plain glass bottle kept in dark, while the least was in case of china clay jar kept in fridge. The wines of ST_2 did not differ significantly with respect to the alcohol strength between containers.

The alcohol strength of wines showed no significant difference between the containers as well as the environments in treatment ST_3.

4.3.2.8 Overall acceptability

A significant improvement in the overall acceptability of wine stored in dark and under refrigeration was observed over the fresh wine in wine from ST_1 (Table 21). However, wines from ST_2 and ST_3 did not show a significant improvement over the fresh wines.

Table 20. Effect of storage containers and environments on alcohol strength of cashew apple wine in case of three treatments.

Storage containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**	**Open**	**Fridge**	**Dark**	**Mean**
SC_1	2.11	2.00	2.20	2.10	1.89	2.00	3.22	2.37	3.00	2.60	1.90	2.50
SC_2	1.89	2.00	2.20	2.03	2.44	2.00	2.89	2.44	3.33	2.80	2.50	2.88
SC_3	1.67	2.25	2.30	2.07	2.22	2.20	2.67	2.36	1.67	2.20	2.30	2.06
SC_4	1.78	2.00	2.40	2.06	1.44	2.20	2.56	2.07	2.00	1.80	2.10	1.97
SC_5	1.90	2.00	2.50	2.13	1.78	1.67	2.40	1.95	2.67	2.00	1.80	2.16
SC_6	1.70	1.67	2.40	1.92	2.11	2.00	2.30	2.14	2.00	2.00	2.30	2.10
Mean	1.84	1.99	2.33	2.05	1.98	2.01	2.67	2.22	2.45	2.33	2.15	2.28
Fresh wine				2.11				2.28				2.01
t-value	*3.86	1.71	*4.40		2.14	*3.38	*2.79		1.63	2.00	1.27	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1
CD for comparison of storage environment – NS
CD for comparison of storage container – NS

T2
CD for comparison of storage environment – 0.36
CD for comparison of storage container – NS

T3
CD for comparison of storage environment – 0.22
CD for comparison of storage container – NS

Table 21. Effect of storage containers and environments on overall acceptability of cashew apple wine in case of three treatments.

Storage containers	Storage environments											
	ST_1				ST_2				ST_3			
	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean	Open	Fridge	Dark	Mean
SC_1	2.78	3.00	3.20	2.99	3.56	2.60	3.88	3.35	3.87	2.60	2.10	2.86
SC_2	2.44	3.00	2.90	2.78	2.44	3.20	3.11	2.92	2.33	1.80	2.40	2.18
SC_3	2.33	2.75	2.30	2.46	2.56	2.80	3.56	2.97	2.25	2.00	3.00	2.42
SC_4	2.67	3.00	2.90	2.86	2.11	2.60	4.00	2.90	2.33	2.00	2.30	2.21
SC_5	3.10	3.00	2.80	2.97	2.44	3.33	2.20	2.66	2.33	2.67	1.70	2.23
SC_6	2.80	3.00	3.00	2.93	2.33	3.67	2.30	2.77	3.33	3.00	2.20	2.84
Mean	2.69	2.96	2.85	2.83	2.58	3.03	3.18	2.93	2.74	2.35	2.28	2.46
Fresh wine				2.43				2.69				2.40
t-value	2.36	*13.25	*3.50		0.52	1.89	1.53		1.21	0.26	0.71	

t-value – for comparison of fresh and stored wines

* - significant at 5% level

T1

CD for comparison of storage environment – NS
CD for comparison of storage container – 0.32

T2 and T3

CD for comparison of storage environment – NS
CD for comparison of storage container – NS

Comparison of the wines between containers and environments showed no significant difference in the overall acceptability of wines from ST_2 and ST_3.

The overall acceptability of wines from ST_1 showed a significant difference between containers, whereas between environments there was no significant difference. The wines from all the environments in plain glass bottle had the highest mean score of 2.99 for its overall acceptability. It was found to be on par with wines kept in coloured glass bottle, coloured pet jar, china clay jar and steel container, except plain pet jar which had a poor overall acceptability.

4.4 Development of cashew apple wine based products.

A. Blended Wines

The best wine sample obtained from Experiment I, after a storage period of six months was selected based on its biochemical as well as sensory quality and used for blending with six other fruit wines of wider acceptability.

This experiment was carried out to improve the acceptability of cashew apple wine. The cashew wine alone was not highly acceptable due to its prominent astringency. In order to mask this taste, blending of wines was done.

Wines were also prepared from grapes, banana, pineapple, mango, jackfruit and gooseberry. These were blended with cashew apple wine and served to a panel of ten judges for its sensory evaluation. The results of the same are presented below (Table 22).

A significant difference in most of the sensory attributes of the blended wines was obtained, as ranked by the panelists. However, in case of aroma as well as alcohol strength no difference was obtained statistically.

The colour and appearance of the blended wines obtained from gooseberry wine was most appreciated by all the panelists. It scored the highest mean of

Table 22. Sensory evaluation of blended wines.

Blended wines	Sensory attributes (mean score value)							
	Colour	Aroma	Taste	Flavour	Astringency	Sugar -acid	Alcohol strength	Overall accept.
BW_1	15.00	24.80	20.10	22.70	25.00	23.50	21.00	22.70
BW_2	15.00	10.70	17.30	12.70	16.40	21.40	19.30	16.90
BW_3	28.00	14.20	20.10	17.70	8.10	8.10	14.50	15.00
BW_4	15.00	17.40	25.70	27.90	27.00	23.50	19.30	22.70
BW_5	7.40	17.40	12.40	15.10	18.60	21.00	13.40	19.80
BW_6	17.75	22.10	27.00	25.30	27.00	23.50	19.30	25.60
BW_7	25.50	19.40	2.60	4.60	3.90	5.00	19.20	3.30
H-st. value	*17.29	7.24	*21.77	*21.32	*26.85	*19.20	2.56	*18.43

* - significant at 5% level

H-st.value - Kruskal Wallace H-statistic value

BW_1 - cashew apple wine + pineapple wine
BW_2 - cashew apple wine + jackfruit wine
BW_3 - cashew apple wine + gooseberry wine
BW_4 - cashew apple wine + banana wine
BW_5 - cashew apple wine + mango wine
BW_6 - cashew apple wine + grape wine
BW_7 - cashew apple wine alone (control)

28.00 and it was closely followed by the control, which scored 25.50 as the mean. The colour of the blended wine involving mango wine was less acceptable to the judges and it scored a mean of only 7.40.

The taste of the blended wines differed significantly from each other, where that from grape tasted the best with a mean score of 27.00. All blended wines were superior to the control, which scored only 2.60. The blended wines from pineapple, gooseberry and banana recorded intermediate scores. However, mango wine did not produce a blended wine of good taste and scored only 12.40.

The flavour of the blended wines was found to be superior to the control, which scored a mean of 4.60. The flavour of blended wine from that of banana wine recorded the best flavour with a mean score of 27.90, closely followed by that from grape wine scoring 25.30.

The astringency of all the blended wines was low as compared to the cashew apple wine alone. Wines blended with banana and grape wines recorded the least astringency with a mean score of 27.00 in both cases, followed by that blended with pineapple wine. The cashew apple wine scored a mean of 3.90. Gooseberry blended wine also retained quite a high astringent taste and scored 8.10.

The sugar-acid blend of all the wines was better that the control, which secured a low mean score of 5.00. However, the wine obtained by blending gooseberry wine did not possess a good sugar-acid blend and it obtained a mean score of only 8.10. The sugar-acid blend in the case of pineapple, banana and grape wines scored the highest mean of 23.50 in all three cases.

The alcohol strength of all the blended wines and the control did not differ significantly from each other.

The overall acceptability of all the blended wines was superior to that of the control. The acceptability of the blended wine using grape wine ranked

Plate 7.

A - cashew apple wine + banana wine
B - cashew apple wine + pineapple wine
C - cashew apple wine + gooseberry wine
D - cashew apple wine + jackfruit wine
E - cashew apple wine + grape wine
F - cashew apple wine + mango wine
G - cashew apple wine alone

Plate 8.

A – cashew apple wine + cashew apple juice
B - cashew apple wine + tender coconut water
C - cashew apple wine + pineapple juice
D - cashew apple wine + orange juice
E - cashew apple wine + grape juice
F - cashew apple wine + tomato juice
G - cashew apple wine + toddy
H - cashew apple wine + mango juice
I - cashew apple wine alone

Table 7. Cashew apple wine blended with other fruit wines.

