QUALITY EVALUATION OF FRUIT BEVERAGES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Quality evaluation of fruit beverages"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled **"Quality evaluation of fruit beverages"** is a record of research work done independently by **Miss. Sujata Sethy,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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AFFECTIONATELY DEDICATED TO MY BAPA, MAA AND SATYA

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ABBREVIATIONS

BHC	-	Benzene Hexa Chloride
cfu	-	colony forming unit
DDT	-	Dichloro Diphenyl Trichloroethane
FPO		Fruit Product Order
g	-	gram
HACCP	-	Hazard Analysis and Critical Control Point
kg	-	kilogram
mg	-	milligram
μg	-	microgram
PFA	-	Prevention of Food Adulteration
ppm	-	parts per million
RTE	-	Ready To Eat
RTS	-	Ready To Serve
SNF	-	Solid Non Fat
UV	-	Ultra Violet

INTRODUCTION

1. INTRODUCTION

India is endowed with varied topography and diversity in climatic conditions to grow an array of tropical fruits like mango, banana, grapes and citrus fruits; subtropical fruits like oranges, pineapple as well as temperate fruits like apple, plum, peaches and apricot in different soil types. India has good adaptability to divergent flora and rich technical manpower for fruit production (Jain, 2002).

Area under fruit cultivation increased from 2.87 million hectares during 1991-92 to 3.73 million hectares during 1998-99. Similarly, production increased from 28.63 to 44.04 million tones during 1998-99 recording an increase of 53.83 per cent (Negi, 2001 and Jain, 2002). India produces 44.30 million tones of fruits, out of 474.03 million tones in the world, which accounts for 10 per cent of the total world production of fruits and stands second after China (FAO, 2001)

Fruits are perishable and are available in seasonal surpluses during certain parts of the year in different regions and are wasted in large quantities due to the absence of facilities and know-how for proper handling, distribution, marketing and storage. About 35 per cent of the total production is unfortunately wasted due to inadequate facilities for processing (Narasimhan, 1998 and Hemasankar and Bhuvaneswari, 1999). In this scenario, fruit processing becomes critical.

Several processed foods from fruits have been developed such as beverages, jams, jellies, candies, preserves canned fruits, dehydrated fruits, sauces and wines (Swatiyandagni, 1995). The above products are prepared from specific fruits, individually or in combination with other fruits commercially to suit the palate of consumer and the same are also marketed.

Fruit juices and fruit beverages are becoming popular due to their pleasing flavour, taste, and nutritional characteristics. Beverages have been increasingly gaining popularity throughout the country. These beverages have been successfully prepared from different fruits such as mango, kinnow, watermelon, grapes, pineapple, apricot etc. In India, among the various fruit based beverages, Ready to Serve (RTS) beverages ranks first with a production of 258.9 thousand tones followed by squashes/syrup (74.20 thousand tones), fruit juices (30.80 thousand tones) and fruit juice concentrate (8.50 thousand tones) during 1996-1997 (Deka *et al*., 2002)

Fast growth in processing sector is expected to occur in both developing and developed countries. The beverage industry is growing at a faster rate and more new health foods including beverages are entering in the market. So, the beverages should be adequate not only in terms of quantity but also of good quality, free from microbial and chemical contamination. A wide range of biological, chemical and physical agents may contaminate food at different stages of the food chain. The extraneous matters that contaminate foods are in the form of pesticides, heavy metals, man made chemicals existing as pollutants in environment and the pathogenic microorganisms with their toxic metabolites.

Though, the developed countries have evolved safety oriented food processing techniques and depend on the most modern HACCP system to achieve food safety and to ensure exclusion of health hazards, in developing countries the general public is still exposed to various kinds of food borne diseases. This adversely affects the health and efficiency of the public and the tourism industry.

The consumers have several expectations on the foods available in the market including the nutritive value, wholesomeness, purity and safety. So it is imperative to focus sufficient attention on quality assurance and hygienic standards of foods. Hence, the present study has been undertaken to evaluate the quality attributes of commercially available fruit beverages.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Food processing industry has been termed as "sun-rise industry" and several efforts have been made in the last few years to give a big trust to this sector. To avoid the waste during surplus, fruits have to be processed into juice, pulp, squash, syrup, jam and the like. The increasing demand for fruit and vegetable products had resulted with rising standard of living, the desire for a more diversified diet through out the year (Saxena and Arora, 1997)

Fruit beverages are processed from natural fruit juice obtained from single fruit or a combination of fruits. In this study, survey of literature by pertinent texts and research related to the study was carried out and is presented under the following headings.

1. Quality characteristics of fruit beverages.
2. Storage stability of fruit beverages.
3. Contaminants present in fruit beverages.
4. Microbiological evaluation of fruit beverages.

2.1. QUALITY CHARECTERISTICS OF FRUIT BEVERAGES

The chemical constituents of pomegranate juice was analysed by Wasker and Deshmukh (1994). It had 16.84^0 brix TSS, 5.10 pH, 0.38 g acidity, 15.15 g reducing sugar and 54.40 mg total anthocyanin per 100 g. Similarly, mango juice developed by Shesadri *et al*. (1994) contained 0.37 g acidity, 3.7 pH, 50 mg ascorbic acid and 898 μ g beta-carotene per 100 g.

The canned alphonso mango juice had recorded 20.8^0 brix TSS, 0.3 per cent acidity, 0.2 g reducing sugar, 17.0 g total sugar, 5.1 mg carotenoids and 13.1 mg vitamin C per100 g (Gowda and Ramanjaneya, 1995). Chemical constituents of kinnow juice was analysed by Saini and Pal (1997) and the juice contained 3.94 pH, 0.96 g acidity, 4.89 g reducing sugar, 10.38 g total sugars and 14.6 mg ascorbic acid per 100 g.

Khurdiya *et al* (1997) reported 17.3^0 brix, 0.82 g acidity per 100 ml of grape juice. Similarly, Tejinder *et al*. (1999) reported that pasteurized grape juice containing 14.5^0 brix TSS, 3.54 pH, 0.71 per cent acidity and 13.5 per cent reducing sugar.

The squash prepared from apricot by Manan *et al*. (1992) contained 45^0 brix and 1.2 per cent acidity. Papaya squash prepared by Sheeja (1994) was analysed for different chemical constituents and contained 1.60 per cent acidity, 5 per cent reducing sugar, 67-70 per cent total sugar and TSS of 56.80^0 brix.

Muskmelon squash prepared by Teotia *et al*. (1995) contained 1.04 per cent acidity, 2.70 pH, 44.0 per cent total sugar and 102.0 mg of vitamin C per 100 ml. The squash prepared from different cultivars of plum contained 25 percent pulp, 45^0 brix and 1.2 per cent acidity (Gothwal *et al*., 1998)

Gooseberry squash prepared by Manimegalai and Hilda (1999) contained 5.85 g reducing sugar, 44.83 g total sugar and 87.50 mg vitamin C per 100 ml. Pear and pineapple squash prepared by Sudhagar (2001) contained 3.07-3.14 pH, 1.08 per cent acidity, 1.97-2.01 g reducing sugar and 35.05-35.19 g of total sugar per 100 ml respectively. Strawberry squash prepared from two varieties of fruits contained 1.01 to 1.20 per cent acidity, 45^0 brix TSS, 1.70 to 1.85 per cent reducing sugar, 35.44 to 35.64 per cent total sugar and 15.00 to 18.96 mg vitamin C per 100 ml (Saravanakumar and Manimegalai, 2003).

RTS beverages prepared from Dasheri pulp contained 16.0^0 brix TSS, 3.09 pH, 0.28 g acidity, 8.3 g reducing sugar, 14.0 g total sugars and 0.328 µg of carotenoids per 100g (Beerh *et al*., 1989). RTS prepared from Gola apricot variety contained 16.0^0 brix TSS, 0.3 g acidity, 6.6 reducing sugar and 13.6 per cent total sugar (Manan *et al*., 1992)

The kinnow RTS prepared by Ranote *et al*. (1992) had 15^0 brix TSS, 0.45 g acidity, 4.36 g reducing sugar, 9.95 g total sugar, 0.06 g protein and 3.50 mg ascorbic acid per 100 g. Teotia *et al*. (1992) analysed the nutrient content of RTS prepared by blending muskmelon and mango and the RTS had 15.0^0 brix TSS, 0.26 per cent acidity, 6.55 per cent reducing sugar, 12.80 per cent total sugar. Similarly, RTS beverage prepared from unclarified watermelon juice had 15.0^0 brix TSS, 12.20 g total sugar, 7.26 g reducing sugar and 3.5 pH per 100 g (Chakrabarthy *et al*., 1993)

Chitra (2000) analysed chemical constituents of clarified banana RTS. The RTS beverage contained 0.26 - 0.28 percent acidity, 4.88 to 4.95 pH, 1.58 to 1.75 g reducing sugar and 9.84 to 10.66 g total sugar per 100 ml of juice. Jackfruit RTS developed by Krishnaveni *et al*. (2001) contained 18^0 brix TSS, 5.75 pH, 0.25 g acidity, 15.67 g total sugar, 5.81 g reducing sugar, 5.85 mg ascorbic acid and 15 μg β-carotene per 100g. Jamun RTS beverage contained 20^0 brix, 0.30 per cent acidity, 3.90 pH, 20.5 per cent total sugar and 51.3 mg anthocyanin per 100 ml (Kannan and Thirumaran, 2002).

The ascorbic acid content of limejuice, citrus juice, orange juice and apple drink when analysed were found to be 34, 37, 41 and 47 mg per 100 ml respectively (Yamane and Ogawa, 1998). Cardwel and Christophersen (2000) indicated an ascorbic acid content in the range of 3 to 50 mg per litre in red and white wines prepared from various fruit juices

The nutritional value of ten fruit juices purchased from retail outlets in Doha, Qatar was evaluated by Al-Jadah and Robinson (2002) and among the fruit juices avocado juice was found to be the best source of energy and potassium, followed by banana juice. Guava juice was found to be an outstanding source of vitamin C and carotene.

Carotenoids and ascorbic acid content of cashew apple products namely concentrated juice, frozen pulp, nectar, ready to serve drinks and sweetened concentrated juice were analysed by Assuncao and Mercadante (2003). Ascorbic acid contents varied from 13.7 to 121.7 mg per 100g and total carotenoid varied from 8.2 to 197.8 μ g per 100 g. β-carotene was the main carotenoid present in majority of the products

Gajeswska *et al*. (1998) analysed stewed fruit, herb syrups and honey for nitrates and nitrites. In stewed fruit, herb syrups and in honey nitrate and nitrite content ranged from 1.0 to 94.5 mg KNO_3 per kg and 0.0 to 0.40 mg $NaNO_2$ per kg respectively and were found to be harmless from the health point of view.

The sulphur dioxide content in red and white wines and various fruit juices varied from 0.25-15 mg per litre with detection limit of 0.05 mg per litre (Cardwel and Christophersen, 2000). Ten samples of fruit juices and three sauces were evaluated for benzoic acid and sorbic acid contents and confirmed the legal limit for these constituents (Mota *et al*., 2003).

Seventy-five samples of soft drinks, including lemon and lime juice, orange or lemon barley water commercially available in UK were analysed and the sulphur dioxide content in all the samples were found to be within the statutory limit (Food Standards Agency, UK, 2004a).

In a study conducted by Rajan (1987), it was found that among the 12,575 samples of foodstuffs analysed, 8820 were adulterated with food colours, which were banned by government. Similarly, Crivaro and Feberro (1992) reported the presence of food yellow FCF (F110) in fruit juices and juice based soft drinks.

The analysis done by Biswas *et al*. (1994) to detect the presence of synthetic colouring matters in jam, jelly and sweets it was seen that the levels were within the range of 18 to 220 mg per Kg. Chou *et al*. (2002) developed a method of micellar electrokinetic capillary chromatography (MEKC) for determination of 14 synthetic colours in soft drinks and confectionaries and the presence of illegal colours were not found in the samples. However, in retail foods, about 155 µg of tartrazine per g of sample was detected.

Two hundred and one samples of soft drinks were purchased and analysed for the presence of added colours. The level of colour in all tested samples was within the statutary limits of 100 mg per litre for total colour. Among the 201 retail ready to drink soft drinks, four samples contained levels of sunset yellow or carmoisine in excess of the perspective legal limit of 50 mg per litre in soft drinks. Four other samples contained colours that were not listed on the label (Food Standards Agency, UK, 2004b).

The type and extent of colours added to ready to eat foods prepared in non-industrial sector in India were investigated by Jannalagadda *et al*. (2004). Of the 545 ready to eat foods analysed, 2 per cent contained a combination of permitted and non-permitted colours and 8 per cent contained only non-permitted colours. Among the permitted colours, tartrazine was the most widely used colour followed by sunset yellow. However, in RTE foods with permitted colours, 37 per cent exceeded 100 ppm and 27 per cent were within the prescribed levels and in beverages the level exceeded up to 9450 ppm.

Agar, arabic gum, carboxymethylcellulose (CMC), gelatin, pectin and starch were added at different concentration to buffalo milk containing 3 per cent fat and 9 per cent SNF. Increasing stabilizer levels resulted in a significant increase of yield stress values and consistency indices. Generally, yoghurt containing increase amounts of stabilizers gained higher scores for consistency compared with control (Khalafalla and Roushdy, 1997). Tejinder *et al*. (1999) reported that the pasteurized grape juice contained 0.64 per cent pectin.

2.2. STORAGE STABILITY OF FRUIT BEVERAGES

2.2.1. Changes in chemical constituents during storage.

Analysis of citrus juice stored over a period of eight months at room temperature showed an increase of 37.25 per cent in total acidity, a gradual increase in reducing sugar by 50.88 per cent and slight increase of 1.03^0 brix in TSS (Mehta and Bajaj, 1983). A slight increase in acidity and a negligible change in total sugar was noticed after 150 days of storage of canned papaya juice and nectar (Kulwal *et al*., 1985).

Sethi (1985) analysed stored litchi juice during storage and observed an increase in acidity. However, Bawa and Saini (1987) reported a decrease in acidity and total sugar during storage period of bottled carrot juice at room temperature.

Preserved grape juice was analysed by Sandhu *et al*. (1988) and indicated that processing and pretreatments had negligible effect on acidity, no change in reducing sugar and a little change in TSS during 24 weeks of storage.

Tripathi *et al*. (1988) reported an increase of 0.86 per cent in acidity, 0.19 per cent in reducing sugar and 1 per cent increase in total sugar and TSS of amla juice during 135 days storage.

Lotha (1992) reported that the quality attributes of kinnow mandarin natural juices were not much affected due to temperature and period of storage.

Analysis of kinnow juice over a period of storage of six months at ambient temperature indicated negligible to slight change in acidity, improvement in invert sugar, negligible change in TSS and a decline in total sugar (Ranote *et al*., 1992).

Inyang and Abah (1997) assessed the chemical composition of juice from steamed cashew apple blended with orange juice and indicated an increase in the soluble solids, titratable acidity, reducing sugar and total sugar with increase in the proportion of orange juice.

Goyle and Ojha, (1998) stored orange juice at refrigerated temperature without preservative and at room temperature with preservative for a period of four weeks. The result revealed a decrease in pH and an increase in titratable acidity with increase in storage time at refrigerated temperature and no appreciable changes for the juice stored at room temperature.

Ghorai and Khurdiya (1998) analysed kinnow mandarin juice during storage and noted a decrease in total soluble solids, acidity, total sugars and an increase in reducing sugar during the storage of four months with the increase in temperature and period of storage.

Watermelon juice was analysed for its storability by Chahal and Saini (1999) and found comparatively higher losses in acidity, total sugar with respective increase in reducing sugar during the storage period of six months.

Dhaliwal and Hira (2001) studied the storage changes in four different combinations of carrot juice with two levels each of beetroot and black carrot juice. The change in pH, acidity, and total solids of the juices during storage was found to be insignificant.

More *et al.* (2001) observed a reduction of 0.78 to 0.012 per cent acidity and 0.285 to 0.200 per cent tannin in the clarified pomegranate juice during storage of 120 days.

Lime juice stored at room temperature for 75 days was analysed by Sarolia and Mukharjee, (2002) and indicated an increase in total and reducing sugars, pH and TSS and a decrease in acidity through out storage.

Litchi juice stored for 12 months was analysed for their chemical properties by Alex *et al*. (2003) and an increase in total soluble solids, acidity and reducing sugar was noted with an increase in storage period.

Alaka *et al*. (2004) analysed the storage stability of chemical attributes of Ogbomoso mango juice and observed a decrease in titratable acidity and increase in pH with increase in storage temperature. However, the soluble solid content of the juice remained constant during the period of storage.

Beerh *et al*. (1989) observed an increasing trend in acidity and reducing sugar and decrease in total sugar content during storage of mango RTS beverage. However, a negligible change in reducing sugar was noted by Ranote *et al*. (1992) in kinnow RTS beverage during storage.

Kinnow RTS stored at ambient temperature conditions over 24 weeks indicated negligible changes in TSS (Shah and Bains, 1992). In the storage studies conducted by Thirumaran *et al*. (1992) in fermented carrot based RTS, a decline in TSS was noticed.

The beverage prepared from enzyme clarified muskmelon juice by Teotia *et al*. (1997) showed an increase in reducing sugar from 4.69 to 11.48 g and a decrease in acidity from 0.36 to 0.28 per cent. The brix content remained constant during storage.

RTS beverage prepared from two varieties of jackfruit were packed in green coloured and colourless glass bottles and stored at room temperature (Krishnaveni *et al*., 2001). The authors observed an increasing trend in the acidity and reducing sugar and decreasing trend in pH and total sugar. However, the TSS content in the beverage during storage remained constant. Sindhumathi (2002) also indicated an increase trend in acidity (0.31-0.32%), reducing sugar (4.26-4.45%) and total sugar (12.50-12.65%) and a decreasing trend in pH (3.79-3.68) for papaya-pineapple blended RTS beverages during the 120 days of storage.

Agrahari and Khurdiya (2003) studied the storage behaviour of RTS beverages prepared from pulp of culled apple pomace and observed a gradual increase in the content of acidity, reducing sugar, total sugar and non-enzymatic browning with increase in storage period. The RTS beverage prepared from tamarind juice was stored at room temperature and low temperature for 180 days and indicated an increase in TSS, titratable acidity and total sugar content of RTS beverage stored at both temperatures (Kotecha and Kodam, 2003).

Analysis of mango squash by Palaniswamy and Muthukrishnan (1974) showed an increase in total acidity over a period of eight months of storage at room temperature.

Orange, lemon, and bael squashes stored at low temperature were analysed by Jain *et al*. (1984) and reported an increase in the percentage of reducing sugars and decrease in non-reducing sugar.

Storage stability of squashes prepared from four varieties of litchi was studied by Jain *et al*. (1988) and indicated a progressive increase in soluble solid content, sugar and browning during storage.

Kalra *et al*. (1991) did not observe significant change in acidity and TSS during twelve months of storage of mango-papaya blended beverage at ambient temperature. Lotha (1992) reported that the quality attributes of kinnow mandarin squash was not much affected due to temperature and period of storage. The papaya-mango blend squash when stored for six months showed an increase in acidity (1.1-1.23%), and decrease in the reducing sugar (33.3-43.4%) content (Manimegalai *et al*., 1994).

The papaya squash stored at ambient temperature for twelve months did not show any change in acidity, reducing sugar and total sugar up to four months. However, after four months an increase in acidity from 1.6 to 1.95 per cent and reducing sugar from 5.61 to 8.42 per cent and a decrease in total sugar from 71.03 to 61.99 per cent were noticed. The TSS remained constant up to three months and there after a steady increase in TSS from 57.4 to 57.8 per cent was observed (Sheeja, 1994).

Jamun squash when stored for eight months indicated a decrease in acidity (1.97-1.20), anthocyanins (53.4-12.9 μg /100 ml) and tannin (170-130 mg /100 ml) and an increase in pH (3.06-3.10), TSS (45-48^0 brix), total sugar (39.0-49.3%) and reducing sugar (18.3-24.4%) (Garande *et al*., 1995).

Hilda and Manimegalai (1996) observed a decrease in pH (1.72-1.69), acidity (1.37-1.34), and reducing sugar (5.85-5.76%), and an increase in total sugar (44.06-44.83%) in amla squash prepared from local variety stored at room temperature for three months.

Saxena *et al*. (1996) developed grape-mango and grape pineapple beverage blends and reported that there was no conspicuous change in the brix of any of the samples during six months of storage. The acidity of the grape-mango blend decreased slightly with corresponding increase in brix/acid ratio. The effect of storage on the level of reducing sugar was also marginal.

Thakur and Barwal (1999) studied the chemical constituent of squashes from two cultivars of kiwi packed in bottles during storage at ambient condition for 150 days and indicated a decrease in TSS (45.0-44.67^0 Bx) and total sugar (36.7-35.18%) and an increase in pH (2.49-2.53) during storage.

The squash prepared from clarified juices of Rasthali, Poovan and combination of Rasthali and Poovan varieties showed a gradual increase in acidity (1.05-1.26%) and reducing sugar (3.40-5.75%) and a decrease in pH (2.51-2.33) and total sugar (33.80-28.80%) during storage of 300 days stored at room temperature and refrigerated temperature (Chitra, 2000). Sudhagar (2001) observed an increasing trend in acidity and total sugar and a decreasing trend in pH and reducing sugar in pear squash and pear-blended squash during storage of 180 days at room temperature.

Kannan and Thirumaran (2002) studied the storage behaviour of jamun squash for a period of six months. The initial and final chemical constituents of the jamun squash varied from 45-47.6^0 brix TSS, 1.20-1.16 per cent acidity, 3.06-3.10 pH, and 39-48.2 per cent total sugar, 18.32-23.5 per cent reducing sugar, 53.42-12.5 mg per 100ml anthocyanin and 172-120 mg tannin per 100 ml respectively.

The storage stability of tamarind syrup was studied by Kotecha and Kodam (2003) and observed a gradual increase in TSS, titratable acidity and total sugars. The rate of increase or decrease, however, was higher in syrups stored at ambient condition than in low temperature.

Lotha (1992) reported that the quality attributes of kinnow mandarin natural juices were not much affected due to temperature and period of storage. However, the author observed cloudiness and considerable change in ascorbic acid content in the juice due to storage temperature.

Goyle and Ojha (1998) stored orange juice at refrigerated temperature without preservative and at room temperature with preservative for a period of four weeks. The authors observed a loss of 5-8 per cent of vitamin C in the juices both at refrigerated and at room temperature after four weeks.

Kinnow mandarin juice was analysed during storage and noted a decrease in ascorbic acid and total carotenoid content (Ghorai and Khurdiya 1998). Similarly, watermelon juice was analysed for its storability by Chahal and Saini (1999) and found comparatively higher losses in ascorbic acid content during the storage period of six months.

Dhaliwal and Hira (2001) observed 70-80 per cent loss of ascorbic acid and 57-67 per cent β-carotene content during storage of four different combinations of carrot juice with two levels each of beetroot and black carrot juice.

More *et al*. (2001) in clarified pomegranate juice, Sarolia and Mukharjee (2002) in lime juice, Alex *et al*. (2003) in litchi juice and Alaka *et al*. (2004) in Ogbomoso mango juice observed a decrease in ascorbic acid content through out the storage period.

Beerh *et al*. (1989) observed a decrease in β-carotene content during storage in mango RTS. Rosario (1996) studied the effect of storage time and temperature on the fermented juice blends of guava-carrot-bilimbi RTS and found a significant decline in ascorbic acid and pro vitamin A during storage with increase degradation at higher temperature. The beverage prepared from enzyme clarified muskmelon juices by Teotia *et al*. (1997) showed a decrease in ascorbic acid from 2.93 to 1.89 mg per 100 g during storage.

Jackfruit RTS beverage packed in green coloured and colourless glass bottles stored at room temperature showed decreasing trend in ascorbic acid and β-carotene content. The authors also indicated that the retention of ascorbic acid and β-carotene content were much better in the samples stored in green coloured bottles (Krishnaveni *et al*., 2001). Similarly, Sindhumathi (2002) also indicated a decreasing trend in ascorbic acid (9.12-7.90%) and beta-carotene (450-418 μg/100g) during storage of papaya-pineapple blended RTS beverage.

Agrahari and Khurdiya (2003) studied the storage changes of RTS beverages prepared from pulp of culled apple pomace with respect to ascorbic acid content and observed a gradual decrease in the content of ascorbic acid with increase in storage period.

The RTS prepared from tamarind and tamarind syrup (Kotecha and Kodam, 2003) was stored for 180 days and a decrease in ascorbic acid content was observed in both.

Orange, lemon, and bael squashes stored at low temperature were analysed by Jain *et al*. (1984) and reported a gradual loss in ascorbic acid content. Storage stability of squashes prepared from four varieties of litchi was studied by Jain *et al*. (1988) and indicated a decrease in ascorbic acid and tannin content during storage. Kaushik and Nath (1991) in mango beverage and Lotha (1992) in kinnow mandarin juice also observed a decrease in ascorbic acid content during storage.

The papaya-mango blended squash when stored for six months showed a decrease in carotene (1476.3-1082.6 μg/100g) content (Manimegalai *et al*., 1994). Hilda and Manimegalai (1996) observed a decrease in vitamin C (87.6-43.58 mg/100g) stored at room temperature for three months.

Kaushik and Nath (1991) analysed mango beverage from four varieties of mango during storage and a decrease in sulphur dioxide content with an increase in the duration of storage at room temperature. Thakur *et al*. (2000) also observed a decrease in sulphur dioxide concentration in debittered kinnow juice concentrate during storage.

Alex *et al*. (2003) analysed the storage stability of sulphur dioxide in processed litchi juice and observed a decrease in sulphur dioxide content with an increase in the duration of storage. However the decrease was found to be at a slower rate at low temperature than at room temperature.

The canned juices were analysed during a storage period of two years by Arvanitoyannis (1990) for the mineral content and an increase in iron, copper and zinc was noticed in tinned peach, pear, apricot and apple juice. However, the aluminium, nickel and antimony contents remained constant during storage.

Mango beverages from four varieties of mango was analysed by Kaushik and Nath, (1991) and a decrease in pectin content was reported during storage. Chahal and Saini (1999) also found a loss of pectin during storage at room temperature and at refrigerated temperature in watermelon juice.

2.2.2. Changes in organoleptic characteristics

Sandhu *et al*. (1988) evaluated the organoleptic qualities of grape juice during storage and indicated no change in colour. A total of seventy-five samples of whey and fruit juice blended beverages were subjected to sensory evaluation using a scoring system with weighted factors. All the beverages had good sensory properties, characterized by satisfactory clarity, good colour and pleasant typical odour and flavour (Vojnovic *et al*., 1993)

Inyang and Abah (1997) evaluated the organoleptic qualities of blended juice of steamed cashew apple and orange juice and the flavour, taste and overall acceptability was found to be good for the blended juices prepared in a proportion of 60:40.

Vaidya *et al*. (1998) assessed the acceptability study on ber, pomegranate and guava mixed fruit juice beverage and the guava: pomegranate blend in the proportion of 30:70 was turned to be superior to other combinations.

The blending of pomegranate juice and kokum juice in 80 and 20 per cent gave the highest organoleptic scores as 8.90, 8.40, 7.88 and 8.39 for colour, flavour, consistency and overall acceptability respectively (Wasker, 2003).

Ranote *et al*. (1992) evaluated the kinnow juice and beverages organoleptically and indicated that the products were highly acceptable in the chilled form as fresh or processed. The fermented carrot based RTS beverage was acceptable for all the quality attributes like colour, appearance, flavour and taste for more than six months (Thirumaran *et al*., 1992)

Chakrabarthy *et al*. (1993) reported that the watermelon RTS beverage prepared with or without blending with lime juice or pineapple juice had acceptable quality and shelf life upto six months. The organoleptic evaluation of RTS prepared by using different levels of custard apple juice indicated that the colour and appearance, body, taste, aroma and acceptability scores increased with increase in custard apple upto 20 per cent. The beverage prepared from 20 per cent juice was extremely liked by the panelist and had a flavor of custard apple (Kotecha *et al*., 1995)

The RTS beverage containing grape juice and mango pulp were light brown in colour where as those containing grape and pineapple were light yellow in colour at the end of six months of storage. The aroma of mango and pineapple dominated in the respective beverages containing an increased proportion of mango pulp and pineapple juice. Though all the beverage blends were acceptable to the taste panel, the blends containing juice: pulp in the ratio of 1:1 and brix acid ratio of 60:1 was liked most because of the balanced taste and flavours (Saxena *et al*., 1996).

The RTS beverage prepared from watermelon had excellent sensory quality attributes such as colour, flavour, taste and aroma (Teotia *et al*., 1997). The use of ascorbic acid had improved the taste and flavour of the products.

The feasibility of blending of fruit juice/pulp of lime, anola, grape, pineapple and mango in different proportions (5-95%) for the preparation of RTS beverage was studied by Deka *et al*. (2001). The prepared RTS beverages were organoleptically evaluated. Among the different combinations, 95 per cent lime and 5 per cent anola was found to be the best on overall sensory score.

The RTS beverage prepared from two varieties of jackfruit was evaluated for sensory quality attributes. A slight decrease in sensory scores for appearance, colour, flavour, taste and overall acceptability was observed during storage of six months (Krishnaveni *et al*., 2001).

The pomegranate juice blended with mango pulp for the preparation of RTS beverage indicated that, pomegranate: mango in the proportion of 60:40 blend was superior than other combination because of good colour and appearance, flavour, taste and overall acceptability compared to other combinations (Nakadi *et al*., 2001).

Saravanakumar and Manimegalai (2001) studied the organoleptic characteristics of the RTS beverages based on blended pear, pineapple and pomegranate juices and indicated a decreasing trend in colour, flavour and taste and overall acceptability through out the storage period.

Three brands of RTS mango drinks namely Frooti, Real, Slice were evaluated for sensory attributes along with vacuum dried reconstituted mango powder drink by Jaya (2003) and the mango drink ‘Slice’ was found to be the best followed by Real and Frooti.

The squash prepared from Rangpur limes were quite acceptable upto nine months of storage with attractive light yellow colour, pleasant taste and flavour. Beyond this period the colour was brown and had a slight terpenous flavour (Krishnamurthy and Giridhar, 1990).

The squashes prepared from two varieties of apricot were found to be quite satisfactory with respect to sensory quality attributes upto six months of storage at room temperature (Manan *et al*., 1992). However, a slight fading of colour was observed after four months of storage.

The papaya mango blended squash prepared in the ratio of 50:50 was stored for six months at room temperature and evaluated by Manimegalai *et al*. (1994) and observed a decrease in the over all acceptability of the squash.

Garande *et al*. (1995) reported a slight decrease in organoleptic scores of jamun squash during storage of eight months at ambient temperature. The initial score varied from 7.3-6.4 for colour, 6.5-6.1 for flavour and the average score was found to vary from 6.9-6.2.

The overall acceptability scores of squashes prepared from local and hybrid varieties of amla stored at room temperature for three months indicated a reduction of 4.0 to 3.5 and 3.8 to 3.17 respectively (Hilda and Manimegalai, 1996).

Organoleptic characteristics of pear, pineapple and pear blended squashes were studied by Sudhagar (2001) during storage of 180 days and indicated a decrease in appearance, colour, flavor, taste and overall acceptability of pear squashes and pineapple and pear blended squashes.

2.3. CONTAMINANTS PRESENT IN FRUIT BEVERAGES

The canned fruit juice was analysed for heavy metals by Arvanitoyannis (1990) and a significant increase in lead content was observed during a storage period of two years. However, there was no change in the cadmium content of the juices. The lead and cadmium content of juices were determined by Tahvonen (1998) and the mean lead content of juices was found to be 9 μg per kg and cadmium content was found to be less than 1 μg per kg.

Forty-five samples of musambi juice from three different categories of sellers i.e. shopkeepers having low, moderate and high sale intensity were studied for the presence of trace minerals and the minerals like iron (1.45 mg), nickel (0.53 mg), copper (0.27 mg), manganese (0.04 mg), zinc (0.16 mg), cadmium (0.19 mg) and lead (0.89 mg) were found in all musambi samples (Choudhary, 1999).

Chromium level of fruit juices was determined by Garcia *et al*. (1999) and found that in fruit juices the value ranged from not detectable to 17.60 μg per litre. Several beverages including fruit juices and food drinks available in the market in Nigeria were analysed for cadmium, cobalt, chromium, copper, iron, nickel, lead and zinc by Onianwa *et al*. (1999). The level of the various metals was found to be low and within statutory limit.