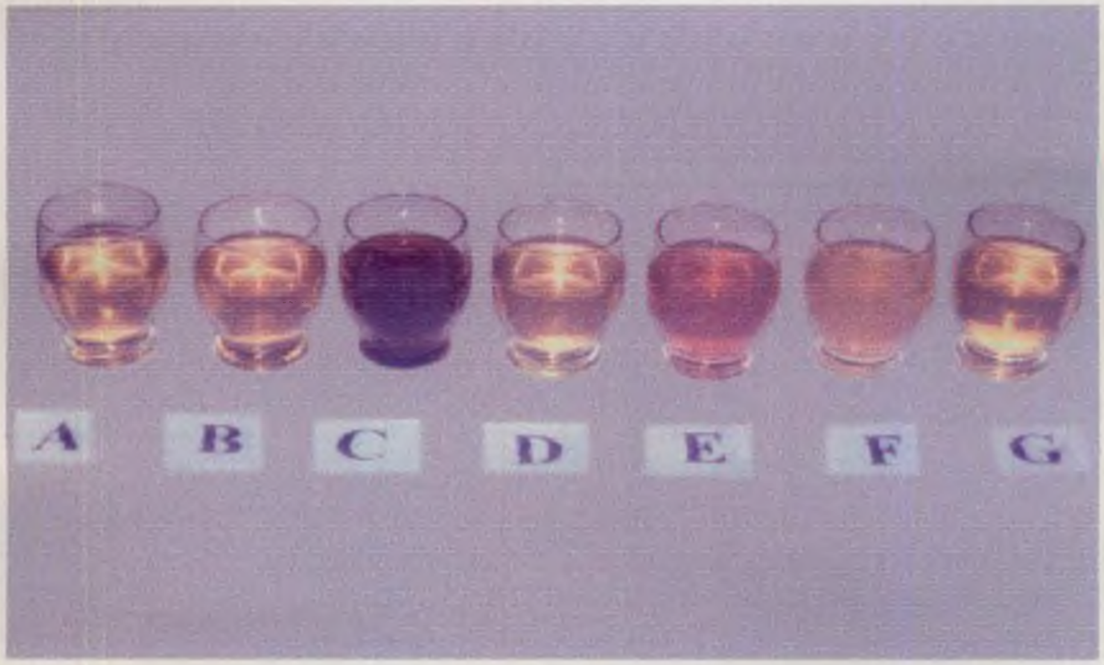
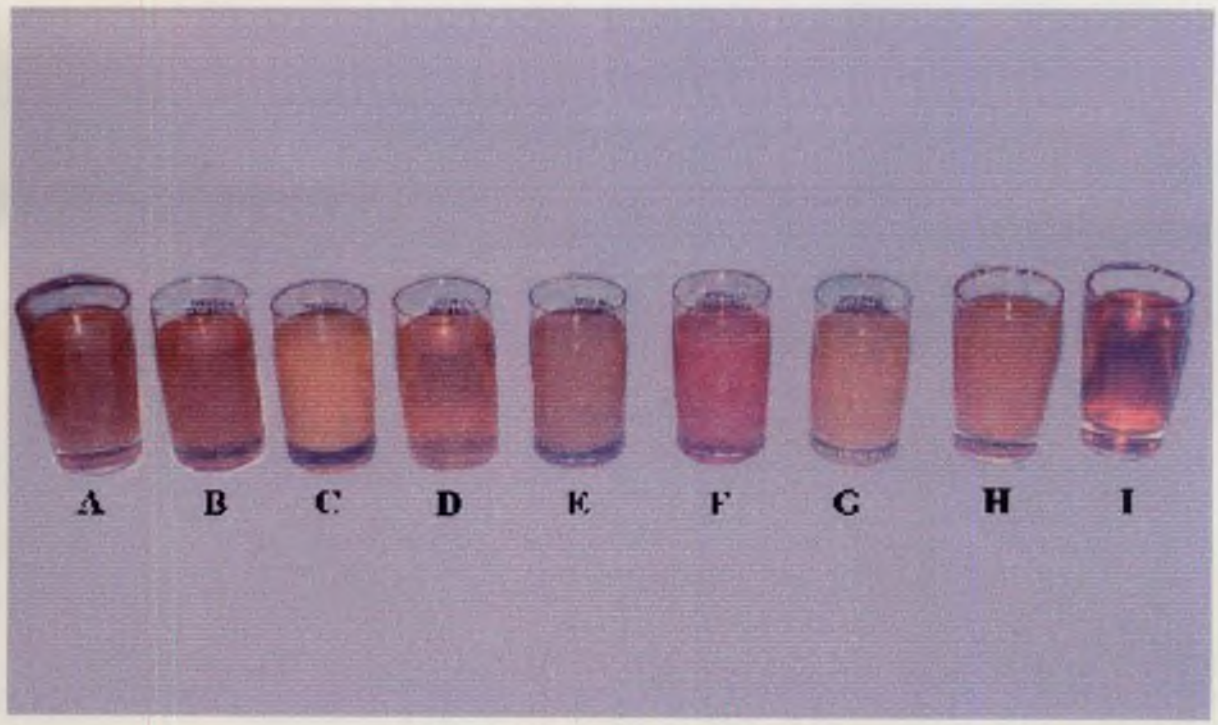


Plate 8. Cashew apple wine blended with fruit juices



superior by the panelists and it scored a mean of 25.60. This was closely followed by blended wines from pineapple and banana, both of which scored 22.70.

In general, it was observed that to some extent mango as well as jackfruit wine did not form a good blend with cashew apple wine as these wines scored comparatively less in most attributes.

B. Wine coolers

This is a latest class of beverages, which includes low alcoholic drinks obtained by mixing grape wines with fruit juices (Ethiraj and Suresh, 1990).

A similar alcoholic drink was prepared in the present investigation by mixing cashew apple wine with fruit juices. The wine coolers were then subjected to sensory evaluation by a panel of ten experienced judges. The results obtained are presented in Table 23.

The wine coolers showed significant difference in all sensory attributes except aroma and alcohol strength as revealed by the Kruskal Wallace test.

No significant difference between the alcohol strength of the coolers was observed. However, the control (cashew apple wine alone), obviously scored the highest in this respect. In the case of aroma of the coolers also, no significant difference was noticed.

In the case of colour and appearance, that of the control was appreciated the most, as it was clear and transparent. It scored the highest mean of 39.00. All the other samples appeared turbid due to the mixing of fruit juices and were not much liked. The lighter fruit juices such as that from cashew apple, tomato, pineapple and tender coconut water were the next best in their appearance and all recorded the same mean score of 27.60. But, juices of thicker consistency such as that from mango, grape and even toddy scored less due to the highly turbid nature of the drink.

Table 23. Sensory evaluation of wine coolers.

Wine coolers	Sensory attributes (mean score value)							
	Colour	Aroma	Taste	Flavour	Astrin-gency	Sugar-acid	Alcohol strength	Overall accept.
WC_1	13.90	30.90	19.80	25.30	20.00	22.20	20.10	27.10
WC_2	27.60	14.50	26.00	30.00	24.00	24.50	20.10	23.50
WC_3	13.90	18.50	22.90	25.30	24.00	24.50	20.10	27.40
WC_4	15.90	24.50	23.50	15.60	24.00	29.40	22.90	23.50
WC_5	27.60	24.50	25.40	22.80	32.00	22.20	20.10	27.40
WC_6	15.90	14.20	22.90	18.10	25.80	23.80	27.40	23.80
WC_7	27.60	34.90	25.40	31.40	28.00	27.40	20.10	27.40
WC_8	27.60	24.50	28.50	32.50	24.00	29.40	20.10	23.50
WC_9	39.00	20.50	3.60	6.00	3.20	3.60	36.10	3.40
H-st. value	*22.67	13.69	*16.94	*19.63	*18.15	*16.31	7.78	*17.75

* - significant at 5% level

H-stat.- Kruskal Wallace H-statistic

WC_1 – Mango wine cooler
WC_2 – Cashew apple wine cooler
WC_3 – Orange wine cooler
WC_4 – Grape wine cooler
WC_5 – Tomato wine cooler
WC_6 – Toddy wine cooler
WC_7 – Pineapple wine cooler
WC_8 – Coconut water wine cooler
WC_9 – Cashew apple wine alone (control)

The taste of the coolers also differed significantly and all were found to be superior to the control. However, the best taste was from the cooler, obtained by the mixing of tender coconut water and cashew apple wine with a mean score of 28.50. The wine cooler resulted from the mixing of cashew apple juice was also much liked by the panelists and scored a mean of 26.00. The scores of coolers prepared from tomato and pineapple juices, closely followed that of cashew apple juice. Mango was found to score the least compared to the other coolers with a mean score of 19.80.

The flavour of all the wine coolers was found to be superior to the control. The cooler from tender coconut water had the best flavour scoring a mean of 32.50, closely followed by that from pineapple and cashew apple. The flavour of that from grape however, scored less with a mean of 15.60.

Significant difference was also observed in the case of astringency between wine coolers. The control was highly astringent as expected, securing the least mean score of 3.20, but the wine coolers did not retain the predominant astringency and hence, all were superior to the control. The wine cooler prepared using tomato juice ranked as the least astringent beverage and scored a mean of 32.00. The coolers from cashew apple juice, orange, grape and tender coconut water scored the same of 24.00 for astringency.

The sugar-acid blend of the wine coolers from tender coconut water as well as grape was found to be the best securing a mean score of 29.40 in both cases. In this regard too, all the coolers were superior to the control, which scored only 3.60. Between the coolers, those from mango and tomato juice recorded a comparatively low sugar-acid blend and obtained a mean score of 22.20.

The overall acceptability of all the wine coolers was better that the control, which scored a mean of only 3.40. The coolers prepared from orange, tomato and pineapple juices scored the highest with 27.40, whereas those prepared from cashew apple, and grape juices as well as tender coconut water obtained the same mean score of 23.50.

Since there was a significant difference between the scores obtained by the wine coolers and that of the control, the aim of improving the acceptability of cashew apple wine by the development of wine based products could be achieved to a great extent.

Discussion

Discussion

Cashew apple, a valuable by-product of the cashew industry is wasted as a whole almost throughout the country, except in Goa, where 'feni', an alcoholic beverage is prepared from it. Being a nutritionally and medicinally important fruit, many steps have been undertaken in the development of products such as jam, syrup, candy, etc. But the commercialization of these products had not been achieved yet. Alcoholic beverages, such as production of wine, liquor and vinegar have also been tried.

Wine, being considered a healthful beverage from early times may have indeed been the world's oldest medicine. The large number of antioxidants present in wines protect the body systems from the ravaging attacks of harmful substances. The antioxidants, besides preventing certain forms of liver damage, cirrhosis and cancer and diseases like diabetes and associated visual loss, are recently known to have an important role in the prevention of coronary heart disease.

The production of cashew apple wine had been tried by many workers. Due to high astringency in the wine, good consumer acceptability and palatability could not be achieved yet, being the major reason for its non-production on a commercial scale.

However, the present study entitled 'Standardization of techniques for cashew apple wine production and development of wine based products' was taken up mainly to enhance the utilization of cashew apple on a small scale or household level. Due to expected astringency in the wine, further improvement of the product was undertaken by blending it with other fruit wines of wider acceptability and also with fruit juices.

The research programme was conducted under four experiments, the results of which are discussed below.

5.1 Standardization of techniques for cashew apple wine making and identifying promising strains for wine making.

Cashew apple wine was prepared from cashew juice clarified using the conventional method of rice gruel. Wine was prepared using three strains of wine yeast, each under nine treatments.

5.1.1 Microbial population in the fermenting must

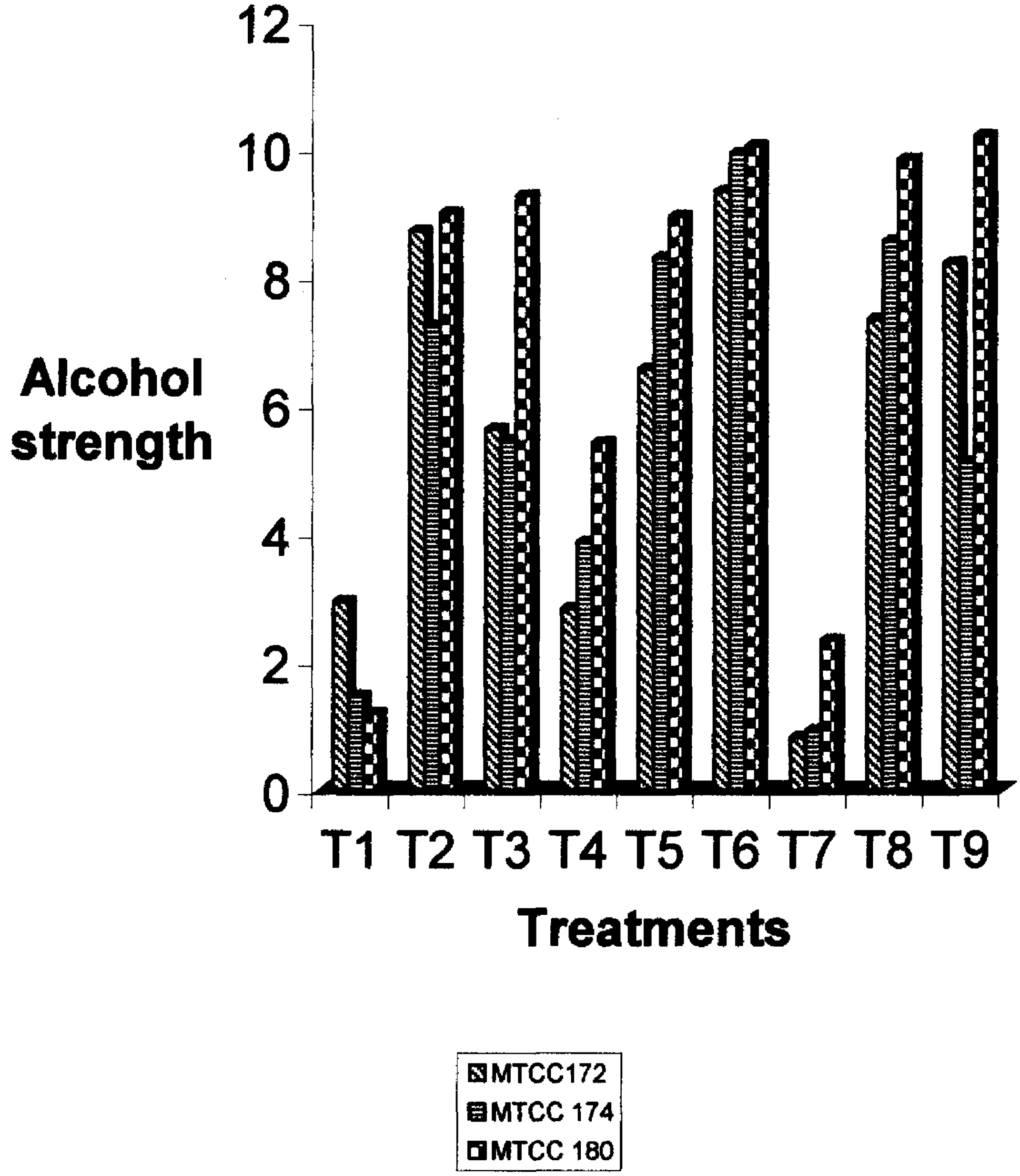
The growth of microorganisms on any substrate or media is highly influenced by the surrounding environmental conditions. Temperature plays a prominent role in their growth and development. The temperature right from the initial step, where one ml of juice was pipetted from the fermenting must to the temperature during dilution and spreading on petri-plates influences the microbial growth. Hence, the daily variations in the room temperature could have been one of the possible reasons for the wide fluctuations in the population of yeast, observed in the present study (Appendix I).

In most of the samples, an increase in yeast population during the first few days followed by a decreasing trend as noticed. This could be due to the rapid growth of the yeast cells, which was in turn due to the available sugars in the fermenting must. At this point rapid fermentation occurred, as a sharp decline in TSS was observed daily. Singh *et al.* (1998) also reported high alcohol production in kinnow fruits during the first five days followed by a decrease. The decrease was however, due to the exhaustion of sugars and hence, decreased fermentation.

5.1.2 Alcohol strength

The alcohol strength in the cashew apple wine prepared from the nine treatments varied from 0.82 to 10.20 per cent. The treatments without any added nutrient supplements resulted in wines of lower alcohol content ranging from 0.82 to 5.42 per cent (Fig.1).

Fig.1 Effect of yeast strains on alcohol strength of wines



The wide variations in concentration of alcohol might be due to the difference in the composition of other nutrients as stated by Kulkarni *et al.* (1980) in the case of mango wine.

The other treatments were ameliorated with either cane sugar or jaggery to raise the TSS content to 20^0brix so as to obtain a desired alcohol content. Jarezyk and Wzorek (1977) stressed the need for sweetening of musts because of the low sugar content in majority of the fruits.

The alcohol content obtained in the cashew apple wine was in accordance with wines obtained from other fruits like plum (Vyas and Joshi, 1982), wild apricot (Joshi *et al.*, 1990), jambal (Shukla *et al.*, 1991), muskmelon (Teotia *et al.*, 1991), custard apple (Kotecha *et al.*, 1995), karonda (Bhajipale *et al.*, 1998), kinnow (Singh *et al.*, 1998), and cider (Joshi and Sandhu, 2000). However, wine from mango recorded a higher alcohol content of upto 13% as reported by Kulkarni *et al.* (1980).

The treatments using jaggery as a source of nutrient for the yeast produced higher alcohol contents than the treatments using cane sugar. It could probably be because jaggery contains more available sugars than cane sugar for the yeast to act on and hence, produce alcohol.

Among the three yeast strains namely, MTCC 172, MTCC 174 and MTCC 180, the latter was found to be superior to the former two in alcohol production and hence, can be recommended for production of good quality wine from cashew apple. This strain was found to produce higher alcohol in all the treatments involving addition of sugar as well as jaggery compared to the other two strains.

5.1.3 Titrable acidity and pH

The strain, MTCC 180 was also found to be superior to the other two with regard to the acidity of wines by producing the least acidic wines with a mean of

0.52 per cent, while MTCC 172 produced comparatively more acidic wines with a mean of 0.85%. Even though the titrable acidity content of the wines from the three strains varied significantly (Fig.2), there was no much influence on the pH of the wines as they showed a non-significant difference in this regard (Fig.3).

A similar finding was reported by Kulkarni *et al.* (1980) while screening mango varieties for wine making. Theoretically, increase in acidity should have resulted in a decrease in pH as reported by Vyas and Joshi (1982) in plum, as well as in sapota by Gautum and Chundawat (1998).

Amerine *et al.* (1980) reported that the buffer capacity of the wine and the relative amount of various acids influence the acidity. Although various constituents of acids were not analysed in the present study, similar situation as observed by them could be true.

5.1.4 TSS and Brix-acid ratio

Since the strain, MTCC 180 was earlier discussed to be more efficient in alcohol production compared to the other two, the TSS of wines prepared using this strain was lesser recording a mean of 5.38^0 brix. The strain, MTCC 172, (Fig.4) was least efficient in its capacity to produce alcohol and so retained higher TSS content in the wines (7.78^0 brix).

The TSS content had been reported to bear an inverse relationship with alcohol content of wine (Kotecha *et al.*, 1995). The results on TSS content of cashew apple wine substantiate the above findings and were also found to be in accordance with the report of Bhajipale *et al.* (1998) in karonda wine.

The TSS of wines in the case of fermenting musts with no added supplements ranged from 2.40 to 6.00^0 brix, while those from ameliorated ones ranged from 5.87 to 11.73^0 brix. The results obtained in the case of the latter were similar to those reported in case of fruit wines by Vyas and Joshi (1982) in plum, Joshi *et al.* (1990) in wild apricot, Kotecha *et al.* (1995) in custard apple,