Levels of manganese (15-22 ppm) in commercial pineapple juices purchased in Australia and the UK were found to be much higher than those of chromium, iron, nickel or copper and much higher than in other common fruit juices (Beattie and Quoc, 2000). The fruit juices were analysed for aluminum concentration by Sepe *et al*. (2001) and the apricot juice showed the highest Aluminium level (X=602±190 mg/l), being statistically different from that of pear (X=259±102 mg/l), but not different from that of peach juice (X= 486±269 mg/l).

Concentration of pesticide residues in fruit juices was detected by Tadeo and Sanchez (2003). The recoveries obtained for pesticides in different fruit juices at various fortification levels were higher than 74 per cent with relative standard deviations between 1 and 12 per cent. The detection limits ranged from 1 to 5 μg per kg.

Venkataraman and Anandavalli (1995) reported that surface water samples collected from five different stations of Tuticorin coast contained heavy metals such as copper, zinc, manganese, iron, cadmium, chromium and arsenic. A simple and rapid method without sample pretreatment was developed to detect trace amounts of arsenic, lead, cadmium and tin in soft drinks. The amounts of arsenic and lead in the soft drinks were less than 0.025 ppm in all samples; cadmium and antimony were detected only in two (0.006-0.019 ppm) and five (6.9-86 ppm) of 150 samples, respectively (Tanaka *et al*., 1996).

Chromium level of portable water and soft drinks was determined by Garcia *et al*. (1999) Chromium level ranged from not detectable to 11.80 μg per litre in portable water and from 3.60 to 60.50 μg per litre in soft drinks.

An increase in the Hydroxy Methyl Furfural in soft drinks from 28 ppm to 897 ppm was observed at 28th day of storage by Ghosh (2001) when the maximum permissible limit in the food is 80 ppm.

The soft drinks were analysed for aluminium concentration by Sepe *et al*. (2001). It was found that in soft drinks the concentration of aluminium was lower, ranging from 9.1 to 179 μg per litre. The highest values were observed in samples of orange squash.

Samples of 10 brands of beer produced by different Polish manufactures were taken from shops and the concentration of some metals was estimated by

Bulinski *et al*. (1996). It was estimated that the corresponding values for lead, cadmium and nickel were 3.3-7.6, 0.7-1.4 and 7.0-28.0 µg per kg respectively.

Seventy samples of wine produced in Spain and 64 samples of other alcoholic beverages widely consumed were estimated for lead contamination. It was found that the concentration of lead in wine varied from not detectable to 1125.00 µg per litre and in other alcoholic beverages from not detectable to 444.70 µg per litre (Mena *et al*., 1997).

The lead and cadmium content of beer and wines were determined by Tahvonen (1998) and found that the mean lead content of domestic beers is 3 µg per kg where as in imported beer it is 4 µg per kg. The mean lead content was 16 µg per litre in domestic miscellaneous wines, 33 mg per litre in imported white wines, 9 µg per litre in domestic red wines and 34 µg per litre in imported red wines. The cadmium content in all beverages was less than 1 µg per kg, except for domestic red wines made from raspberry, which contained 2 µg per kg.

Different alcoholic beverages were estimated for cadmium concentration and found a cadmium content in between less than 0.01 to 0.13 mg per g of the sample (Kikuchi *et al*., 2002).

Lead and cadmium contents of various wines on Korean market were determined by Kim (2004) and mean lead and cadmium contents of the wines were found to be 29 µg per litre and 0.5 µg per litre.

Different authors have reported organochlorine residues, DDT, BHC, lead, cadmium, mercury, nickel, arsenic, tin etc. in other beverages like human and dairy milk, milk products and yoghurt (Naseema *et al*., 1991; Visalakshi *et al*., 1991; Handa, 1992; Sanchez *et al*., 1996; Szkoda and Zmudzki, 1996; Sanchez *et al*., 1997; Surendranath *et al*., 2000 and NIN, 2002).

2.4. MICROBIOLOGICAL EVALUATION OF FRUIT BEVERAGES

Hassan *et al*. (1992) studied the microbiological load of apple juice and pulp and observed an average load of $6.2x10^3$, $1.8x10^5$, $9.2x10^3$ and $2.3x10^5$ yeast, moulds and bacteria and osmophiles respectively per 100 ml of juice. The authors also noted that heat treatment reduced the overall microbial load from 96.0 to 93.3 per cent without any detrimental effect on physico-chemical characteristics of the juice.

Microbiological evaluation of pineapple juice and guava, passion fruit and grape fruit nectars was conducted by Tchango *et al*. (1992) and observed thermo tolerant coliforms such as Escherichia coli, Klebsiella pneumoniae, Enterobactor agglomerans and Serratia rubidaea in pineapple juice. The authors also observed many spoilage microorganisms such as Yeasts, coliforms, non-pathogenic Staphylococcus and Leuconostoc, Lactobacillus, Bacillus, Micrococcus, Pediococcus and Acinetobactor sp. in deep frozen juice and nectars without previous pasteurization and fecal microorganisms in non-pasteurized pineapple juice.

Total bacterial count of commercially prepared carrot, sobia, tamarind and sugarcane juice and drinks was studied by Daw *et al*. (1994) and sobia drink was found to have a bacterial count with a mean value of $2.3x10^8$ cfu per ml. The least count was found in tamarind juice with a mean value of $3.9x10^5$ cfu per ml. The presence of coliform was detected in 90, 30, and 10 per cent of carrot, sugarcane and sobia samples respectively.

While studying the microbial quality of sugarcane juice, Kumari (1995) found that the samples were highly loaded with microbes. The mean values observed were $237.37x10^7$, $117.06x10^2$, $114.12x10^2$, and $51.115x10^2$ cfu per ml for total viable organisms, yeast and moulds, S. aureus and coliforms respectively.

Microbial evaluation of pineapple and lemon juices by Sharma (1995) indicated that fresh lemon juice had zero total viable count; where as, raw pineapple juice had $0.15x10^2$ to $0.21x10^2$ total viable count.

Goyle and Ojha, (1998) evaluated orange juice for microbial load and reported a plate count of $5.2x10^2$ and $65x10^2$ cfu per ml at the beginning of the study in the preservative and non-preservative groups respectively. The authors also observed an increase in bacterial count during the first week and a decrease in bacterial count from second to forth week of storage in both groups.

Debittered kinnow juice concentrate was evaluated for microbial count by Thakur *et al*. (2000) and detected low microbial count in the concentrate at the beginning, which increased with the advancement of storage. Walls and Chuyate (2001) observed acid tolerant bacteria like Alicyclo bacillus and Acido terrestris in thermally treated high acidic fruit juices due to high TSS.

Microbiological quality of fresh fruit juices sold through retail outlets in Qatar was evaluated by Al-Jadah and Robinson (2002) and the microbiological quality of all the fruit juices was well outside the Gulf standards. The authors observed a coliform count above $1.0x10^6$ cfu per ml in mixed fruit juice, in which both Escherichia coli and Enterococcus faecalis ($1.0x10^7$ cfu per ml) were detected.

Apple cider in the state of Iowa was found to be not contaminated with E. coli (Cummins *et al*., 2002). Khan and Malik (2002) indicated the presence of total viable count (TVC) ($68x10^6$ to $2080x10^6$ cfu per 100 ml), staphylococcus ($147x10^6$ cfu per 100 ml), coliforms (2.24×10^3 MPN per 100 ml), and faecal coliforms (1.64×10^3 MPN per 100 ml.) in fruit juices. However, Shigella and Salmonella were not detected in any of the fruit juices.

Sripathy *et al*., (2002) examined fruit juices like fruity mango, orange, jumpin pineapple, orange and mango juices for microbial quality and observed a total bacterial and staphylococcal count of less than 50 per ml and 10 per ml respectively. Studies carried out by the authors on tender coconut and sugarcane juices were found to be free from coliforms. However, sugar cane juice, which is very popular and comparatively economical, had very high coliforms and staphylococcal count.

Thirty-two samples of fruit juices were examined for the presence of moulds, yeast, coliform bacteria, Escherichia coli and Salmonella sp. by Boas *et al*. (2003) and twenty-one samples had mould and yeast count higher than the microbiological standards established by the 1997 federal legislation.

Singh and Sankhla (2003) analysed sixty-four samples of sugar cane juice collected from different categories of vendors and shopkeepers and the samples obtained from vendors were found to be highly contaminated with microbes.

Presence of bacteria (5.0×10^6/g), fungi (6.0×10^4/g) and yeast (4.0×10^5/g) were detected in strawberry squash after 180 days storage at room temperature (Saravanakumar, 1997) and (Chitra, 2000) observed microbial loads of 4×10^6 per gram for bacteria and 4×10^4 per gram for fungi in clarified banana squash which increased to 12×10^6 per g and 13×10^4 per g after 300 days of storage. Sudhagar (2001) also observed $7\text{-}9 \times 10^6$ per gram for bacteria, $6\text{-}8 \times 10^4$ for fungi and $4\text{-}5 \times 10^5$ per gram for yeast in pear and pear-blended squash after six months of storage at room temperature. However, Bobby and Radhi (2003) indicated a microbial load within the permissible level immediately after formulation and on storage in citrus squashes ensuring that they are safe for consumption.

Yeast, mould and acid producing bacteria were observed at 45 days of storage in sapota, anola and kinnow RTS beverages, which increased during storage (Sirohi *et al*., 1998)

Deka and Sethi (2001) did not observe any bacteria in the spice mixed fruit juice RTS beverages due to the inhibitory effect of spices towards microorganisms. However, there was a negligible growth of mould and yeast in the drinks.

Sindhumathi (2002) did not observe any bacterial load in papaya based blended RTS beverages up to 80 days. However, the author detected bacteria on the 100th day, which later increased to $2.0x10^6$ per gram after 120 days of storage in all the stored RTS samples. Fungal population was not observed in the RTS beverages before and after storage.

Soft drinks like Pepsi, Cola, Mirinda, Sprite, Fanta, Thums up and 7 up were examined for bacteriological quality by Sripathy *et al*. (2002) and it was noted that all beverages had very low bacterial count. However, staphylococcal count of 15 and 18 (x 10^6 cfu per ml) was detected in four soft drinks and one sample contained up to 200 x 10^6 cfu per ml.

Quality evaluation of bottled drinking water (Ambili *et al*., 2003) of different brands available in and around Thrissur district indicated the presence of coliform, staphylococci, faecal staphylococci and Pseudomonas in most of the samples. Spores of Clostridium sp. at hazardous level were observed in drinking water and other foodstuffs by Vasanthi and Natarajan, (2003).

Quality evaluation of pasteurized milk (John *et al*., 2003) and toned pasteurized milk (Sethulakshmi *et al*., 2003) of different brands available in and around Thrissur district indicated the presence of Coliforms, Staphylococci, Fecal Streptococci and Pseudomonas in most of the samples. Vasanthi and Natarajan (2003) indicated spores of Clostridium sp. at hazardous level in raw and pasteurized milk, cream, ghee and cheese.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled "Quality evaluation of fruit beverages" was attempted to evaluate the quality parameters of the selected commercial fruit beverages available in Thrissur market. The materials and methods used for the study are given under the following headings.

1. Selection of fruit beverages
2. Analysis of chemical constituents during storage.
3. Acceptability of the beverages during storage.
4. Enumeration of total microflora of the beverages during storage.
5. Statistical analysis

3.1. SELECTION OF FRUIT BEVERAGES

A market survey was conducted in the various supermarkets and bakeries of Thrissur town to prepare a list of beverages available in the market. From the list different brands of beverages were identified and three most popular and three less popular brands were selected for the study.

Three different latest batches of the selected beverages available in the market were purchased from three different shops and stored at ambient temperature till the expiry date of the beverages.

3.2. ANALYSIS OF CHEMICAL CONSTITUENTS DURING STORAGE

The selected beverages were analysed for the following chemical constituents using standard procedures at bimonthly intervals upto the expiry date.

1. Acidity
2. Total Soluble Solids (TSS)
3. Total sugar
4. Reducing sugar
5. Non-reducing sugar
6. Vitamin C
7. β-carotene
8. Sodium
9. Potassium
10. Emulsifying and stabilizing agents
11. Preservative
12. Coloring substances
13. Heavy metals

3.2.1. Acidity

Titratable acidity of the selected beverages was estimated by titration method with standard alkali using phenolphthalein indicator (Ranganna, 1986).

3.2.2. TSS

TSS of the beverages was estimated by an Erma hand juice Brix refractometer at room temperature and the results were expressed in degree Brix (Ranganna, 1986).

3.2.3. Total sugar

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

3.2.4. Reducing sugar

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

3.2.5. Non-reducing sugar

The difference between the total sugar and reducing sugar was calculated and expressed as per cent of non-reducing sugar (Ranganna, 1986).

3.2.6. Vitamin C

Vitamin C content of the beverages was estimated by the method of A.O.A.C. (1980) using 2,6 dichlorophenol indophenol dye.

3.2.7. Beta-carotene

Beta-carotene content was estimated by the method of A.O.A.C. (1980) using water-saturated n-butanol and the color intensity was read in a spectrophotometer at 435.8 nm

3.2.8. Sodium

Sodium content in selected fruit beverages was estimated by using Flame photometer as suggested by Jackson (1973)

3.2.9. Potassium

Potassium content in selected fruit beverages was estimated by using Flame photometer as suggested by Jackson (1973)

3.2.10. Preservative

Sulphur dioxide added to the beverages as preservative was estimated as per the titration method described by Ranganna (1986) and expressed in ppm.

3.2.11. Colouring substances

The synthetic colours added to the fruit beverages were identified by paper chromatography method and the colour identified was quantified by UV spectrophotometer (ICMR, 1990).

3.2.12. Emulsifying and stabilizing agent

Pectin was extracted by the method suggested by Sadasivam and Manickam (1992) and was expressed as calcium pectate in percentage.

3.2.13. Heavy metals

Lead and cadmium contents were estimated by using Atomic Absorption Spectrophotometer and expressed in ppm.

All the analysis except the colouring agent was carried out in triplicate samples at bimonthly intervals till the expiry date. The presence of synthetic colouring agents of the selected beverages was estimated initially.

3.3. ACCEPTABILITY OF THE BEVERAGES DURING STORAGE

A series of organoleptic trials were carried out using simple triangle test at the laboratory level to select a panel of ten judges between the age group of 18-35 years as suggested by Jellinek (1985).

Organoleptic evaluation of beverages was carried out using the score card (Swaminathan, 1974) by the panel of ten selected judges in the morning time. Four quality attributes like appearance, colour, flavour and taste were evaluated.

Each of the above mentioned attributes was assessed by a five point Hedonic scale at bimonthly intervals upto the expiry date. The score card used for the organoleptic evaluation is furnished in Appendix I

3.4. ENUMERATION OF TOTAL MICROFLORA OF THE BEVERAGES DURING STORAGE

The microbial evaluation of stored beverages were conducted at bimonthly intervals up to the expiry date by Serial dilution and Plate count method as described by Agarwal and Hasija (1986). Ten grams of sample was added to 99-milliliter sterile water and shook for 20 minutes. One ml of this solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution. Similarly 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were also prepared serially.

Enumeration of total microflora was carried out using Nutrient Agar media for bacteria, Potato Dextrose Agar media for fungi and Sabouraud's Dextrose Agar media for yeast and ECD media for *E. coli* obtained from Himedia laboratory, Mumbai.

3.5. STATISTICAL ANALYSIS

The observations recorded were tabulated and the data was analyzed statistically using Completely Randomized Design (CRD). The significant difference between the batches was assessed using the critical difference (CD) at five per cent level.

Different periods of storage were taken into consideration as the different phases of storage to evaluate the impact of storage. The scores of organoleptic evaluation were analysed by Kendall Wallace Analysis of Variance. Statistically, Kendall's coefficient of concordance (w (a)), which expresses the degree of association among the ten judges was worked out for each character under study. Logarithmic transform was effected to microbial count to satisfy the assumption of analysis of variance.

RESULTS

4. RESULTS

The results pertaining to the study entitled "Quality evaluation of fruit beverages" are presented in this section under the following headings

4.1 Selection of fruit beverages
4.2. Chemical constituents of fruit beverages and changes during storage
4.3. Acceptability of fruit beverages and changes during storage
4.4. Microbial count of fruit beverages and changes during storage

4.1 Selection of fruit beverages

For selecting the fruit beverages, a market survey was conducted in Trichur corporation area. To conduct the market survey, a questionnaire was developed (Appendix II) and the survey was conducted in different supermarkets and bakeries of Thrissur corporation area to know the popularity of the fruit beverages. A list of different fruit beverages available in the market was prepared. From this list, different brands of beverages were identified and from this list, three most popular and three less popular brands of beverages were selected. The list of beverages selected were coded (Table 1). The beverages, which are available atleast in two shops, were taken as least popular.

Table 1. Fruit beverages selected for study

Sl. No.	Most popular beverages	Code	Less popular beverages	Code
1	Orange squash	Squash A	Lemon squash	Squash D
2	Pineapple squash	Squash B	Orange squash	Squash E
3	Pineapple syrup	Syrup C	Pineapple syrup	Syrup F

From each brand, three different batches were purchased to conduct the study and these were coded as A_1, A_2, A_3 (squash A), B_1, B_2, B_3 (squash B), C_1, C_2, C_3 (syrup C), D_1, D_2, D_3 (squash D), E_1, E_2, E_3 (squash E) and F_1, F_2, F_3 (syrup F)

4.2. Chemical constituents of fruit beverages and changes during storage.

The chemical constituents such as acidity, TSS, total sugar, reducing sugar, non reducing sugar, β-carotene, vitamin C, sodium, potassium, sulphur dioxide, coloring agents, lead and cadmium in the selected fruit beverages were analyzed at bimonthly intervals upto the expiry date.

4.2.1. Acidity

The acidity of the three most popular beverages varied from 0.64 per cent to 1.28 per cent with a mean acidity of 1.15 per cent in squash A and 0.85 per cent in Squash B, and 0.64 per cent in syrup C initially. In the case of the least popular beverages, the mean acidity varied from 0.64 per cent in syrup F to 0.96 per cent in squash D and E. The acidity of all different batches of squash and syrup was found to be lower than the acidity of not less than 1.5 per cent suggested for squash and syrup by FPO (Table 2).

Significant variation in the acidity was found between squash A_1 and A_3 and squash A_2 and A_3 but the differences was insignificant between squash A_1 and A_2. In squash B, the difference in acidity between squash B_1 and B_3 as well as B_2 and B_3 were found to be statistically significant. The variation in acidity between the batches of all other beverages was statistically insignificant.

During the storage period an increase in the acidity of all the beverages was observed (Table 2 and Fig.1). Among the three most popular beverages the acidity increased from a mean of 1.15 per cent (squash A), 0.85 per cent

Table 2. Acidity (%) of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	1.28	1.6	1.92	2.24	2.56
	Squash A_2	1.2	1.6	1.92	2.24	2.56
	Squash A_3	0.96	1.6	1.92	1.92	2.56
	Mean	1.15	1.5	1.81	2.13	2.34
	CD ($p<0.05$)	0.082				
2.	Squash B_1	0.64	0.64	0.96	1.28	1.29
	Squash B_2	0.64	0.64	0.96	1.28	1.28
	Squash B_3	1.28	1.6	1.6	1.29	1.29
	Mean	0.85	0.96	1.17	1.49	1.70
	CD ($p<0.05$)	0.003				
3.	Syrup C_1	0.64	0.96	1.28	1.6	1.92
	Syrup C_2	0.64	0.96	1.28	1.6	1.92
	Syrup C_3	0.64	0.96	1.28	1.6	1.92
	Mean	0.64	0.96	1.28	1.6	1.92
	CD ($p<0.05$)	NS				
4.	Squash D_1	0.96	1.6	1.6	1.92	2.24
	Squash D_2	0.96	1.6	1.6	1.92	2.24
	Squash D_3	0.96	1.6	1.6	1.92	2.24
	Mean	0.96	1.6	1.6	1.92	2.24
	CD ($p<0.05$)	NS				
5.	Squash E_1	0.96	1.28	1.6	2.24	2.24
	Squash E_2	0.96	1.28	1.6	2.24	2.24
	Squash E_3	0.96	1.28	1.6	2.24	2.24
	Mean	0.96	1.28	1.6	2.24	2.24
	CD ($p<0.05$)	NS				
6.	Syrup F_1	0.64	1.28	1.6	1.92	2.24
	Syrup F_2	0.64	1.28	1.6	1.92	2.24
	Syrup F_3	0.64	1.28	1.6	1.92	2.24
	Mean	0.64	1.28	1.6	1.92	2.24
	CD ($p<0.05$)	NS				

NS – Not Significant

(squash B) and 0.64 per cent (syrup C) during first month to 2.34 per cent, 1.7 per cent and 1.92 per cent during ninth month in squash A, B and syrup C respectively.

Table 3. Changes in acidity of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	0.35	0.11	0.32	0.64	0.32	0.64
2 (3-5)	0.32	0.21	0.32	0.00	0.32	0.32
3 (5-7)	0.32	0.32	0.32	0.32	0.64	0.32
4 (7-9)	0.21	0.21	0.32	0.32	0.00	0.32
CD ($P<0.05$)	0.131	NS	+	0.003	0.003	0.003

+ - No statistical analysis could be conducted.

NS – Not Significant

Among the least popular beverages, acidity increased from 0.96 per cent in squash D and E and 0.64 per cent in syrup F during first month to 2.24 per cent during ninth month of storage in squash D, E and syrup F.

The increase in acidity observed during different storage periods in squash A was found to be statistically significant (Table 3) while the increase in acidity in squash B was statistically insignificant. The increase in acidity in the case of syrup C was found to be uniform during different months of storage. So, no statistical analysis could be conducted. The increase in acidity during different months of storage in the case of least popular beverages was found to be statistically significant.

4.2.2. TSS

The mean total soluble solid content of squash A and B was found to be 50.67^0 and 40.5^0 brix and syrup C was 75^0 brix. In case of least popular beverages the mean TSS was found to be 42^0 brix in squash D, 51^0 brix in Squash E and 74.33^0 brix in Syrup F. The mean TSS of all brands of beverages was found to be in accordance with the FPO standards of not less than 40^0 brix for squash and not less than 65^0 brix for syrup.

When the different batches of the beverages were analysed it was found that in all brands the difference between batches was statistically insignificant except squash A in which a significant difference in TSS content between squash A_1 and A_2 and also between squash A_2 and A_3 were observed (Table 4).

The changes noted in the TSS content of beverages (Table 5) indicated that in squash A and D the TSS remained constant through out the storage period where as in squash B, syrup C, squash E and syrup F an increasing trend in TSS was noticed. In different batches of squash A also TSS content remained constant with a mean TSS content of 50.67^0 brix. In squash B from a mean TSS of 40.5^0 brix initially it increased to 42.67^0 brix during ninth month of storage. In case of syrup C the mean TSS increased from 75^0 brix to 75.66^0 brix during ninth month. The TSS content of squash E increased from 51^0 brix in first month to 53^0 brix in ninth month of storage while in syrup F it increased from a mean of 74.33^0 brix to 77.33^0 brix during storage. The effect of storage in TSS content of beverages is represented in Fig. 2.

The increase in TSS observed during storage in squash B was found to be statistically significant between the third and fifth month and between fifth and seventh month. The increase in the TSS content of different batches of syrup C was found to be insignificant statistically. In the case of least popular beverages, the increase in the TSS content of syrup E was significant during different storage periods except during fifth and seventh month (Table 5). In case of syrup F also the increase in TSS was found to be statistically significant during third and fifth month and seventh and ninth month of storage.

Table 4. TSS (^{0} brix) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	51	51	51	51	51
	Squash A_2	50	50	50	50	50
	Squash A_3	51	51	51	51	51
	Mean	50.67	50.67	50.67	50.67	50.67
	CD (p<0.05)	0.002				
2.	Squash B_1	40.5	41	42.5	43	43
	Squash B_2	41	41	42	43	43
	Squash B_3	40	40.5	41	42	42
	Mean	40.5	40.83	41.83	42.67	42.67
	CD (p<0.05)	NS				
3.	Syrup C_1	75	75.5	75.5	76	76
	Syrup C_2	75	75	75	75.5	76
	Syrup C_3	75	75	75	75	75
	Mean	75	75.17	75.17	75.5	75.67
	CD (p<0.05)	NS				
4.	Squash D_1	42	42	42	42	42
	Squash D_2	42	42	42	42	42
	Squash D_3	42	42	42	42	42
	Mean	42	42	42	42	42
	CD (p<0.05)	NS				
5.	Squash E_1	51	52	52.5	52.5	53
	Squash E_2	51	52	52.5	52.5	53
	Squash E_3	51	52	52.5	52.5	53
	Mean	51	52	52.5	52.5	53
	CD (p<0.05)	NS				
6.	Syrup F_1	74	74	75	76	77
	Syrup F_2	74	75	76	76	77.5
	Syrup F_3	75	75	76	77	77.5
	Mean	74.33	74.67	75.67	76.33	77.33
	CD (p<0.05)	NS				

NS – Not Significant

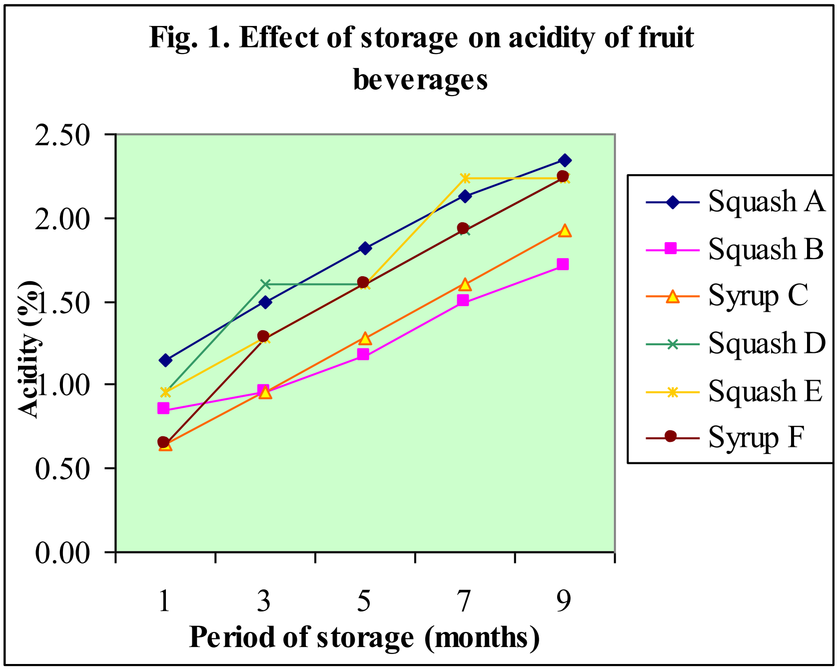


Fig. 1. Effect of storage on acidity of fruit beverages
2.50
2.00
1.50
1.00
0.50
0.00
Acidity (%)
1
3
5
7
9
Period of storage (months)
Squash A
Squash B
Syrup C
Squash D
Squash E
Syrup F

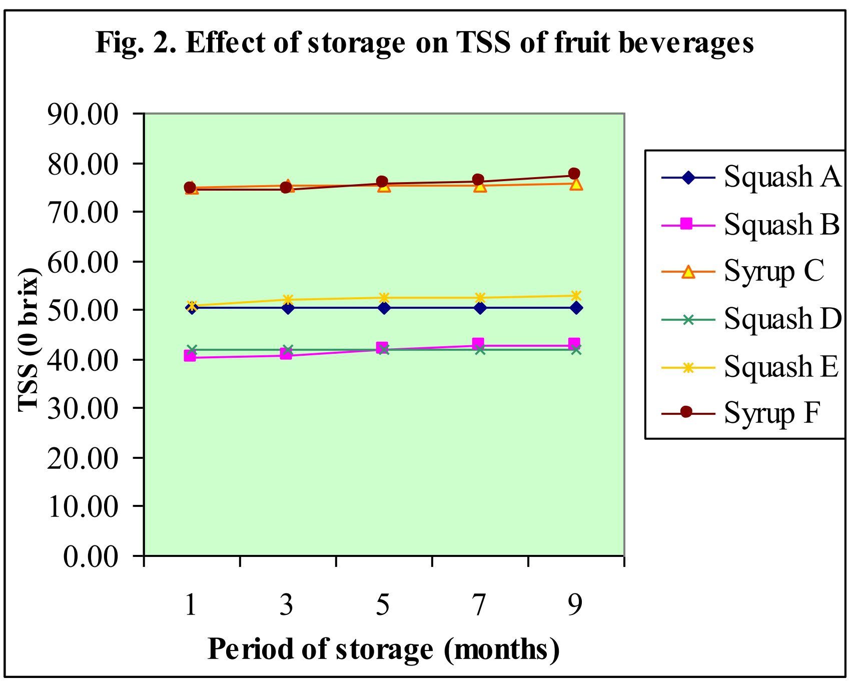


Fig. 2. Effect of storage on TSS of fruit beverages
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TSS (0 brix)
1
3
5
7
9
Period of storage (months)
Squash A
Squash B
Syrup C
Squash D
Squash E
Syrup F

Table 5. Changes in TSS of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	0	0.33	0.17	0	1.00	0.33
2 (3-5)	0	1.00	0.00	0	0.50	1.33
3 (5-7)	0	0.83	0.33	0	0.00	0.33
4 (7-9)	0	0.00	0.17	0	0.50	1.00
CD ($P<0.05$)	+	0.499	NS	+	0.003	0.841

\+ No statistical analysis could be conducted.

NS – Not Significant

4.2.3. Total sugar

Total sugar content of the three most popular beverages varied from 30.64 per cent (squash B_1) to 52.08 per cent (syrup C_1, C_2 and C_3) with a mean content of 32.05 per cent (squash A), 31.26 per cent (squash B) and 52.08 per cent (syrup C). The total sugar content varied from 30.19 per cent (squash D_1) to 54.82 per cent (syrup F_1, F_2 and F_3) in least popular beverages with a mean of 30.79 per cent in squash D, 35 .31 per cent in squash E and 54.82 per cent in syrup F (Table 6).

The difference in total sugar content between different batches of squash A, syrup C, squash E and syrup F was statistically insignificant. In squash B, the difference in the total sugar content of squash B_1 and B_3 and B_2 and B_3 and squash D_1 and D_2 and D_1 and D_3 was found to be statistically significant.

During storage, the total sugar content of fruit beverages increased in all the three most popular beverages. It increased from a mean of 32.05 per cent (squash A), 31.26 per cent (squash B) and 52.08 per cent (syrup C) initially to 37.2 per cent (squash A), 36.77 (squash B) and 61.27 per cent (syrup C) during ninth month of storage. The total sugar content of the three least popular beverages also showed an increase during storage, which increased, from 30.79 per cent (squash D), 35.31 per cent (squash E) and 54.82 (syrup F) initially to 34.53

Table 6. Total sugar (%) content of fruit beverages during storage

Sl. No.	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	32.05	33.60	34.15	35.92	37.20
	Squash A_2	32.05	33.60	34.15	35.92	37.20
	Squash A_3	32.05	33.60	34.15	35.92	37.20
	Mean	32.05	33.60	34.15	35.92	37.20
	CD ($p<0.05$)	NS				
2.	Squash B_1	31.57	33.60	34.15	37.20	37.20
	Squash B_2	31.57	33.07	35.92	35.92	37.20
	Squash B_3	30.64	31.57	33.07	34.15	35.92
	Mean	31.26	32.75	34.38	35.76	36.77
	CD ($p<0.05$)	0.027				
3.	Syrup C_1	52.08	53.42	54.11	55.56	61.27
	Syrup C_2	52.08	53.42	54.11	55.56	61.27
	Syrup C_3	52.08	53.42	54.11	55.56	61.27
	Mean	52.08	53.42	54.11	55.56	61.27
	CD ($p<0.05$)	NS				
4.	Squash D_1	30.19	31.57	32.55	33.60	34.15
	Squash D_2	31.09	32.05	33.07	33.60	34.72
	Squash D_3	31.09	32.05	32.52	33.60	34.72
	Mean	30.79	31.89	32.71	33.60	34.53
	CD ($p<0.05$)	0.027				
5.	Squash E_1	35.31	35.92	36.55	37.88	38.58
	Squash E_2	35.31	35.92	36.55	37.88	38.58
	Squash E_3	35.31	35.92	36.55	37.88	38.58
	Mean	35.31	35.92	36.55	37.88	38.58
	CD ($p<0.05$)	NS				
6.	Syrup F_1	54.82	56.31	57.13	57.13	61.27
	Syrup F_2	54.82	56.31	57.13	57.13	61.27
	Syrup F_3	54.82	56.31	57.13	57.13	61.27
	Mean	54.82	56.31	57.13	57.13	61.27
	CD ($p<0.05$)	NS				

NS – Not Significant

Percent, 38.58 per cent and 61.27 per cent during ninth month of storage. The effect of storage on the total sugar content of beverages is given in Fig.3.