Fig.2 Effect of yeast strains on acidity of wines

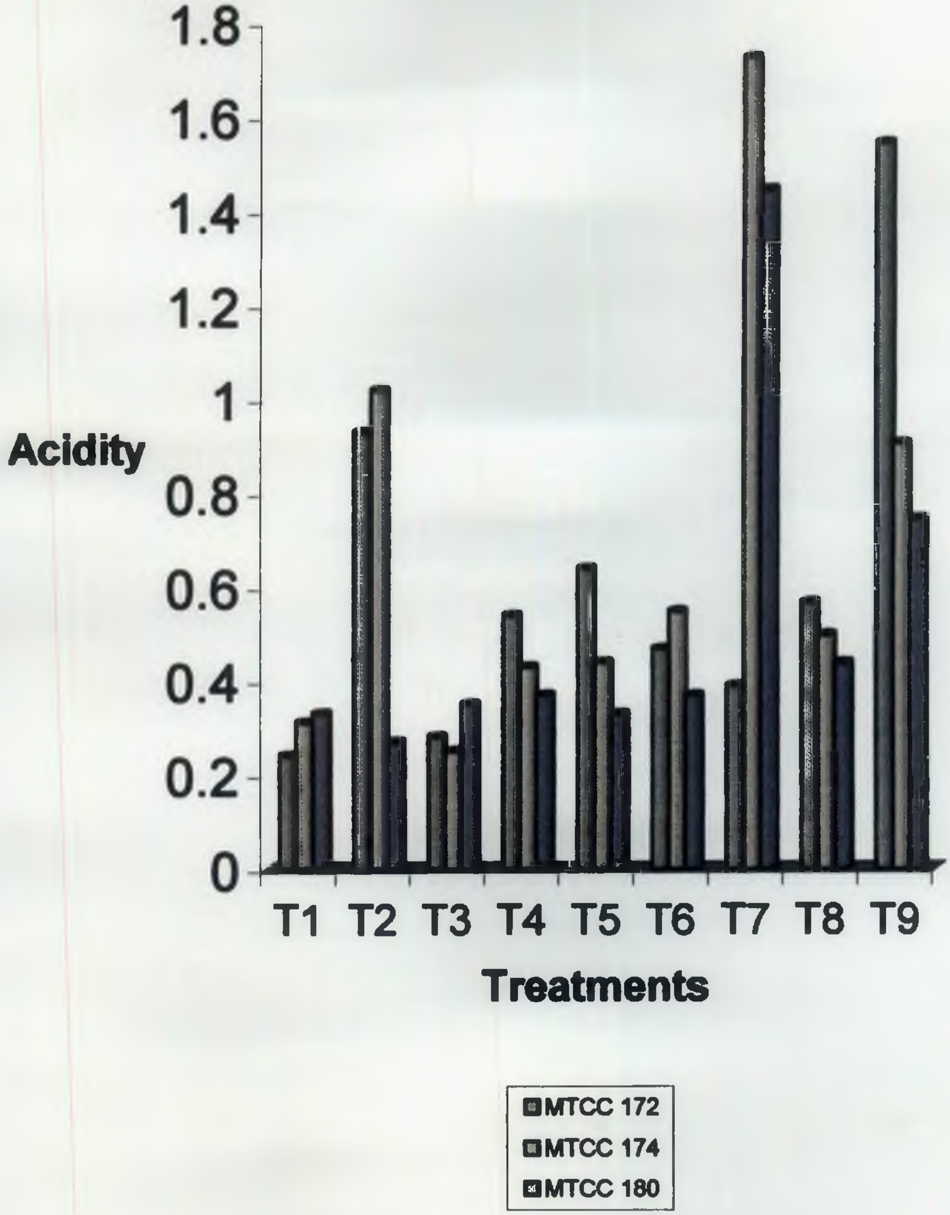
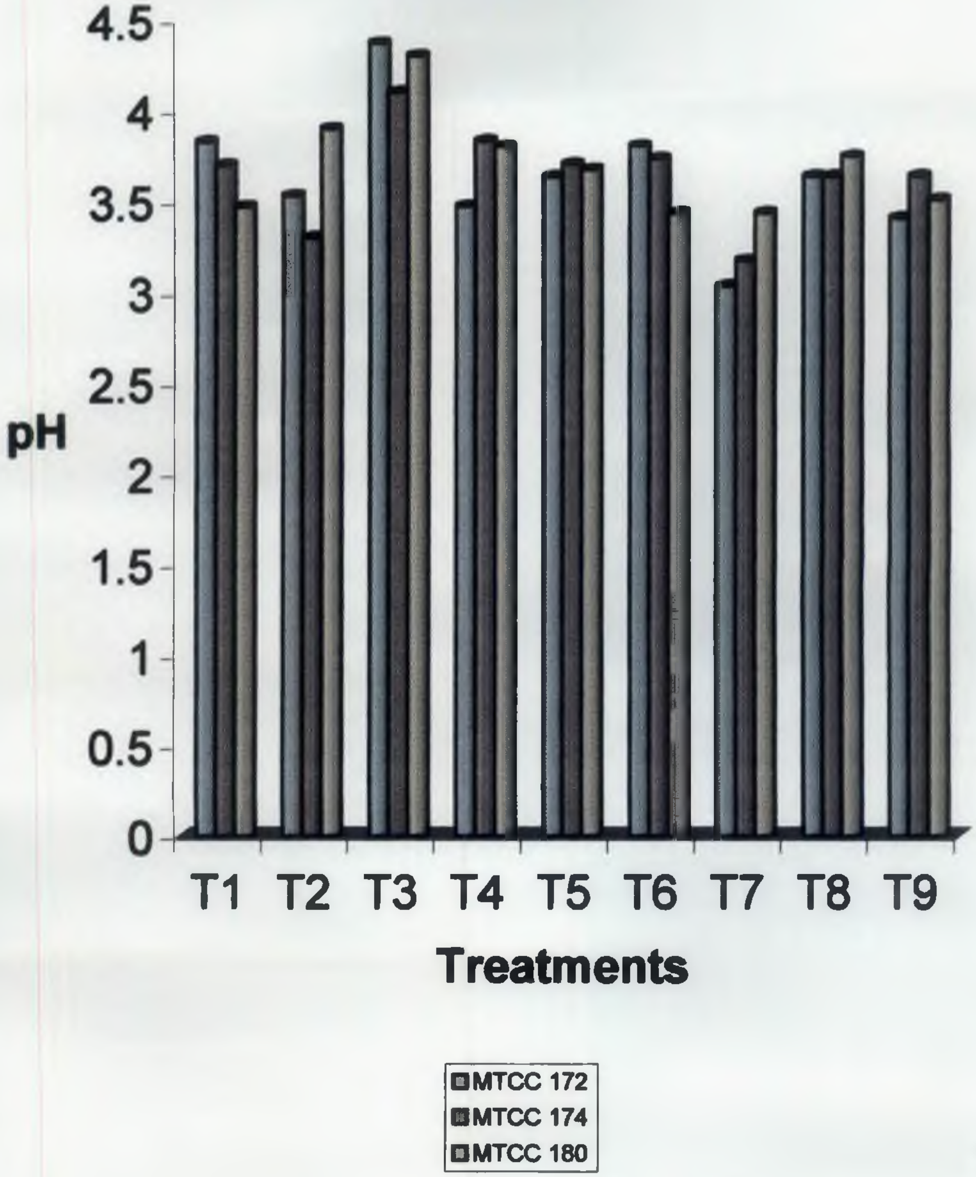


Fig.3 Effect of yeast strains on pH of wines



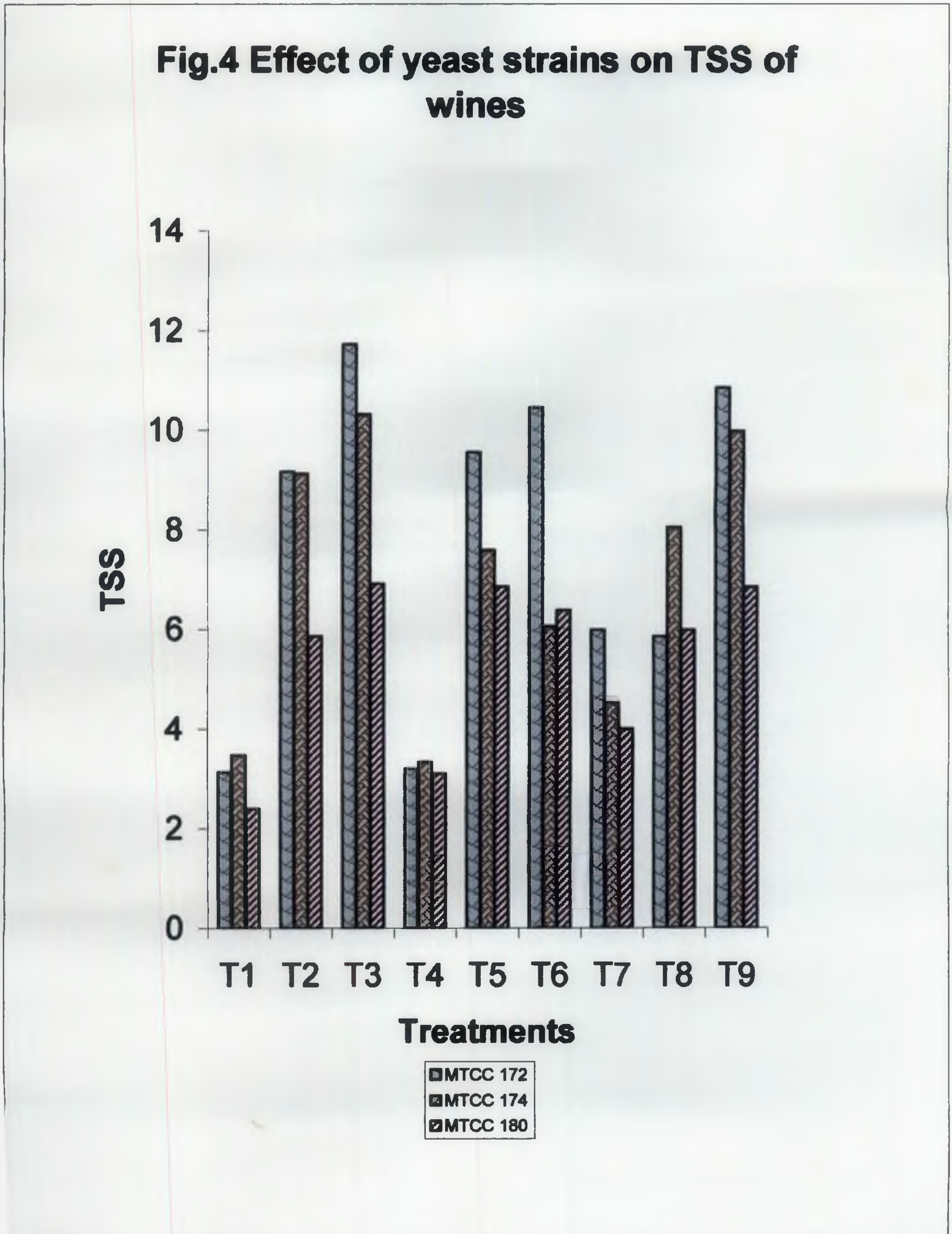


Fig.4 Effect of yeast strains on TSS of wines
14
12
10
8
6
4
2
0
TSS
T1 T2 T3 T4 T5 T6 T7 T8 T9
Treatments
MTCC 172
MTCC 174
MTCC 180

Bhajipale *et al.* (1998) in karonda, Gautum and Chundawat (1998) in sapota and Singh *et al.* (1998) in kinnow fruit.