The increase in total sugar content of beverages during different months of storage was analysed statistically and are presented in Table 7. It was found that the increase in total sugar content of squash B and D was statistically insignificant. In all other brands, the increase in total sugar content during different months of storage was significant statistically except in syrup F during fifth and seventh month.

Table 7. Changes in total sugar content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	1.55	1.49	1.34	1.10	0.61	1.49
2 (3-5)	0.55	1.64	0.69	0.83	0.63	0.82
3 (5-7)	1.77	1.38	1.45	0.89	1.33	0.00
4 (7-9)	1.28	1.02	5.71	0.93	0.70	4.14
CD ($P<0.05$)	0.003	NS	0.003	NS	0.003	0.003

NS – Not Significant

4.2.4. Reducing sugar

The mean reducing sugar content of most popular beverages was found to be 19.24 per cent in squash B to 24.51 per cent in squash A and 34.20 per cent in syrup C (Table 8). In the case of least popular beverages the mean reducing sugar content was found to be 22.83 per cent in squash D, 23.81 per cent in squash E and 35.91 per cent in syrup F.

The variation in reducing sugar content of different batches of beverages was statistically insignificant except in squash B and squash D. In case of squash B, the difference was significant in between squash B_1, B_3 and squash B_2 and B_3. Similarly, in case of squash D the difference was found to be statistically significant between squash D_1 and D_2 and D_1 and D_3.

While observing the storage changes it was noticed that in squash B and syrup C, reducing sugar content increased through out the storage period where as, in squash A, a gradual decrease in the reducing sugar content was observed in which it decreased from a mean of 24.51 to 18.94 per cent during ninth month (Table 8 and Fig.4). In squash B and syrup C the reducing sugar content increased from a mean of 19.24 per cent and 34.20 per cent during first month to 21.4 per cent and 41.25 per cent respectively in ninth month of storage. In squash D and E the reducing sugar content gradually decreased from 22.83 per cent to 16.67 per cent in squash D and from 23.81 to 17.36 per cent respectively. In syrup F, a gradual increase in the reducing sugar content from 35.91 per cent to 41.25 per cent was observed.

The decrease in reducing sugar content observed in squash A during storage was statistically insignificant during first and third months while, during rest of the storage periods the decrease was found to be statistically significant. The increase in reducing sugar observed in syrup C was also found to be statistically significant during different periods of storage except during third and fifth months.

In case of squash D, the decrease in reducing sugar was found to be statistically significant during different periods of storage except between seventh and ninth months. In case of squash E, the decrease was significant in all months except between first and third months. In syrup F also the increase in reducing sugar was found to be significant only during first and third and seventh and ninth months of storage (Table 9).

Table 8. Reducing sugar (%) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	24.51	24.51	21.92	19.84	18.94
	Squash A_2	24.51	24.51	21.92	19.84	18.94
	Squash A_3	24.51	24.51	21.92	19.84	18.94
	Mean	24.51	24.51	21.92	19.84	18.94
	CD ($p<0.05$)	NS				
2.	Squash B_1	18.94	20.33	20.83	21.93	21.93
	Squash B_2	18.94	18.52	19.38	19.38	20.33
	Squash B_3	19.84	20.83	20.83	21.93	21.93
	Mean	19.24	19.89	20.35	21.08	21.40
	CD ($p<0.05$)	0.003				
3.	Syrup C_1	34.20	35.31	35.31	36.45	41.25
	Syrup C_2	34.20	35.31	35.31	36.45	41.25
	Syrup C_3	34.20	35.31	35.31	36.45	41.25
	Mean	34.20	35.31	35.31	36.45	41.25
	CD ($p<0.05$)	NS				
4.	Squash D_1	20.88	19.84	18.94	17.36	16.67
	Squash D_2	23.81	22.52	20.37	17.36	16.67
	Squash D_3	23.81	22.52	18.94	17.36	16.67
	Mean	22.83	21.63	19.42	17.36	16.67
	CD ($p<0.05$)	0.082				
5.	Squash E_1	23.81	23.81	21.93	18.94	17.36
	Squash E_2	23.81	23.81	21.93	18.94	17.36
	Squash E_3	23.81	23.81	21.93	18.94	17.36
	Mean	23.81	23.81	21.93	18.94	17.36
	CD ($p<0.05$)	NS				
6.	Syrup F_1	35.91	37.20	37.20	37.20	41.25
	Syrup F_2	35.91	37.20	37.20	37.20	41.25
	Syrup F_3	35.91	37.20	37.20	37.20	41.25
	Mean	35.91	37.20	37.20	37.20	41.25
	CD ($p<0.05$)	NS				

NS – Not Significant

Fig. 3. Effect of storage on total sugar content of fruit beverages

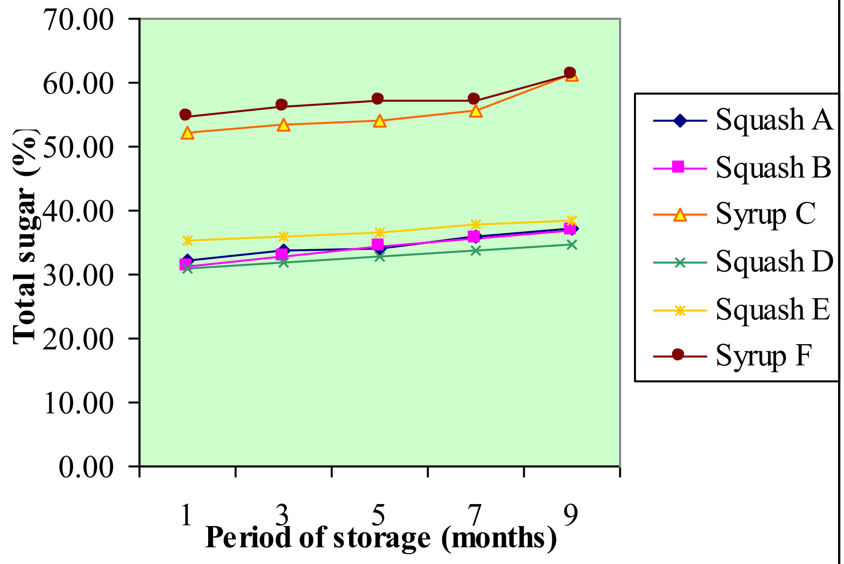


Fig. 4. Effect of storage on reducing sugar content of fruit beverages

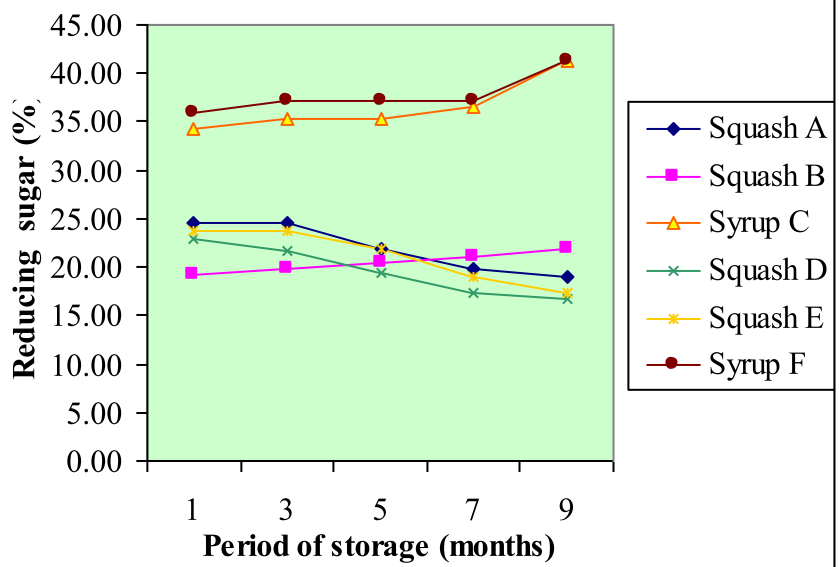


Table 9. Changes in reducing sugar content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	0.00	0.93	1.11	1.21	0.00	1.29
2 (3-5)	2.59	0.46	0.00	2.21	1.88	0.00
3 (5-7)	2.08	0.73	1.14	2.05	2.99	0.00
4 (7-9)	0.90	0.32	4.80	0.70	1.58	4.05
CD ($P<0.05$)	0.003	NS	0.003	1.210	0.003	0.003

NS – Not Significant

4.2.5. Non-reducing sugar

The mean non-reducing sugar content of three most popular beverages varied from 7.77 per cent (squash A) to 17.88 per cent (syrup C). In least popular beverages it varied from 7.29 per cent to 18.91 per cent in squash D and syrup F.

Significant difference in non-reducing sugar content of different batches of squash B were observed while the difference observed between the different batches of syrup C and between squash A_1 and squash A_3 was statistically insignificant. In the case of least popular beverages the difference between squash D_1 and D_2 and squash D_1 and D_3 was statistically significant while the non reducing sugar content between other batches of squash D, E and syrup F was statistically insignificant (Table 10).

The storage changes in non-reducing sugar content of different beverages are also presented in Table 8. In case of the most popular beverages the non-reducing sugar content increased from 7.77 per cent, 12.11 per cent and 17.88 per cent initially to 18.26 per cent, 15.38 per cent and 20.02 per cent during ninth month of storage in squash A, B and syrup C respectively. But, in the case of least popular beverages the non-reducing sugar content increased from 7.29 per cent (squash D), 11.50 per cent (squash E) and 18.91 per cent (syrup F) during first month to 17.49 per cent (squash D), 21.22 (squash E) and 20.02 per cent (syrup F)

Table 10. Non-reducing sugar (%) content of fruit beverages during storage

Sl. No	Fruit beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	7.54	9.09	12.23	16.08	18.26
	Squash A_2	8.24	9.09	12.23	16.08	18.26
	Squash A_3	7.54	9.09	12.23	16.08	18.26
	Mean	7.77	9.09	12.23	16.08	18.26
	CD ($p<0.05$)	0.027				
2.	Squash B_1	12.63	13.28	13.32	15.27	15.27
	Squash B_2	12.98	15.08	16.54	16.54	16.87
	Squash B_3	10.73	10.80	12.74	13.83	13.99
	Mean	12.11	13.05	14.20	15.21	15.38
	CD ($p<0.05$)	0.027				
3.	Syrup C_1	17.88	18.11	18.80	19.11	20.02
	Syrup C_2	17.88	18.11	18.80	19.11	20.02
	Syrup C_3	17.88	18.11	18.80	19.11	20.02
	Mean	17.88	18.11	18.80	19.11	20.02
	CD ($p<0.05$)	NS				
4.	Squash D_1	9.31	11.72	13.61	16.24	17.49
	Squash D_2	6.29	9.53	12.70	16.24	17.49
	Squash D_3	6.29	9.53	13.61	16.24	17.49
	Mean	7.29	10.26	13.31	16.24	17.49
	CD ($p<0.05$)	0.027				
5.	Squash E_1	11.50	12.77	14.62	18.94	21.22
	Squash E_2	11.50	12.77	14.62	18.94	21.22
	Squash E_3	11.50	12.77	14.62	18.94	21.22
	Mean	11.50	12.77	14.62	18.94	21.22
	CD ($p<0.05$)	NS				
6.	Syrup F_1	18.91	19.11	19.93	19.93	20.02
	Syrup F_2	18.91	19.11	19.93	19.93	20.02
	Syrup F_3	18.91	19.11	19.93	19.93	20.02
	Mean	18.91	19.11	19.93	19.93	20.02
	CD ($p<0.05$)	NS				

NS – Not Significant

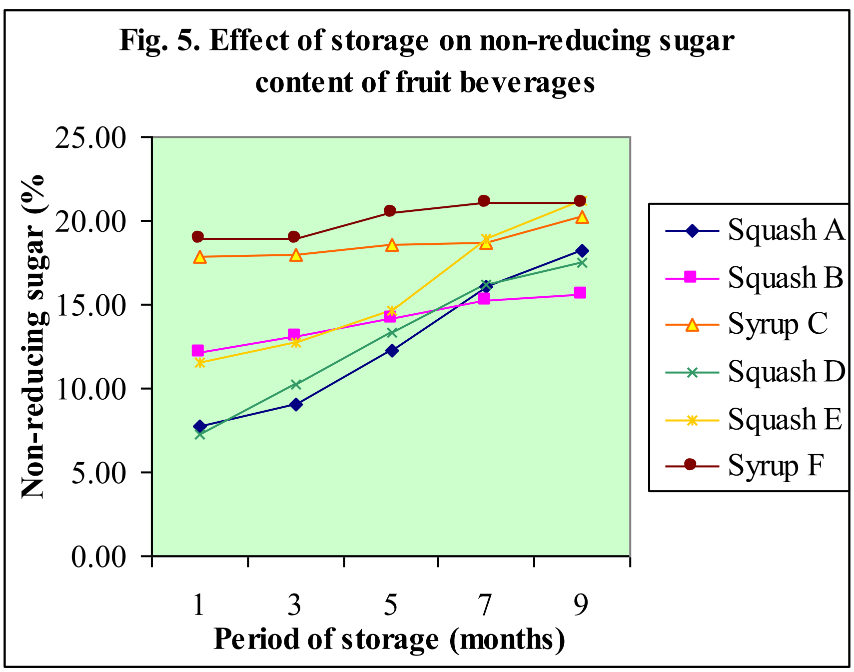


Fig. 5. Effect of storage on non-reducing sugar content of fruit beverages
25.00
20.00
15.00
10.00
5.00
0.00
Non-reducing sugar (%
1
3
5
7
9
Period of storage (months)
Squash A
Squash B
Syrup C
Squash D
Squash E
Syrup F

during ninth month of storage. The effect of storage on non-reducing sugar content of beverages is furnished in Fig. 5.

The increase in non-reducing sugar content of beverages during different months was found to be statistically significant in all brands except squash B and between fifth and seventh months for syrup F (Table 11).

Table 11. Changes in non-reducing sugar content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	1.32	0.94	0.23	2.97	1.27	0.20
2 (3-5)	3.14	1.15	0.69	3.05	1.85	0.82
3 (5-7)	3.85	1.01	0.31	2.93	4.32	0.00
4 (7-9)	2.19	0.17	0.91	1.25	2.28	0.09
CD ($P<0.05$)	0.315	NS	0.003	0.999	0.003	0.003

NS – Not Significant

4.2.6. Vitamin C

Vitamin C content of the three most popular beverages was found to be 92.8 mg 100 ml^{-1} in squash A, 64.4 mg 100 ml^{-1} in squash B as well as syrup C (Table 12). In case of least popular beverages highest vitamin C content was found in squash E (116 mg 100 ml^{-1}) followed by squash D (69.6 mg 100 ml^{-1}) and lowest in syrup F (64.4 mg 100 ml^{-1}) initially. The variation observed in the vitamin C content of different batches of selected beverages was found to be statistically insignificant.

During storage, among the three most popular beverages the vitamin C content decreased from 92.8 mg 100 ml^{-1} (squash A), 64.4 mg 100 ml^{-1} in squash B and syrup C during first month to 39.83 mg 100 ml^{-1} in squash A and 23.87 mg 100 ml^{-1} in squash B and syrup C during ninth month of storage. In the case of least popular beverages the decrease in vitamin C was found to be from 69.6 mg 100 ml^{-1} (squash D), 116 mg 100 ml^{-1} (squash E) and 64.4 mg 100 ml^{-1} (syrup F)

Table 12. Vitamin C (mg 100 ml^{-1}) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	92.8	84.7	72.6	64.4	48.4
	Squash A_2	92.8	84.7	72.6	58	36.3
	Squash A_3	92.8	84.7	69.6	60.5	34.8
	Mean	92.8	84.7	71.6	60.97	39.83
	CD ($p<0.05$)	NS				
2.	Squash B_1	64.4	60.5	48.4	36.3	24.2
	Squash B_2	64.4	60.5	46.5	34.8	24.2
	Squash B_3	64.4	60.5	48.4	36.3	23.2
	Mean	64.4	60.5	47.77	35.8	23.87
	CD ($p<0.05$)	NS				
3.	Syrup C_1	64.4	60.5	46.5	34.8	24.2
	Syrup C_2	64.4	60.5	46.5	34.8	24.2
	Syrup C_3	64.4	60.5	46.5	36.3	23.2
	Mean	64.4	60.5	46.5	35.3	23.87
	CD ($p<0.05$)	NS				
4.	Squash D_1	69.6	58	46.5	34.8	27.6
	Squash D_2	69.6	58	58	48.4	29.4
	Squash D_3	69.6	58	46.5	36.3	23.2
	Mean	69.6	58	50.33	39.83	26.73
	CD ($p<0.05$)	NS				
5.	Squash E_1	116	92.8	84.7	72.6	58.8
	Squash E_2	116	92.8	72.6	46.4	39.3
	Squash E_3	116	92.8	84.7	72.6	58.8
	Mean	116	92.8	80.67	63.87	52.3
	CD ($p<0.05$)	NS				
6.	Syrup F_1	64.4	58	46.5	34.8	27.6
	Syrup F_2	64.4	58	46.5	34.8	23.2
	Syrup F_3	64.4	58	46.5	36.3	24.2
	Mean	64.4	58	46.5	35.3	25
	CD ($p<0.05$)	NS				

NS – Not Significant

during first month to 26.73 mg 100 ml^{-1} (squash D), 52.3 mg 100 ml^{-1} (squash E) and 25.0 mg 100 ml^{-1} (syrup F) during ninth month of storage (Table 12 and Fig. 6).

Table 13. Changes in vitamin C content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	8.10	3.90	3.90	11.60	23.20	6.40
2 (3-5)	13.10	12.73	14.00	7.67	12.13	11.50
3 (5-7)	10.63	11.67	11.20	10.50	16.80	11.20
4 (7-9)	21.13	11.93	11.43	13.10	11.57	10.30
CD ($P<0.05$)	4.73	1.29	1.29	NS	8.7	2.16

NS – Not Significant

The decrease in vitamin C content of all beverages during different periods of storage was found to be statistically significant except in squash D (Table 13).

4.2.7. β - carotene

The β-carotene content of the three most popular beverages varied from 83.16 µg 100 ml^{-1} (squash C_1) to 116.42 µg 100 ml^{-1} (squash A_3) initially with a mean value of 112.82 µg 100 ml^{-1} (squash A), 89.63 µg 100 ml^{-1} (squash B) and 90.09 µg 100 ml^{-1} (syrup C). In the case of least popular beverages the β-carotene content varied from 83.16 mg per 100 ml (squash D_1) to 117.8 µg 100 ml^{-1} (squash E_3) initially with a mean of 98.96 µg 100 ml^{-1} (squash D), 115.31 µg 100 ml^{-1} (squash E) and 99.88 µg 100 ml^{-1} (syrup F).

A significant variation in the β-carotene content was found in between different batches of beverages except in syrup F where the β-carotene of syrup F_2 and F_3 was found to be same (Table 14).

Table 14. Beta-carotene (μg 100 ml^{-1}) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	110.60	70.68	55.44	52.67	49.34
	Squash A_2	111.43	97.02	70.13	63.76	56.83
	Squash A_3	116.42	110.8	95.08	84.55	81.50
	Mean	112.82	92.83	73.55	66.99	62.55
	CD ($p<0.05$)	0.027				
2.	Squash B_1	69.3	54.05	50.17	45.74	38.25
	Squash B_2	95.63	83.16	82.05	76.23	65.14
	Squash B_3	103.95	90.09	85.1	74.29	70.69
	Mean	89.63	75.77	72.44	65.42	58.03
	CD ($p<0.05$)	0. 274				
3.	Syrup C_1	83.16	69.3	57.66	55.44	52.67
	Syrup C_2	88.70	73.74	57.38	54.89	50.17
	Syrup C_3	98.41	77.62	57.66	53.45	50.17
	Mean	90.09	73.55	57.57	54.59	51.00
	CD ($p<0.05$)	0.027				
4.	Squash D_1	83.16	76.23	72.07	64.59	56.14
	Squash D_2	108.11	80.39	77.62	70.96	65.42
	Squash D_3	105.61	80.39	77.62	68.19	67.36
	Mean	98.96	79.00	75.77	67.91	62.97
	CD ($p<0.05$)	0.219				
5.	Squash E_1	111.71	109.49	88.98	85.1	76.23
	Squash E_2	116.42	108.11	90.09	85.93	82.61
	Squash E_3	117.8	113.65	95.08	87.32	81.77
	Mean	115.31	110.42	91.38	86.12	80.20
	CD ($p<0.05$)	0.329				
6.	Syrup F_1	91.75	81.77	74.29	70.13	56.83
	Syrup F_2	103.95	81.77	69.85	65.97	55.16
	Syrup F_3	103.95	81.77	69.85	65.42	54.05
	Mean	99.88	81.77	71.33	67.17	55.35
	CD ($p<0.05$)	0.577				

During storage a decrease in the β-carotene content was observed in all brands of beverages Table 14 and Fig.7. Among the three most popular beverages the β-carotene content decreased from a mean value of 112.82 μg 100 ml^{-1} , 89.63 μg 100 ml^{-1} and 90.09 μg 100 ml^{-1} to 62.55 μg 100 ml^{-1}, 58.03 μg 100 $ml^{-1}$and 51.00 μg 100 ml^{-1} in squash A, B and syrup C respectively. In case of least popular beverages the β-carotene content decreased gradually from a mean value of 98.96 μg 100 ml^{-1}, 115.31 μg 100 ml^{-1} and 99.88 μg 100 ml^{-1} to 62.97 μg 100 ml^{-1}, 80.20 μg 100 $ml^{-1}$and 55.35 μg 100 ml^{-1}in squash D, E and syrup F respectively.

The storage changes in β-carotene content was analysed statistically and are presented in Table 15. In case of squash A the decrease in β-carotene content between first and third month and between third and fifth months were statistically significant. In squash B, the decrease was significant in all months except in between third and fifth months. In case of syrup C, the decrease was significant in between first and third and third and fifth months of storage. In case of least popular beverages the decrease in β-carotene content in squash D was found to be insignificant in all months except between first and third months. In case of squash E the decrease was significant in all months and in syrup F the decrease was significant in all months except between fifth and seventh month of storage.

Table 15. Changes in β-carotene content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	19.99	13.86	16.54	19.99	4.89	18.11
2 (3-5)	19.28	3.33	15.99	3.23	19.04	10.44
3 (5-7)	6.56	7.02	2.97	7.85	5.27	4.16
4 (7-9)	4.44	7.39	3.59	4.94	5.91	11.83
CD ($P<0.05$)	14.81	4.24	4.39	9.18	3.71	5.79

Fig. 6. Effect of storage on vitamin C content of fruit beverages

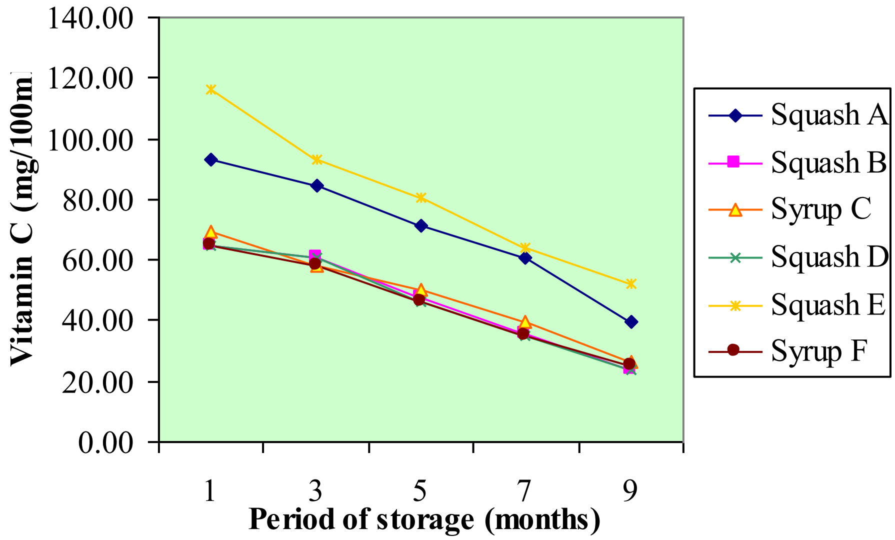
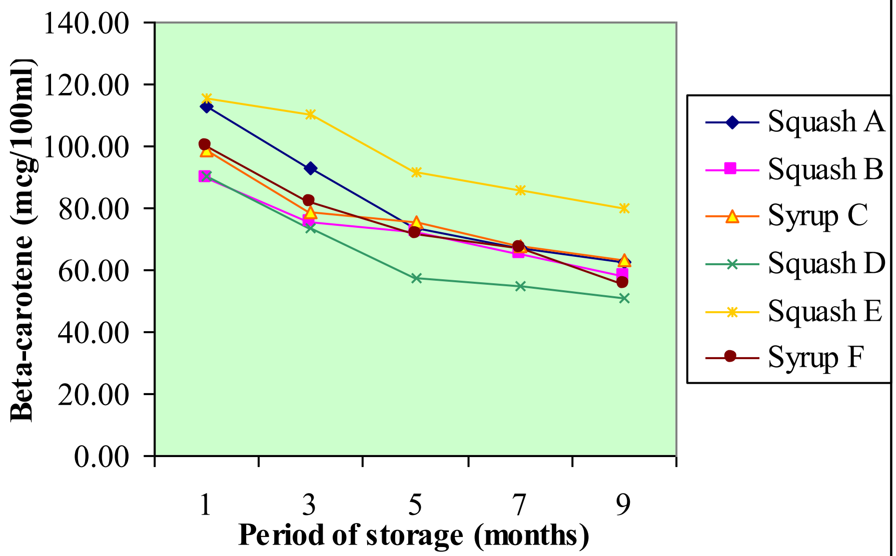


Fig. 7. Effect of storage on beta-carotene content of fruit beverages during storage



4.2.8. Sodium

The sodium content of the three most popular beverages varied from 10.8 mg (syrup C_1 and C_2) to 88.2 mg 100 ml^{-1} (squash A_1) with a mean value of 81.6 mg 100 ml^{-1} in squash A, 26.4 mg 100 ml^{-1} in squash B and 11.2 mg 100 ml^{-1} in syrup C. In the case of least popular beverages sodium content varied from 14 mg 100 ml^{-1} (squash D_1) to 37.8 mg 100 ml^{-1} (squash E_1, E_2 and E_3) with a mean value of 16 mg 100 ml^{-1} in squash D, 37.8 mg 100 ml^{-1} in squash E and 34.47 mg 100 ml^{-1} in syrup F (Table 16).

Significant variation in the sodium content of different batches of squash A and B was observed where as in syrup C, significant variation was observed in the sodium content of syrup C_1 and C_3 and C_2 and C_3. In the case of least popular beverages significant difference was found in the sodium content of squash D_1 and D_2 and squash D_1 and D_3. In the case of syrup F also the variation in the sodium content of syrup F_1 and F_2 and F_2 and F_3 were significant statistically.

The sodium content of the beverages remained constant through out the storage period (Fig. 8).

4.2.9. Potassium

The mean potassium content of the most popular beverages varied from 31.67 mg 100 ml^{-1} to 58 mg 100 ml^{-1}. Lowest potassium content was observed in squash B2 (29 mg 100 ml^{-1}) and the highest in syrup C_1, C_2 and C_3 (58 mg 100 ml^{-1}). In the least popular beverages the mean potassium content varied from 27 mg 100 ml^{-1} (squash D) to 54 mg 100 ml^{-1} in syrup F.

The variation in the potassium content of different batches of beverages was statistically insignificant except in squash B in which, the variation observed in potassium content of three batches was statistically significant (Table 17).

Table 16. Sodium (mg 100 ml^{-1}) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	88.2	88.2	88.2	88.2	88.2
	Squash A_2	73.8	73.8	73.8	73.8	73.8
	Squash A_3	82.8	82.8	82.8	82.8	82.8
	Mean	81.6	81.6	81.6	81.6	81.6
	CD (p<0.05)	0.412				
2.	Squash B_1	21.6	21.6	21.6	21.6	21.6
	Squash B_2	30.6	30.6	30.6	30.6	30.6
	Squash B_3	27	27	27	27	27
	Mean	26.4	26.4	26.4	26.4	26.4
	CD (p<0.05)	0.467				
3.	Syrup C_1	10.8	10.8	10.8	10.8	10.8
	Syrup C_2	10.8	10.8	10.8	10.8	10.8
	Syrup C_3	12	12	12	12	12
	Mean	11.2	11.2	11.2	11.2	11.2
	CD (p<0.05)	0.329				
4.	Squash D_1	14	14	14	14	14
	Squash D_2	17	17	17	17	17
	Squash D_3	17	17	17	17	17
	Mean	16	16	16	16	16
	CD (p<0.05)	0.219				
5.	Squash E_1	37.8	37.8	37.8	37.8	37.8
	Squash E_2	37.8	37.8	37.8	37.8	37.8
	Squash E_3	37.8	37.8	37.8	37.8	37.8
	Mean	37.8	37.8	37.8	37.8	37.8
	CD (p<0.05)	NS				
6.	Syrup F_1	34.2	34.2	34.2	34.2	34.2
	Syrup F_2	35	35	35	35	35
	Syrup F_3	34.2	34.2	34.2	34.2	34.2
	Mean	34.47	34.47	34.47	34.47	34.47
	CD (p<0.05)	0.027				

NS – Not Significant

Table 17. Potassium (mg 100 ml^{-1}) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	55	55	55	55	55
	Squash A_2	55	55	55	55	55
	Squash A_3	57	57	57	57	57
	Mean	55.67	55.67	55.67	55.67	55.67
	CD ($p<0.05$)	2.747				
2.	Squash B_1	34	34	34	34	34
	Squash B_2	29	29	29	29	29
	Squash B_3	32	32	32	32	32
	Mean	31.67	31.67	31.67	31.67	31.67
	CD ($p<0.05$)	1.59				
3.	Syrup C_1	58	58	58	58	58
	Syrup C_2	58	58	58	58	58
	Syrup C_3	58	58	58	58	58
	Mean	58	58	58	58	58
	CD ($p<0.05$)	NS				
4.	Squash D_1	26	26	26	26	26
	Squash D_2	28	28	28	28	28
	Squash D_3	27	27	27	27	27
	Mean	27	27	27	27	27
	CD ($p<0.05$)	NS				
5.	Squash E_1	41	41	41	41	41
	Squash E_2	42	42	42	42	42
	Squash E_3	41	41	41	41	41
	Mean	41.33	41.33	41.33	41.33	41.33
	CD ($p<0.05$)	NS				
6.	Syrup F_1	54	54	54	54	54
	Syrup F_2	54	54	54	54	54
	Syrup F_3	54	54	54	54	54
	Mean	54	54	54	54	54
	CD ($p<0.05$)	NS				

NS – Not Significant

Fig. 8. Effect of storage on sodium content of fruit beverages

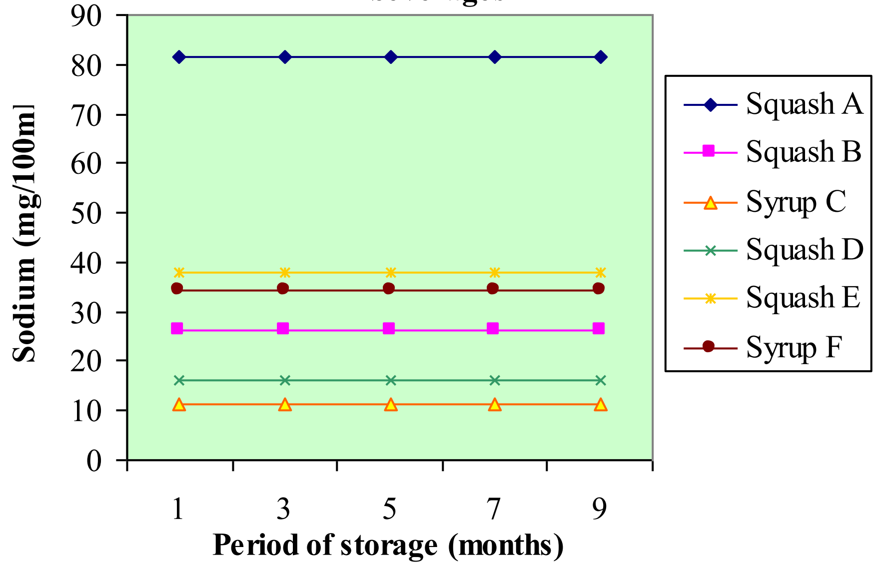
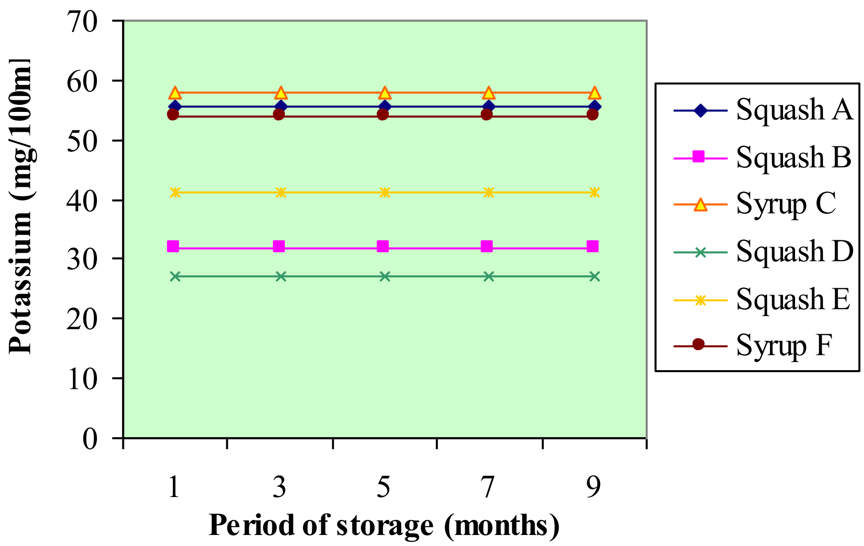


Fig. 9. Effect of storage on potassium content of fruit beverages



Significant variation in the potassium content of squash A_1 and A_3 and squash A_2 and A_3 was also observed.