The TSS of the wines prepared using jaggery as nutrient supplement were higher, ranging from 6.07 to 11.73^0 brix, compared to the wines where cane sugar was used, which had TSS ranging from 5.87 to 9.57^0 brix. Jaggery probably contains other natural sweetening substances which may be lost during the manufacture of cane sugar.

Corresponding to the high TSS and low acidity in wine prepared by addition of jaggery, a high brix-acid ratio was obtained. The treatments with nutrient supplements had brix-acid ratios ranging from 9.09 to 18.38. One of the treatments without any nutrient supplemented recorded a ratio comparable to the others, eventhough it recorded a low TSS, due to its extremely low acidity. Hence, not only a high TSS indicates a high brix-acid ratio, but also low acidity is equally important.

5.1.5 Reducing and total sugars

The wines prepared from three strains did not differ significantly from each other with regard to their reducing sugar content. The content of reducing sugars ranged from 1.05 to 4.98 per cent. Similar results were earlier reported by Gautum and Chundawat (1998) in sapota wine, Bhajipale *et al.* (1998) in karonda wine and Joshi and Sandhu (2000) in apple cider.

The above workers reported a total sugar content ranging from 2.47 to 2.60%in case of sapota and 3.23 to 3.64% in karonda wine. But this was not in agreement with the findings of the present study where the total sugar content of the cashew apple wine ranged from 1.90 to 14.52% probably due to variation in the fermentation process by the wine yeast strains and other treatment variations.

High total sugar content was recorded from wines prepared using jaggery, especially when strain, MTCC 172 was used. MTCC 180 produced wine of low total sugar content indicating that it was more efficient in converting the sugar into alcohol. This was further supported by the low TSS and high alcohol content estimated in the wine.

Since jaggery supplemented wines had higher total sugars, while the corresponding reducing sugar content did not vary much from that of wine prepared using cane sugar as supplement, it probably indicates that either jaggery has higher content of non-reducing sugars, or the strains are more effective on cane sugar as substrate for the production of alcohol.

There are reports of cane sugar being used to increase the TSS upto a desired level of 20 to 25^0 brix in most cases of fruit wine production, but the use of jaggery for the same has not been reported.

5.1.6 Sensory evaluation

The evaluation of the sensory quality of the cashew apple wine in order to compare the three strains did not show much of a difference in most of the attributes. The three strains were on par with each other with respect to the quality of wine produced, except in case of aroma and overall acceptability in two different treatments, where strain MTCC 172 yielded wine of superior aroma when jaggery was used and a wine of better overall acceptability when cane sugar was used. Hence, based on the sensory evaluation the strain MTCC 172 could be recommended for the production of cashew apple wine of good acceptability.

Schaeffer (1981) suggested that wine should be clarified and centrifugation gave best quality retention of wine and development of good sensory properties.

Shklyaruk *et al.* (1982) improved the stability of wines and thereby its organoleptic properties by using enzyme systems from coagulated yeast cells. The resultant wines were found to contain less phenols, proteins and polysaccharides, which affect the wine stability.

5.2 Effect of treatments on the yield and quality of cashew apple wine.

Cashew apples were subjected to pre-treatments and the juice was clarified using different clarifying agents namely, gelatin (1.0 per cent), pectin (0.5 per cent), PVP (0.4 per cent) and rice gruel at 150ml per litre of cashew juice, to find if there was any effect on the yield and quality of cashew apple wine. The clarified juice was subjected to fermentation using commercial Baker's yeast.

5.2.1 TSS of fresh and clarified juice

The treatments making use of the conventional method of rice gruel for clarification resulted in a considerable reduction in the TSS content. This could be possible due to the dilution effect caused by the addition of rice gruel at 150 ml per litre of cashew apple juice. The reduction in TSS brought about by rice gruel ranged from 1.53 to 2.27^0 brix and it resulted in clearer cashew apple juice compared to the others.

In the present study, it was found that gelatin (1.0 per cent) caused a reduction of only 1.07^0 brix in the TSS, while Nanjundaswamy (1984) obtained a 2.00^0 brix reduction in TSS of clarified juice with gelatin (0.5 per cent) treatment. PVP caused a 1.40^0 brix reduction in TSS and pectin (0.5 per cent) caused the least reduction of 0.47^0 brix.

Here, when we consider the cost of the clarifying agents, the cost of clarification using gelatin was estimated to be Rs. 6.50 for one litre of juice. The use of pectin for clarification was found to cost Rs. 13.30 for a litre of cashew apple juice. However, PVP was the most expensive as it costed Rs. 24.60 for the clarification of one litre of juice. On comparing the cost with the efficiency of clarification, the use of gelatin could be recommended, while the use of pectin for clarification would not be advisable as it had a comparative higher cost and lesser efficiency in clarification. The use of PVP would increase the cost of wine production to a fairly large extent and since no exceptional quality wine was produced using this, it could be as well avoided for the process of cashew apple juice clarification.

Simultaneously, when the use of rice gruel for clarification is considered, this agent is practically free or may have negligible cost. The wine from this clarified juice is of intermediate quality and so this could be used for the clarification of cashew apple juice.

5.2.2 Alcohol content of cashew apple wine

The alcohol content estimated in the wines ranged from 8.40 to 10.95 per cent. As discussed earlier, a must with a TSS of 20^0 brix can be expected to yield around 10 per cent alcohol. Hence, the variation in the alcohol content could be possibly due to the difference in efficiency of clarifying agents in affecting the quality of the juice by way of clarification.

An inverse relationship between alcohol content and TSS of wines was reported by Kotecha *et al.* (1995) and Bhajipale *et al.* (1998). The present study is also supportive of the above findings.

The alcohol content of wine from PVP clarified juice was the highest and at the same time it was on par with the alcohol content of the wine prepared from gelatin as well as rice gruel clarified juices. Since the alcohol content of these were found to be on par, it would be more economical to use gelatin or rice gruel for clarification as the cost of clarification when PVP is used is comparatively higher viz., Rs. 24.60 for clarification of one litre cashew apple juice. However, the cost of gelatin comes to only Rs. 6.50, which is comparatively cheaper. Rice gruel is still cheaper or practically free and is easily available in every home of Kerala, where rice forms the staple food of the people.

Poorly clarified juice obtained by pectin treatment produced lower alcohol content due to lesser utilization of TSS. Gautum and Chundawat (1998) found a greater utilization of sugars and higher rate of fermentation during the preparation of sapota wine from juice clarified using pectinase.

Singleton and Esau (1969) reviewed and concluded that the natural phenols of grapes or wine including the tannins and tannin pigment polymers are definitely inhibitory to yeast and bacteria. This finding was substantiated in the present study, whereby the poorly clarified juice using pectin produced the least alcohol content in wine due to the inhibition of yeast activity by high tannins retained in the juice.

5.2.3 Reducing and total sugar content

Very low reducing as well as total sugar contents of 0.21 to 0.27 per cent and 0.41 to 0.50 per cent respectively, were recorded in the wines. These findings were in accordance with that of Shukla *et al.* (1991), who reported about 0.40 per cent sugars in jambal wine and classified such wines as 'dry' wines. Gautum and Chundawat (1998) reported minimum levels of reducing and total sugars in wine prepared from clarified juice compared to that prepared from unclarified juice as well as pulp, in case of sapota.

The present finding suggests that, when we start with a cashew apple juice of 20^0 brix, the resulting wine contains about 8.5 to 10.5 per cent alcohol and a negligible amount of residual sugars. Obviously, such wines will be classified as 'dry' wines. Therefore, to obtain a cashew apple wine of sweet taste we may have to start with a juice with its TSS raised to around 30^0 brix.

5.2.4 pH and Titrable Acidity

The pH of the clarified juice obtained after the treatments remained the same as that of the fresh juice. However, the wines obtained after the fermentation of these juices showed a significant difference in the pH between treatments.

Wine prepared from pectin clarified juice recorded the least pH and highest acidity. This could be probably due to the less efficiency of pectin in clarification.

Haight (1997) reported that the use of pectinases for clarification of wine had been unsuccessful. Pectinases are used to reduce viscosity of grape must through the hydrolysis of pectin.

Gelatin finds principal application in clarification as well as in modification of astringency. It is also employed to reduce harshness (astringency) and improve the clarity of juice before fermentation. Nanjundaswamy (1984) had reported a considerable reduction in acidity of cashew apple juice after clarification using gelatin. But, in the present study, the wine prepared from gelatin clarified juice did not have very low acidity and at same time it recorded the highest pH.

There is a significant difference between pH and titrable acidity. The former is a measure of the free proton content of the solution, whereas the latter depends on the concentration of wine acids as well as the extent to which they dissociate.

The acid content of a wine is of importance from the standpoint of flavour and indirectly effects the pH, colour, stability and shelf life of wines. The pH value for white wines is often 3.4 or less, whereas higher values are observed for red wines. This is mainly due to the contact of juice and skin before and after fermentation (Zoecklein *et al.*, 1997).

In the present investigation, all clarifying agents resulted in wines of higher pH ranging from 3.53 to 3.83. Wines from PVP as well as rice gruel clarified juice recorded low acidity. Again, considering the cost factor of PVP, clarification using rice gruel would be more cost effective.

The brix-acid ratio of wine from PVP clarified juice was the highest due to its lower acidity and high TSS of the wine. Even though, rice gruel clarified juices recorded low acidity in wines, they had comparatively low brix-acid ratios probably due to the low TSS of these wines.

Based on the biochemical analysis of the wines, those prepared from gelatin as well as PVP clarified juice were found to be superior. But, when the cost of production is estimated, the economically feasible option would be the use of gelatin for clarification of cashew apple juice to obtain best quality cashew apple wine. Rice gruel can be used due to its easy availability to produce wines of average acceptability.

5.2.5 Sensory evaluation

The wines were subjected to sensory evaluation by a panel of ten experienced judges. The wine prepared from gelatin clarified cashew apple juice was rated as superior to all the other treatments with regard to all the attributes, ranging from colour and appearance, aroma, taste, flavour and astringency, to sugar-acid blend, alcohol strength and overall acceptability of the wine.