The potassium content of fruit beverages remained constant through out the storage period (Fig. 9).

4.2.10. Pectin

Pectin content of three most popular beverages varied from 0.85 per cent (syrup C_2) to 1 per cent (squash B_2) with a mean value of 0.97 per cent (squash A and B and 0.90 per cent in syrup C. In least popular beverages the mean pectin content was found to be 1.01 per cent in squash D, 0.78 per cent in squash E and 1 per cent in syrup F (Table 18)

Though, there was a variation in different batches of beverages with respect to pectin content the variation observed was statistically insignificant in squash A, D, E and syrup F. In syrup C significant variation in the pectin content between syrup C_1 and C_2 and syrup C_1 and C_3 were observed.

The changes in pectin content of the beverages during storage are presented in Table 19 and Fig.10. Pectin content gradually decreased with advancement of storage period in all beverages. The pectin content decreased from a mean of 0.97 per cent in squash A and B, and 0.90 per cent in syrup C during first month to 0.63 per cent in squash A, 0.83 per cent in squash B and 0.73 per cent in syrup C during ninth month of storage. In the case of least popular beverages the pectin content was found to be 1.01 per cent (squash D), 0.78 per cent (squash E) and 1 per cent (syrup F) during first month, which decreased to 0.79 per cent, 0.56 per cent and 0.8 per cent in syrup F during ninth month of storage.

Table 18. Pectin (%) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	0.96	0.94	0.86	0.81	0.63
	Squash A_2	0.96	0.94	0.86	0.81	0.63
	Squash A_3	0.98	0.94	0.86	0.81	0.63
	Mean	0.97	0.94	0.86	0.81	0.63
	CD ($p<0.05$)	NS				
2.	Squash B_1	0.94	0.88	0.85	0.8	0.75
	Squash B_2	1	0.99	0.96	0.93	0.88
	Squash B_3	0.98	0.96	0.94	0.88	0.85
	Mean	0.97	0.94	0.92	0.87	0.83
	CD ($p<0.05$)	0.109				
3.	Syrup C_1	0.98	0.8	0.8	0.75	0.73
	Syrup C_2	0.85	0.83	0.8	0.74	0.63
	Syrup C_3	0.86	0.83	0.76	0.75	0.73
	Mean	0.90	0.82	0.79	0.75	0.69
	CD ($p<0.05$)	0.027				
4.	Squash D_1	1.01	0.98	0.76	0.81	0.79
	Squash D_2	1.01	0.98	0.89	0.81	0.79
	Squash D_3	1.01	0.98	0.89	0.81	0.79
	Mean	1.01	0.98	0.85	0.81	0.79
	CD ($p<0.05$)	NS				
5.	Squash E_1	0.78	0.73	0.68	0.6	0.56
	Squash E_2	0.78	0.73	0.68	0.6	0.56
	Squash E_3	0.78	0.73	0.68	0.6	0.56
	Mean	0.78	0.73	0.68	0.6	0.56
	CD ($p<0.05$)	NS				
6.	Syrup F_1	1	0.94	0.93	0.88	0.8
	Syrup F_2	1	0.94	0.93	0.88	0.8
	Syrup F_3	1	0.94	0.93	0.88	0.8
	Mean	1	0.94	0.93	0.88	0.8
	CD ($p<0.05$)	NS				

NS – Not Significant

Table 19. Changes in pectin content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	0.03	0.03	0.04	0.08	0.05	0.06
2 (3-5)	0.08	0.03	0.13	0.03	0.05	0.01
3 (5-7)	0.05	0.05	0.07	0.04	0.08	0.05
4 (7-9)	0.19	0.04	0.03	0.05	0.04	0.08
CD ($p<0.005$)	0.003	0.026	0.052	NS	0.003	0.003

NS – Not Significant

The decrease in pectin content observed during different storage periods was statistically significant in squash A, E and syrup F. In case of squash B the decrease was found to be significant during fifth and seventh and seventh and ninth months. In case of syrup C the decrease was found to be significant in between third and fifth and fifth and seventh months of storage (Table 19).

4.2.11. Sulphur dioxide

The sulphur dioxide content of most popular beverages varied from 192 ppm (Squash B_3) to 256 ppm (squash A_1, A_2 and A_3) with a mean value of 256 ppm, 202.67 ppm and 204 ppm in squash A, squash B and syrup C respectively (Table 20). In case of least popular beverages the mean sulphur dioxide content was found to be 172.8 ppm (squash D), 230.4 ppm (squash E) and 198.4 ppm (syrup F). All the brands of beverages satisfied the FPO standards for sulphur dioxide i.e. below 350 ppm.

The sulphur dioxide content of the different batches of the beverages was statistically insignificant except in squash B where the sulphur dioxide content of the different batches of the beverages was statistically significant.

The storage changes observed in the sulphur dioxide content during different months in different brands of beverages are also given in Table 20. In case of the most popular beverages the mean sulphur dioxide content was found to

Table 20. Sulphur dioxide (ppm) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	256	230.4	166.4	166.4	128
	Squash A_2	256	230.4	166.4	166.4	128
	Squash A_3	256	230.4	166.4	166.4	128
	Mean	256	230.4	166.4	166.4	128
	CD ($p<0.05$)	NS				
2.	Squash B_1	217.6	192	153.6	102.4	51.2
	Squash B_2	198.4	172.8	166.4	128	44.8
	Squash B_3	192	185.6	172.8	96	51.2
	Mean	202.67	183.47	164.27	108.8	49.07
	CD ($p<0.05$)	2.473				
3.	Syrup C_1	204	198.4	172.8	128	102
	Syrup C_2	204	198.4	172.8	128	102
	Syrup C_3	204	198.4	172.8	128	102
	Mean	204	198.4	172.8	128	102
	CD ($p<0.05$)	NS				
4.	Squash D_1	172.8	166.4	128	87.04	76.8
	Squash D_2	172.8	153.6	102.4	102.4	89.6
	Squash D_3	172.8	153.6	102.4	102.4	89.6
	Mean	172.8	157.87	110.93	97.28	85.33
	CD ($p<0.05$)	NS				
5.	Squash E_1	230.4	224	198.4	172.8	153.6
	Squash E_2	230.4	224	198.4	172.8	153.6
	Squash E_3	230.4	224	198.4	172.8	153.6
	Mean	230.4	224	198.4	172.8	153.6
	CD ($p<0.05$)	NS				
6.	Syrup F_1	198.4	192	128	96	76.8
	Syrup F_2	198.4	192	128	96	76.8
	Syrup F_3	198.4	192	128	96	76.8
	Mean	198.4	192	128	96	76.8
	CD ($p<0.05$)	NS				

NS – Not Significant

Fig.10.Effect of storage on pectin content of fruit beverages

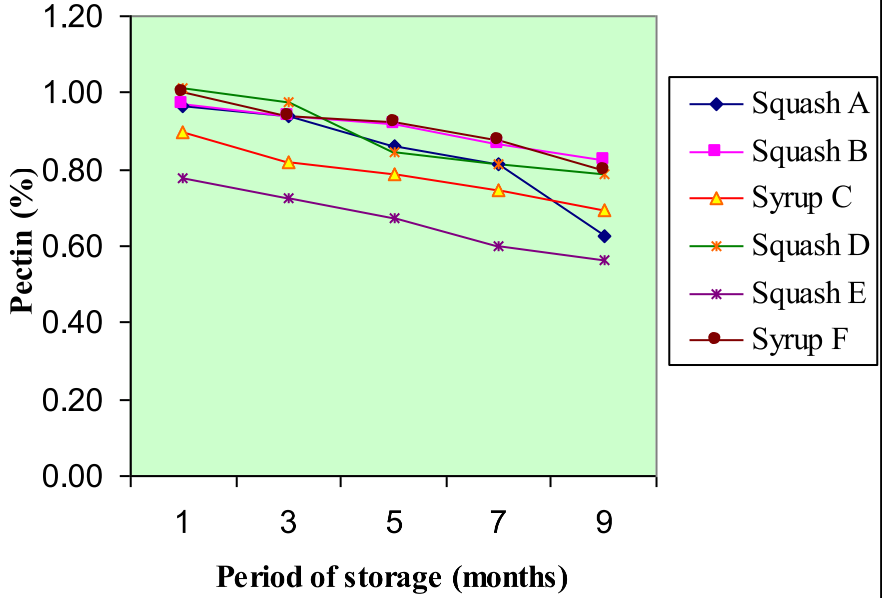
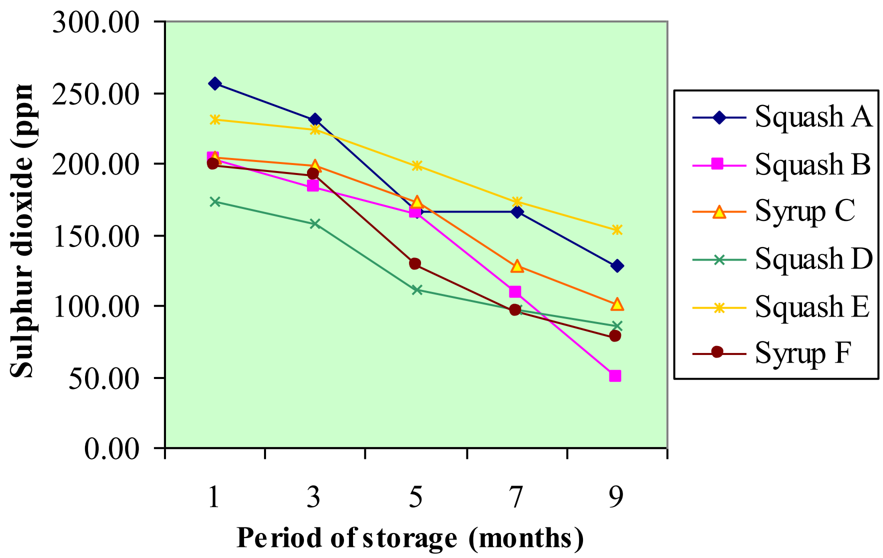


Fig. 11. Effect of storage on sulphur dioxide content of fruit beverages



256 ppm, 202.6 ppm and 204 ppm initially, which gradually decreased to 128 ppm, 49.07 ppm and 102 ppm during ninth month of storage in squash A, B and syrup C respectively. In case of least popular beverages also sulphur dioxide content decreased from a mean value of 172.8 ppm, 230.4 ppm and 198.4 ppm initially, to 85.33 ppm, 153.6 ppm and 76.8 ppm during ninth month of storage in squash D, E and syrup F respectively. The effect of storage in the sulphur dioxide content of the beverages are illustrated in Fig. 11.

Table 21. Changes in sulphur dioxide content of fruit beverages during storage

Months	Squash A	Squash B	Syrup C	Squash D	Squash E	Syrup F
1 (1-3)	25.60	19.20	5.60	14.93	6.40	6.40
2 (3-5)	64.00	19.20	25.60	46.93	25.60	64.00
3 (5-7)	0.00	55.47	44.80	13.65	25.60	32.00
4 (7-9)	38.40	59.73	26.00	11.95	19.20	19.20
CD ($P<0.05$)	0.003	26.4	0.003	19.6	0.003	0.003

The decrease in sulphur dioxide content of beverages was statistically analysed and presented in Table 21. The decrease in sulphur dioxide content in squash A was significant in different months except between fifth and seventh months. The decrease in sulphur dioxide content of squash B was significant in between fifth to seventh and seventh to ninth month but the decrease was insignificant in all other months. In case of squash D the decrease was significant only in between third and fifth months but in syrup C, squash E and syrup F the decrease in sulphur dioxide content of the beverages was statistically significant through out the storage.

4.2.12. Colouring substances

The synthetic colour detected in the beverages indicated that in most popular beverages the colour was sunset yellow (104.4 ppm) in squash A_1 and 168.6 ppm in squash A_2 which exceeded the permissible level of 100 ppm prescribed by FPO. In squash B the predominant colour was found to be

Tartrazine and the quantity was 170.6 ppm in squash B_1 and 95.8 ppm in squash B_2. In syrup C_1, a combination of two colours i.e. sunset yellow (7.2 ppm) and tartrazine (24.6 ppm) was present but, in syrup C_2, only 21.2 ppm tartrazine was detected (Table 22).

Table 22. Colouring substances present in fruit beverages

Sl. No.	Fruit Beverages	Sunset yellow (ppm)	Tartrazine (ppm)
1.	Squash A_1	104.4	-
	Squash A_2	168.6	-
	Mean	136.5	
2.	Squash B_1	-	170.6
	Squash B_2	-	95.8
	Mean		133.2
3.	Syrup C_1	7.2	24.6
	Syrup C_2	-	21.2
	Mean		22.9
4.	Squash D_1	-	2.7
	Squash D_2	-	54.5
	Mean		28.6
5.	Squash E_1	28.8	-
	Squash E_2	55.8	-
	Mean	42.3	
6.	Syrup F_1	66.7	301.8
	Syrup F_2	81.8	320.1
		74.3	310.9

In case of least popular beverages also the sunset yellow and tartrazine were found and the amount of sunset yellow in squash E_1 and E_2 was 28.8 ppm and 55.8 ppm respectively. Tartrazine at the rate of 2.7 ppm and 54.5 ppm was found in squash D_1 and D_2 respectively. In case of syrup F_1, combination of colours was used i.e. sunset yellow 66.7 ppm and tartrazine 301.8 ppm and in syrup $F_{2,}$ the quantity was 81.8 ppm (sunset yellow) and 320.1 ppm (tartrazine). The colours used in syrup F_1 and F_2 exceeded the permissible limit.

4.2.13. Lead

The lead content of the beverages varied from 2 ppm (squash A_1) to 5.8 ppm (squash B_2) in case of most popular beverages with a mean of 2.93 ppm (squash A), 5.37 ppm (squash B) and 3.93 ppm (syrup C). In case of least popular beverages the lead content varied from 2.5 ppm (squash E1) to 4.1 ppm (syrup F3) with a mean value of 2.97 ppm (squash D), 2.77 ppm (squash E) and 3.77 ppm (syrup F).

The lead content of different batches of squash B varied significantly. In case of squash A the variation was significant between squash A_1 and A_2 and between squash A_1 and A_3. In case of syrup C the variation in the lead content observed in syrup C_1 and C_2 and syrup C_1 and C_3 was also statistically significant (Table 23).

In least popular beverages the variation observed in the lead content of different batches of squash D was statistically significant. In squash E the variation was found to be significant in between squash E_1 and E_2 and between squash E_2 and E_3. In syrup F the difference was found to be statistically significant in between syrup F_1 and F_2 and syrup F_1 and F_3.