The wine from gelatin clarified juice had an appealing dark or blackish colour, which was very much appreciated by all the judges and was not noticed in any other of the wines.

Gelatin preferentially binds with larger molecules having more phenolic groups and potentially more hydrogen bonding sites (Singleton, 1967). Thus gelatin has less effect on colour and tannin reduction of younger wines than in older ones, as the latter generally have a greater percentage of larger polymeric phenolics.

Zoecklein *et al.* (1997) stated that gelatin addition might result in colour shifts in red wines from brown to a more ruby red, perceived visually as a shift in hue.

The wine from gelatin clarified juice also had an acceptable taste, aroma, flavour and sugar-acid blend as ranked by the panelists. The astringency in this wine was less detectable and it could be due to the higher removal of tannin content from the juice by gelatin. The wine also had a comparatively higher alcohol content. The overall acceptability of this product was good.

But, on the contrary, the wine prepared from pectin clarified juice obtained the least scores in all attributes except astringency. The low astringency indicates that pectin does help in reducing the tannin content in the juice to a slight extent. Since this treatment could not yield wine of appreciable acceptability and quality, we can conclude that pectin (0.5 per cent) is less effective in the clarification of cashew apple juice.

The significant reduction in total tannins of cashew apple juice brought about by gelatin was also reported by Chandran and Damodaran (1979), Nanjundaswamy (1984), Antarkar et al. (1991) and Attri and Singh (1999).

The wines prepared from rice gruel clarified juice had intermediate sensory quality and acceptability. The wine prepared from PVP clarified juice obtained average scores for most of the sensory attributes but for astringency, the wine scored well indicating that it was less astringent. Hence, PVP was effective in reducing an appreciable amount of tannin content, which is a major reason for the poor acceptability of most cashew apple products.

Hence, from the results obtained, it can be concluded that use of gelatin (1.0 per cent) for the clarification of cashew apple juice yields a wine of high consumer acceptability, followed by rice gruel and PVP as clarifying agents. The efficiency of pectin as a clarifying agent was ranked poor, when such juice was subjected to wine production.

5.2.6 Varietal suitability for wine making

Seven varieties of cashew namely, Madakkathara-1, Madakkathara-2, Dharasree, Priyanka, Dhana, Kanaka and Amrutha were evaluated for their suitability in wine making.

The wines obtained were analysed after a storage period of six months, for its physio-chemical as well as sensory quality, in order to select the best variety for wine making.

The alcohol content of 12.54 per cent was the highest, recorded from variety, Madakkathara-1, while Priyanka produced wines of low alcohol content (8.66 per cent). But, wines from Priyanka also recorded low acidity and a high brix-acid ratio, which are desirable qualities. The TSS, reducing and total sugar contents had intermediate values in case of Priyanka.

The wine from variety, Kanaka recorded the least pH of 3.43 and a corresponding high acidity of 0.65 per cent. The other varieties recorded pH ranging from 3.63 to 3.90. Based on this, we could infer that variety, Kanaka might not be suitable in production of wine of high acceptability.

Based on biochemical analysis alone, suggesting a suitable variety of cashew apple for wine making was not possible. Hence, sensory evaluation carried out by ten judges further helped in the screening of the varieties with respect to wine making.

The variety, Madakkathara-1 scored the highest for its overall acceptability as well as flavour of the wines scoring means of 43.30 and 39.40 respectively. While, wine from Priyanka was appreciated for its taste and it secured a mean score of 43.15. Dhana was observed to have the least astringency and at the same time it had a good sugar-acid blend.

With respect to aroma, that of Dharasree was found to be appealing with a mean score of 43.40. Dharasree obtained low scores for all other parameters. Similarly, Kanaka scored the highest for its wine colour and appearance and low scores for the other attributes. Hence, it could be concluded that these varieties were not desirable for cashew apple wine production.

The variety, Madakkathara-2 was also observed to secure low scores in most attributes, but it ranked second in its taste and overall acceptability.

Since different varieties were found to be superior to the others in various properties, it is very difficult to suggest a particular variety for wine making. Hence, further analysis and characterization of different varieties for evaluating their suitability to wine making should be carried out.

However, based on the present investigation, a favourable attitude would be towards the use of two varieties namely, Dhana and Madakkathara-1 for wine making as Dhana recorded the least acidity, highest brix-acid ratio, comparatively high reducing and total sugar content and an appreciably high amount of alcohol (11.07%). Also, the sensory evaluation indicated that the wine from Dhana was less astringent and had a good sugar-acid blend.

In the case of Madakkathara-1, the wine recorded the highest alcohol of 12.54% and the sensory evaluation ranked it as the best in its overall acceptability as well as flavour.

The study revealed that the wine prepared from cashew varieties showed considerable variation in sensory attributes. However, it was not possible to pin point the best variety for wine production. Results indicated that varietal variability of wine quality is a potential tool that may attain commercial relevance in the coming years.

5.3 Comparison of containers and storage environment with respect to quality of cashew apple wine.

Initially eight storage containers in three different environments were arranged for the study. Due to onset spoilage symptoms and microbial growth on the external surface of clay pots within a week and on wooden containers (bamboo) within a month of storage, these two treatments were discarded from the study. The experiment was preceded with the remaining six containers in the three environments.

Amerine *et al.* (1980) had mentioned the storage of wines in oak, concrete, redwood lined iron or steel, stainless steel and polyester containers. They also suggested that the storage areas should be air-conditioned and in cases where wood was used for storage, humidity control was necessary. The use of stainless steel containers for the storage of wine was also suggested by Caprio (1983), Cologrande (1983) and Botta (1984).

According to Pavlenko *et al.* (1983), the wine quality is not linked to age alone but, also dependent on good storage conditions.

The spoilage of the wine in the clay pots and bamboo containers could be due to the porous nature of the two. The flat taste of the wines in these was probably because of the evaporation of the alcohol through the pores, along with other volatile substances in the wine. Similarly, microorganisms also could have gained entry through the pores and hence, obtained a substrate to feed on, resulting in their rapid growth and development even on the outside of the container. As the clay pots are more porous compared to the bamboo containers, the wines in clay pot could not be kept for more than a week, while wines stored bamboo containers took a month to produce similar spoilage symptoms.

5.3.1 Biochemical properties

The alcohol content of wine stored in all six containers irrespective of the environments was in a similar range. Wines in all the containers were kept airtight.

However, the pH of wine stored in china clay jar was found to be the least (3.58), probably due to the slight acetification of the wine. But wines from both glass bottles, steel container and coloured pet jar retained high pH ranging from 3.77 to 3.86. These containers possibly prevented the acetification of wines to a greater extent by maintaining a proper airtight condition.

The presence of acetic acid bacteria at all stages of wine making was reported by Joyeux *et al.* (1984). He stated that short exposure of wine to air caused rapid proliferation of the organisms and thereby increase in concentration of acetic acid. High temperature of wine storage and high wine pH was found to favour their development.

It was also noticed that wines stored under refrigeration generally recorded higher pH of 3.82 than those in open and dark (Fig.5). The possible reason for this could be the fact that under low temperature, microorganisms are inactive and therefore could not act on the wines. But, in open and dark condition, both of which are at room temperature, there are numerous microorganisms, which could have acted on the wines.

The finding that there was no relationship between the pH and acidity of wines has been further observed here. Eventhough the pH of wine from plain glass bottle was high, the acidity in this wine was also high. But, the opposite was observed in case of coloured glass bottle, as the wine had high pH and corresponding low acidity.

The reducing and total sugar content of the wines were not influenced either by the storage containers or environments and so also did the brix-acid

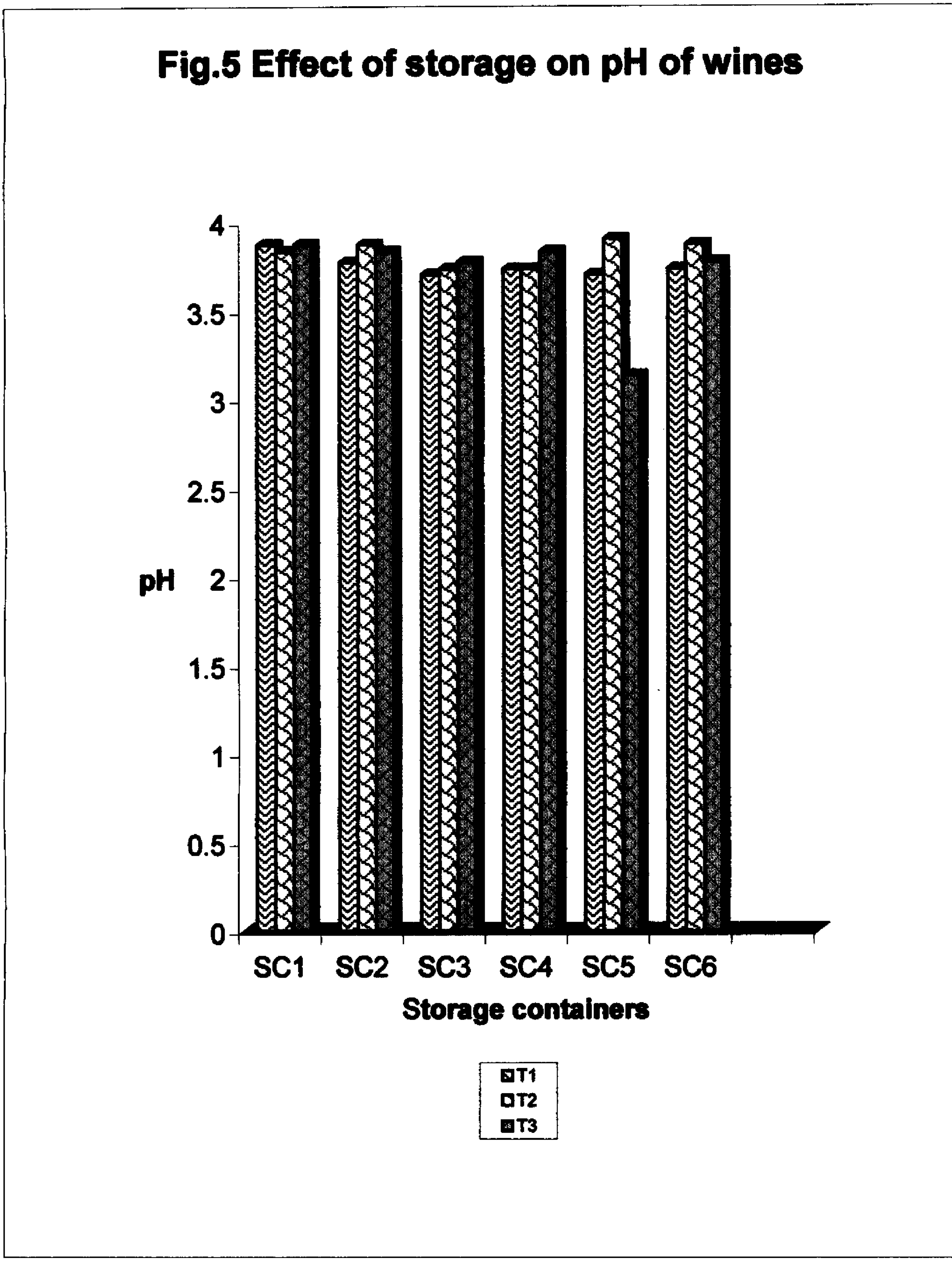


Fig.5 Effect of storage on pH of wines
pH
4
3.5
3
2.5
2
1.5
1
0.5
0
SC1
SC2
SC3
SC4
SC5
SC6
Storage containers
T1
T2
T3

ratio. However, the TSS content did seem to be affected by the storage container. The TSS content of wines in china clay jars was low. This could probably be related to the lower pH and acetification of this wine, which could have resulted in the subsequent drop of TSS.

5.3.2 Sensory evaluation

Aging is basically the storage of wine over long periods of time. It is an important and most complex process in wine making, where the harsh taste and yeasty odour diminish and a smooth, mellow flavour and clean odour are produced. There is a general improvement of the sensory qualities of wine after aging.

In the present study, wines were evaluated for their sensory quality after a storage period of six months. A slight improvement in the overall acceptance of the wine after storage, over the fresh wine was, however, observed. This suggests that aging is a slow process and hence studies of longer storage periods may be needed in order to get a clear idea of the improvement of wine on storage. Wines have been kept for aging for periods ranging from a few to several years, from early days.

The sensory evaluation was conducted separately for three promising wines selected from Experiment I and subjected to storage in various containers and environments for a period of six months in order to evaluate the storage stability of the wines.

The storage containers or environments did not affect the sensory evaluation with respect to most of the attributes.

The colour and appearance as well as aroma did not differ due to their storage in different containers or environments, in case of all three treatments evaluated. Cortes (1981) described oxidation, temperature and effects of enzymes as the major causes of colour changes in wines and suggested the use of fining agents as well as sulphur dioxide and the prevention of access of air to avoid these changes. But, according to Simpson (1982), the factors affecting oxidative browning of white wines are the contents of total phenolics, catechins and procyanidins.

However, for the taste and flavour of the treatment, ST_1 a significant difference between the storage environments was noticed. All the wines stored in open room condition acquired a poorer taste as well as aroma. Hence, storing wines in dark or fridge would be a better option to improve the taste and flavour of the wine.

Also, the astringency and sugar-acid blend of wine stored in all containers and environments were statistically found to show no difference.

In the case of overall acceptability of the wines, the wines in plain pet jars proved to be the least acceptable irrespective of the storage environment. This could probably be due to the composition of the plastic jar, which could have caused some chemical change in the wine, affecting it adversely. All the other containers were on par with each other in producing wines of similar acceptability.

Based on the present storage study, the biochemical analysis indicated that storage of wines in china clay jars and pet jars resulted in poor quality wines. But the sensory evaluation suggested that except plain pet jars the other five containers studied were suitable for wine storage.

5.4 Development of cashew apple wine based products.

The main objective of taking up this experiment was to develop products based on cashew apple wine so as to improve the overall taste and acceptability of the cashew apple wine. Cashew apple wine was blended with other fruit wines as well as fruit juices and subjected to sensory evaluation by a panel of ten judges.

A. Blended wines

The sensory evaluation of cashew apple wine blended with other fruit wines, namely, pineapple (variety, Mauritius), jackfruit ('koozha' type), gooseberry, banana (variety, Palayankodan), mango (variety, Neelum) and grape (variety, Gulabi) wines indicated that there was a definite improvement in the acceptability of cashew apple wine after blending, with regard to all the sensory attributes.

The aroma and alcohol strength of the blended wines however did not show any significant difference from the control (cashew apple wine alone).

As expected, the blended wine using grape wine was the best in taste. Grapes are the most commonly appreciated fruits in the preparation of wines. Grapes yield wines of superior quality with respect to all attributes responsible for sensory quality. Hence, the high quality wine obtained from grapes when blended in equal quantity with cashew apple wine, helped to mask or rather improve the taste of cashew apple wine.

The blending of grape wine was also found to result in a good sugar-acid blend of the product. However, the sugar-acid blends of banana as well as pineapple blended cashew apple wines were also equally comparable to that of grapes.

The taste of blended wine using banana wine was second to that of grape wine. However, the flavour of the banana wine was superior to that of grape as ranked by the judges. This could be probably because the flavour of banana wine merged well with that of cashew apple wine.

There was no significant difference noted in the alcohol contents of the wines probably because all fruit wines were prepared after the respective musts were ameliorated with cane sugar to reach a TSS of 20^0 brix. Theoretically, such musts will produce an alcohol content of around 10%, though a slight variation in the content of alcohol could be due to other nutrient constituents during fermentation by the yeast cells.

The fruit wines did not differ significantly from each other in their estimated alcohol content and hence, did not show a difference when ranked by panelists.

The overall acceptability of the blended wine obtained from grape wine was superior to all the others as it scored the highest mean of 25.60 and it was closely followed by both of that from pineapple as well as banana wine, each scoring means of 22.70.

Based on the sensory evaluation, it could be concluded that blending cashew apple wine with grape, banana or pineapple wines would yield a product of good consumer acceptability, whereas blending with jackfruit, gooseberry or mango wine would not yield a product of better acceptability. This could possibly be because these fruit wines themselves were not of good acceptability and hence, could not mask the mild biting taste of the cashew apple wine. However, the fruits of grape, banana and pineapple probably produced superior quality wines which on blending with cashew apple wine improved the taste through its own superior taste and smooth blend of the individual flavour components of the respective wines.

B. Wine coolers

The preparation of wine coolers by mixing the cashew apple wine with other fruit juices was taken up so as to improve the acceptability of the beverage. Though clarified juice was used for fermentation, it was observed that the resultant wine retained taste of residual tannin in varying degrees of intensity in different treatments. Thus, recommending pure cashew apple wine may not have good consumer acceptability. Hence, the development of wine coolers was sought to and subjected to sensory evaluation, where the cashew apple wine blended with different juices was found to be highly acceptable.

The wine coolers were appreciated by all the judges with regard to all the attributes except their colour and appearance. Fresh fruit juices, due to dissolved fruit particles and high total soluble solids have a thicker consistency and were turbid. On mixing these with the clear and transparent cashew apple wine, rendered the latter to turn turbid and hence, not of appealing appearance to the judges. But the appreciation for all the other characters masked the less acceptable appearance of the wine coolers.

Wine coolers prepared from tender coconut water recorded maximum score for taste, flavour as well as sugar-acid blend. Tender coconut water was found to blend well with cashew apple wine and hence, was ranked as best combination for wine cooler preparation.

Coolers obtained from cashew apple juice also had an acceptable taste and flavour and ranked second to that of the cooler prepared using tender coconut water.

Tomato juice was found to be effective in masking the astringency, hence, the wine cooler prepared from tomato juice was rated as having the least astringency. The constituents of tomato juice probably reduced or combined with tannins or other similar components responsible for astringency, thereby reducing the biting taste of the beverage. However, the sugar-acid blend of the same was not acceptable and scored the least mean of 22.20, while the best using tender coconut water scored a mean of 29.40.

The overall acceptability of wine coolers from orange, tomato and pineapple was the best as ranked by the judges. The other coolers from cashew apple and grape juices and tender coconut water also had a good overall acceptability.

It was, however, noticed that the taste, sugar-acid blend and overall acceptability of cooler prepare using mango juice (variety, Neelum) was least accepted. Also, the astringency of this cooler was rated highest as compared to the others. The colour and appearance of the same scored the least with a mean of 13.90. Since several commercial varieties are available in mango, detailed studies involving scope of making cashew wine coolers blended with juices of other mango varieties need to be undertaken.

Based on the sensory evaluation, it could be concluded that juices from pineapple, orange, tomato, grape and cashew apple were well suited for the preparation of wine coolers using cashew apple wine. The best would, however, be the blend of cashew apple wine with tender coconut water. Mango juice as well as toddy could not form a good blend with the cashew wine and hence, did not produce coolers of good acceptability.

As the wine cooler obtained using cashew apple juice was of good acceptability, further utilization of the cashew apple could be achieved by using the juice for blending with cashew apple wine. This product would also contain the nutritional and medicinal properties rich in cashew apple. Through this approach, the valuable by-product of the cashew industry could be fully utilized.

Joshi and Sandhu (2000) conducted studies on the preparation and evaluation of apple cider. They blended apple base wine with different concentrations of apple juice. The TSS content and pH value recorded a significant increase compared to the base wine, while a decrease in the titrable acidity and alcohol content was observed as the percentage of added juice increased.

In the present study, where equal proportions of cashew apple wine and fruit juices were used, a significant decrease in alcohol content as well as astringency was observed.

In general, all the wine coolers prepared, exhibited a definite improvement over the consumption of cashew apple wine alone. Hence, cashew apple wine can be successfully subjected to the preparation of wine coolers and thereby be consumed as any other low alcoholic beverage. This in turn will help to increase the consumption of cashew apple wine.

Wine coolers being low alcoholic beverages can be given to children as a health drink. By drinking wine coolers, children in a single serving can ingest the medicinal properties of wine as well as rich nutrients and minerals present in fruits. Wine coolers may also be given to patients who are unable to consume solid foods. This will not only lead to the meeting of their energy requirement but also help in their recovery, as wines have been proved to have a preventive action over some of the dreaded diseases such as cancers and heart diseases.

Detailed studies on the preparation and use of these wine coolers as major health drinks have to be undertaken and then popularise this technology of great economic relevance.

Summary

Summary

The results of the present study on 'Standardization of techniques for cashew apple wine production and development of wine based products', undertaken in the Department of Processing Technology, College of Horticulture are summarised below.

1. Among the three strains of wine yeast evaluated for wine making, namely MTCC 172, MTCC 174 and MTCC 180, the latter was more effective in wine production from cashew apple juice. It produced wine of a higher alcohol content and a corresponding low TSS. This wine also had low titrable acidity.
2. The treatments using juice ameliorated with jaggery produced wines of higher TSS and total sugars and at the same time, had the highest alcohol content compared to the other wines.
3. The clarified juice recovery using PVP (0.4 per cent) as clarifying agent was very low, while that using gelatin (1 per cent) was on par with the recovery of juice after clarification using rice gruel.
4. The decrease in TSS after clarification was the least in case of pectin clarified juice, while rice gruel clarification resulted in high TSS reduction.
5. The wine prepared from gelatin (1 per cent) clarified cashew apple juice was superior to the others in all the sensory attributes. The wine had an appealing colour, good taste and flavour, optimum sugar-acid blend, high alcohol content and the best overall acceptability.
6. Rice gruel as well as PVP clarified cashew apple juice resulted in wine of average acceptability. Since rice gruel is easily available in all homes of Kerala, it can be used at household level for clarification very conveniently. The cost of clarification using gelatin worked out to be Rs. 6.50 per litre of cashew apple juice, while PVP costed Rs. 24.60 per litre of juice.
7. The varietal evaluation of cashew apples for wine making, revealed that the varieties, Madakkathara-1 and Dhana were superior to the other varieties tested, namely Madakkathara-2. Dharasree, Kanaka, Priyanka and Amrutha.

7. The varietal evaluation of cashew apples for wine making, revealed that the varieties, Madakkathara-1 and Dhana were superior to the other varieties tested, namely Madakkathara-2. Dharasree, Kanaka, Priyanka and Amrutha.

8. Madakkathara-1 produced wine of high alcohol content and at the same time a high TSS. A good flavour as well as overall acceptability of the wine was also observed.

9. Dhana produced wine of least astringency and a satisfactory sugar-acid blend. The wine obtained also had a high brix-acid ratio and total sugar content.

10. In general, wines stored in glass bottles, plain and coloured as well as steel containers were superior to both the pet jars as well as china clay jar.

11. Wines in bamboo containers as well as clay pots showed spoilage symptoms shortly after their storage. Hence, these are not suited for wine storage due to their porous nature.

12. Between the three environments, wines stored in dark were found to be superior in terms of taste, flavour and alcohol strength as pursued by the panelists, in comparison with wines from open room as well as refrigerated storage.

13. There was a general improvement in the wines after six months of storage. The wines stored in dark showed improvement in their colour, aroma, sugar-acid blend, alcohol strength and overall acceptability.

14. The blended wines prepared by mixing cashew apple wine with grape, pineapple and banana wines were found to be good and were rated superior in the sensory evaluation. The wine blends from mango and jackfruit wines were ranked as less acceptable.

15. The wine coolers prepared using orange, tomato, pineapple, grape and cashew apple juices as well as tender coconut water had good acceptance. But those from mango juice and toddy were rated as of less acceptability.

16. Blending of cashew apple wine with grape wine will help reduce the cost of the latter, since cashew apple is available at a cheap price. Cashew apple wine could be blended to the extent without affecting the taste of grape wine. Through this approach, quality grape wine can be obtained at a much cheaper rate.

17. The wine coolers serve as good health drinks as they contain both, wine with its medicinal properties and fruit juices with high amount of nutrients and minerals. These can serve as a good alternative food for patients. Due to their low alcohol content, they can be also recommended for children.

Cashew apple wine making can serve as an added income to farmers as it is liked by wine fanciers, serves as a good health drink and also helps to prevent the post harvest loss of the fruit by means of the simple technique of fermentation for wine preparation.

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(* - originals not seen)

Appendices

APPENDIX - I

(i) Meteorological data during the period of study (2000)

Weeks	Temperature		Relative Humidity
	Maximum	Minimum	
1	32.2	23.8	58.00
2	31.9	24.3	62.15
3	33.5	22.4	57.50
4	33.8	22.1	60.20
5	33.7	19.9	57.50
6	33.2	22.9	74.50
7	34.2	23.0	62.00
8	33.2	22.6	74.50
9	33.9	23.8	64.00
10	35.1	23.3	71.15
11	34.8	23.9	69.30
12	35.9	23.8	66.35
13	36.3	24.7	69.50
14	33.1	23.6	76.05
15	34.2	24.9	73.50
16	34.1	24.5	73.00
17	34.2	25.1	71.00
18	34.4	25.0	70.50
19	34.9	25.0	68.00
20	31.0	24.5	71.00
21	32.8	24.2	77.00
22	31.6	23.5	80.00
23	28.9	22.4	89.50
24	29.9	22.8	84.50
25	29.6	23.2	84.50
26	29.4	22.5	84.50
27	28.9	22.0	84.50
28	29.2	21.5	84.00
29	30.1	22.8	79.50
30	30.9	23.2	77.00
31	31.1	23.6	80.50
32	29.0	22.8	87.00
33	29.4	22.6	85.50
34	27.7	22.0	91.50
35	29.4	22.1	83.50
36	30.6	22.9	80.50
37	31.2	23.3	79.50
38	30.4	22.9	82.00

39	30.7	23.3	83.00
40	28.9	22.0	85.50
41	30.2	22.1	78.00
42	30.6	23.6	82.00
43	31.7	19.8	74.00
44	32.6	23.3	72.50
45	33.4	23.0	60.00
46	32.5	24.1	57.50
47	32.6	23.9	73.00
48	31.1	20.8	73.00
49	31.1	23.3	61.00
50	31.1	21.2	50.50
51	31.5	22.6	55.00
52	30.7	21.4	65.00

(ii) Meteorological data during the period of study (2001)

Weeks	Temperature		Relative Humidity
	Maximum	Minimum	
1	32.1	23.1	64.50
2	32.5	22.9	57.5
3	32.6	23.0	48.50
4	33.5	23.4	54.00
5	31.9	23.3	64.50
6	34.3	22.1	62.50
7	34.9	22.4	59.50
8	35.9	23.5	71.00
9	35.2	23.7	67.00
10	35.0	23.5	73.00
11	35.2	23.4	58.50
12	34.3	24.2	59.50
13	34.3	25.2	70.50
14	35.2	25.3	73.50
15	33.1	23.4	77.00
16	33.7	24.8	77.00
17	34.3	25.5	76.50
18	33.5	25.4	71.50
19	33.0	25.5	75.00
20	32.8	25.0	76.50
21	31.4	23.5	83.50
22	30.8	23.7	81.50
23	29.0	22.0	88.00
24	28.0	23.1	88.50
25	29.7	23.3	87.50
26	29.3	22.9	85.50
27	28.7	22.7	88.50
28	28.9	22.5	88.50
29	30.2	23.2	78.00
30	28.3	22.6	86.00
31	27.2	22.3	88.50
32	29.9	23.5	83.50
33	29.0	23.1	88.00
34	30.1	23.2	83.00
35	30.3	23.5	81.50

STANDARDIZATION OF TECHNIQUES FOR CASHEW APPLE WINE PRODUCTION AND DEVELOPMENT OF WINE BASED PRODUCTS

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Abstract

The present study on the 'Standardization of techniques for cashew apple wine production and development of wine based products' was conducted in the Department of Processing Technology, College of Horticulture, Vellanikkara during 1999-2001.

The evaluation of the efficiency of three strains of wine yeast in the preparation of cashew apple wine revealed that strain MTCC 180 was superior to the other strains. It produced wine of high alcohol content and low acidity. Jaggery proved to be a better ameliorant than cane sugar in case of all three strains, as the musts resulted in wines of high alcohol and high TSS and total sugar content.

Gelatin (1%) was found to be superior to the other clarifying agents, viz., PVP, pectin and rice gruel, as it produced wine of good quality with regard to all the sensory attributes. Rice gruel and PVP (0.4%) also served as good clarifying agents, but due the high cost of PVP, its use may not be economical. The cost of gelatin being considerably low and rice gruel, available in all house-holds of Kerala in plenty, these two could be used for clarification of cashew apple juice to produce good quality wine.

The varietal evaluation of cashew apples for wine making revealed that the varieties, Madakkathara-1 and Dhana were superior to the other varieties studied. Wine from Madakkathara-1 had high alcohol content, good flavour and overall acceptability, while that from Dhana recorded low astringency and possessed a favourable sugar-acid blend.

Wines kept for a storage period of six months showed a general improvement in its quality and acceptability over the fresh wines. Plain as well as coloured glass bottles and steel containers were found to be superior to pet jars

and china clay jar, for storage of wines. Bamboo containers and clay pots, due to their highly porous nature were not suited for wine storage. Storage of wines in dark, rather than open or refrigerated condition was found superior in terms of quality and acceptablity.

Cashew apple wine blended with wines from that of grape, banana and pineapple was found to result in products of better acceptability. Similarly, cashew apple wine mixed with fresh fruit juices like those of orange, pineapple, tomato, grape and cashew apple as well as tender coconut water produced wine coolers of high consumer acceptance. Hence, preparation of these two products from cashew apple wine can be recommended to increase the consumption of the wine. Besides, wine coolers due to its constituents also possess several nutritional as well as medicinal properties and can be popularised as a health drink. These wine based products, viz., blended wines and wine coolers can bring additional income to farmers through utilization of the otherwise wasted cashew apple.