The lead content remained constant through out the storage period (Fig. 12).

Table 23. Lead (ppm) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	2	2	2	2	2
	Squash A_2	3.5	3.5	3.5	3.5	3.5
	Squash A_3	3.3	3.3	3.3	3.3	3.3
	Mean	2.93	2.93	2.93	2.93	2.93
	CD ($p<0.05$)	0.714				
2.	Squash B_1	5	5	5	5	5
	Squash B_2	5.8	5.8	5.8	5.8	5.8
	Squash B_3	5.3	5.3	5.3	5.3	5.3
	Mean	5.37	5.37	5.37	5.37	5.37
	CD ($p<0.05$)	0.047				
3.	Syrup C_1	3.5	3.5	3.5	3.5	3.5
	Syrup C_2	4.1	4.1	4.1	4.1	4.1
	Syrup C_3	4.2	4.2	4.2	4.2	4.2
	Mean	3.93	3.93	3.93	3.93	3.93
	CD ($p<0.05$)	0.384				
4.	Squash D_1	2.6	2.6	2.6	2.6	2.6
	Squash D_2	3.4	3.4	3.4	3.4	3.4
	Squash D_3	2.9	2.9	2.9	2.9	2.9
	Mean	2.97	2.97	2.97	2.97	2.97
	CD ($p<0.05$)	0.219				
5.	Squash E_1	2.5	2.5	2.5	2.5	2.5
	Squash E_2	3	3	3	3	3
	Squash E_3	2.8	2.8	2.8	2.8	2.8
	Mean	2.77	2.77	2.77	2.77	2.77
	CD ($p<0.05$)	0.302				
6.	Syrup F_1	3.4	3.4	3.4	3.4	3.4
	Syrup F_2	3.8	3.8	3.8	3.8	3.8
	Syrup F_3	4.1	4.1	4.1	4.1	4.1
	Mean	3.77	3.77	3.77	3.77	3.77
	CD ($p<0.05$)	0.329				

Table 24. Cadmium (ppm) content of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	0.15	0.15	0.15	0.15	0.15
	Squash A_2	0.15	0.15	0.15	0.15	0.15
	Squash A_3	0.15	0.15	0.15	0.15	0.15
	Mean	0.15	0.15	0.15	0.15	0.15
	CD ($p<0.05$)	NS				
2.	Squash B_1	0.16	0.16	0.16	0.16	0.16
	Squash B_2	0.16	0.16	0.16	0.16	0.16
	Squash B_3	0.16	0.16	0.16	0.16	0.16
	Mean	0.16	0.16	0.16	0.16	0.16
	CD ($p<0.05$)	NS				
3.	Syrup C_1	0.15	0.15	0.15	0.15	0.15
	Syrup C_2	0.15	0.15	0.15	0.15	0.15
	Syrup C_3	0.15	0.15	0.15	0.15	0.15
	Mean	0.15	0.15	0.15	0.15	0.15
	CD ($p<0.05$)	NS				
4.	Squash D_1	0.16	0.16	0.16	0.16	0.16
	Squash D_2	0.14	0.14	0.14	0.14	0.14
	Squash D_3	0.15	0.15	0.15	0.15	0.15
	Mean	0.15	0.15	0.15	0.15	0.15
	CD ($p<0.05$)	NS				
5.	Squash E_1	0.15	0.15	0.15	0.15	0.15
	Squash E_2	0.15	0.15	0.15	0.15	0.15
	Squash E_3	0.15	0.15	0.15	0.15	0.15
	Mean	0.15	0.15	0.15	0.15	0.15
	CD ($p<0.05$)	NS				
6.	Syrup F_1	0.15	0.15	0.15	0.15	0.15
	Syrup F_2	0.15	0.15	0.15	0.15	0.15
	Syrup F_3	0.15	0.15	0.15	0.15	0.15
	Mean	0.15	0.15	0.15	0.15	0.15
	CD ($p<0.05$)	NS				

NS-Not Significant

Fig. 12. Effect of storage on lead content of fruit beverages

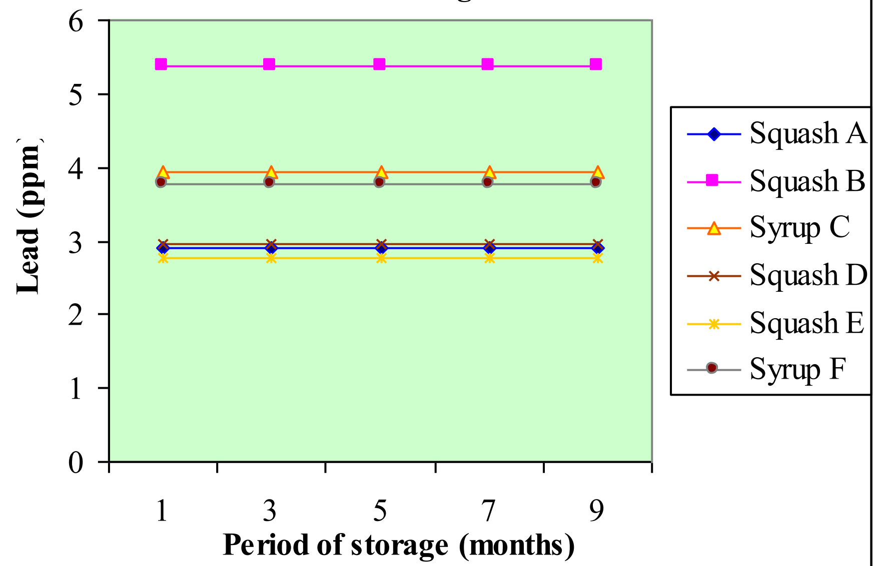
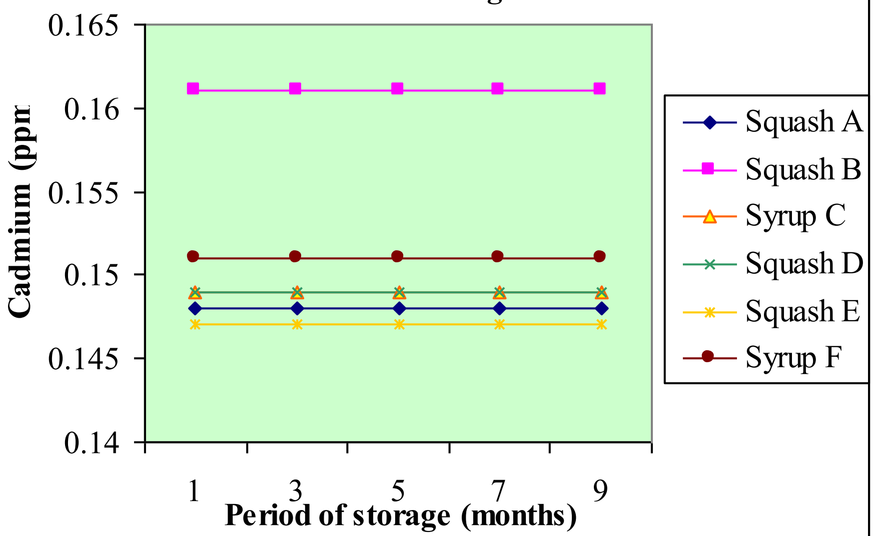


Fig. 13. Effect of storage on cadmium content of fruit beverages



4.2.14. Cadmium

Cadmium content of the most popular beverages was found to be 0.15 ppm and 0.16 ppm and0.15 ppm in squash A, B and syrup C respectively. In case of least popular beverages the cadmium content varied from 0.14 ppm (squash D_2) to 0.16 ppm (squash D_1) with a mean value of 0.15 ppm in three beverages (Table 24).

The variation observed in the cadmium content of different batches of beverages was found to be statistically insignificant except in squash D where the variation observed was statistically significant.

The cadmium content of the beverages remained constant through out the storage period (Fig.13).

4.3. Acceptability of fruit beverages and changes during storage

The fruit beverages were evaluated organoleptically for different attributes like appearance, colour, flavour and taste at bimonthly intervals till the expiry date. Each beverage was ranked for different quality attributes based on their mean score using Kendall's (w) test.

4.3.1. Appearance

The initial score for appearance of most popular beverages ranged from 3.5 (squash B_1, B_2 and B_3) to 4.1 (syrup C_1) with a mean value of 3.97 (syrup C), 3.9 (squash A) and 3.5 (squash B) where as, in least popular beverages the score ranged from 2.9 (syrup F_3) to 3.6 (squash D_1 and E_3) with a mean value of 3.47 (squash D), 3.5 (squash E) and 2.97 (syrup F) during first month of storage (Table 25). The variation between batches of different beverages was found to be statistically insignificant.

Table 25. Appearance (scores) of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	3.9	3.9	3.9	3.4	2.9
	Squash A_2	3.9	3.7	3.7	3.4	3
	Squash A_3	3.9	3.9	3.9	3.3	2.9
	Mean	3.9	3.83	3.83	3.37	2.93
	CD ($p<0.05$)	NS				
2.	Squash B_1	3.5	3.4	3.4	3.2	2.4
	Squash B_2	3.5	3.3	3.3	3.09	2.5
	Squash B_3	3.5	3.4	3.4	3.1	2.4
	Mean	3.5	3.37	3.37	3.13	2.40
	CD ($p<0.05$)	NS				
3.	Syrup C_1	4.1	3.8	3.4	3.4	2.8
	Syrup C_2	3.9	3.9	3.6	3.3	2.8
	Syrup C_3	3.9	3.8	3.5	3.4	2.7
	Mean	3.97	3.83	3.50	3.37	2.77
	CD ($p<0.05$)	NS				
4.	Squash D_1	3.6	3.6	2.9	3	2.7
	Squash D_2	3.2	3.3	3	2.9	2.8
	Squash D_3	3.61	3.4	3	2.9	2.8
	Mean	3.47	3.43	2.97	2.93	2.77
	CD ($p<0.05$)	NS				
5.	Squash E_1	3.5	3.1	3	3	2.8
	Squash E_2	3.4	3.2	3	2.9	2.9
	Squash E_3	3.6	3.5	3	3	2.8
	Mean	3.5	3.27	3.00	2.97	2.83
	CD ($p<0.05$)	NS				
6.	Syrup F_1	3	2.9	2.8	2.1	2
	Syrup F_2	3	2.8	2.7	2.3	2
	Syrup F_3	2.9	2.9	2.9	2.2	2.1
	Mean	2.97	2.87	2.80	2.20	2.03
	CD ($p<0.05$)	NS				

NS – Not Significant

During storage, a gradual decrease in the appearance of all the beverages was observed. In case of most popular beverages the mean scores decreased to 2.93, 2.40 and 2.77 from the initial score of 3.9, 3.5 and 3.97 for squash A, squash B and syrup C respectively. In the case of least popular beverages the decrease in appearance was from 3.47, 3.5 and 2.97 to 2.77, 2.83 and 2.03 in squash D, E and syrup F respectively from first month to ninth month of storage. Kendall's coefficient of concordance w (a) registered for appearance indicated a significant agreement among judges in all periods of storage (Table 26). Effect of storage in the appearance of fruit beverages is illustrated if fig.14.

Sl. No.	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1	SquashA	3.9 (3.85)	3.83 (3.98)	3.83 (4.47)	3.37 (4.13)	2.93 (4.08)
2	Squash B	3.5 (3.75)	3.37 (3.35)	3.37 (3.53)	3.13 (3.85)	2.40 (3.43)
3	Syrup C	3.97 (4.18)	3.83 (4.20)	3.50 (3.60)	3.37 (4.00)	2.77 (3.63)
4	Squash D	3.47 (4.15)	3.43 (3.73)	2.97 (3.73)	2.93 (3.97)	2.77 (4.08)
5	Squash E	3.5 (3.28)	3.27 (3.20)	3.00 (3.10)	2.97 (3.35)	2.83 (3.65)
6	Syrup F	2.97 (2.20)	2.87 (2.12)	2.80 (2.57)	2.20 (1.70)	2.03 (2.12)
	W (a)	0.161**	0.205**	0.139**	0.329**	0.176**

Figurs Figures in parenthesis are mean rank scores
W (a) Kendall's coefficient of concordance
** Significant at 1% level

4.3.2. Colour

Initially, the score for colour in three most popular beverages ranged from 3.4 (squash B_3) to 4.1 (squash A_3) with a mean score of 3.93 in squash A, 3.43 in squash B and 3.80 in syrup C. In least popular beverages the score ranged from 3.2 (syrup F_1) to 3.8 (squash D_1) with a mean score of 3.60 in squash D and E and

Table 27. Colour (scores) of fruit beverages during storage

NS – Not Significant

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	3.9	3.4	3.2	3.2	3.1
	Squash A_2	3.8	3.5	3.4	3.3	3.1
	Squash A_3	4.1	3.5	3.3	3.3	3.2
	Mean	3.93	3.47	3.30	3.27	3.13
	CD (p<0.05)	NS				
2.	Squash B_1	3.49	3.4	2.8	2.7	2.4
	Squash B_2	3.5	3.5	2.7	2.6	2.2
	Squash B_3	3.4	3.3	2.51	2.41	2.39
	Mean	3.43	3.40	2.67	2.57	2.33
	CD (p<0.05)	NS				
3.	Syrup C_1	3.9	3.9	3.3	3.3	2.9
	Syrup C_2	3.6	3.5	3.3	3.2	3.2
	Syrup C_3	3.9	3.8	3.3	3.3	2.9
	Mean	3.80	3.73	3.30	3.27	3.00
	CD (p<0.05)	NS				
4.	Squash D_1	3.8	3.8	3	2.7	2.6
	Squash D_2	3.6	3.5	3.1	2.5	2.5
	Squash D_3	3.4	3.3	2.9	2.5	2.4
	Mean	3.60	3.53	3.00	2.57	2.50
	CD (p<0.05)	NS				
5.	Squash E_1	3.7	3.2	3.2	3	2.4
	Squash E_2	3.5	3.3	3.2	2.9	2.3
	Squash E_3	3.6	3.4	3.2	3.2	2.3
	Mean	3.60	3.30	3.20	3.03	2.33
	CD (p<0.05)	NS				
6.	Syrup F_1	3.2	2.8	2.7	2.1	1.9
	Syrup F_2	3.3	2.9	2.8	2.3	1.8
	Syrup F_3	3.4	2.9	2.9	2.3	2
	Mean	3.30	2.87	2.80	2.23	1.90
	CD (p<0.05)	NS				

NS –Not Significant

3.30 in syrup F during first month (Table 27). The variation between batches of all beverages was found to be statistically insignificant.

In case of colour also the mean score decreased during storage. The decrease in the mean score of colour of three most popular beverages was from 3.93 (squash A), 3.43 (squash B) and 3.80 (syrup C) during first month to 3.13 (squash A), 2.33 (squash B) and 3.00 (syrup C) during ninth month of storage. In case of least popular beverages the scores decreased from 3.60 to 2.50 in squash D 3.60-2.33 in squash E and 3.30-1.90 in syrup F from initial to final month of storage (Fig. 15).

Kendall's coefficient of concordance w (a) registered for colour didn't have significant agreement among judges in first, third, fifth and ninth month of storage but there was a significant agreement among judges during seventh month (Table 28).

Table 28. Mean score for colour of fruit beverages

Sl. No.	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1	Squash A	3.93 (3.67)	3.47 (3.27)	3.30 (3.78)	3.27 (4.22)	3.13 (4.17)
2	Squash B	3.43 (3.55)	3.40 (3.53)	2.67 (3.45)	2.57 (3.13)	2.33 (3.05)
3	Syrup C	3.80 (3.40)	3.73 (3.98)	3.30 (3.65)	3.27 (3.97)	3.00 (3.67)
4	Squash D	3.60 (3.53)	3.53 (3.43)	3.00 (3.10)	2.57 (2.72)	2.50 (3.40)
5	Squash E	3.60 (3.15)	3.30 (3.33)	3.20 (3.52)	3.03 (3.63)	2.33 (2.98)
6	Syrup F	3.30 (3.70)	2.87 (3.45)	2.80 (3.50)	2.23 (3.33)	1.90 (3.73)
	W (a)	0.827^{NS}	0.665^{NS}	0.724^{NS}	0.111**	0.071^{NS}

Figures in parenthesis are mean rank scores
W (a) Kendall's coefficient of concordance
** Significant at 1% level
NS - not significant

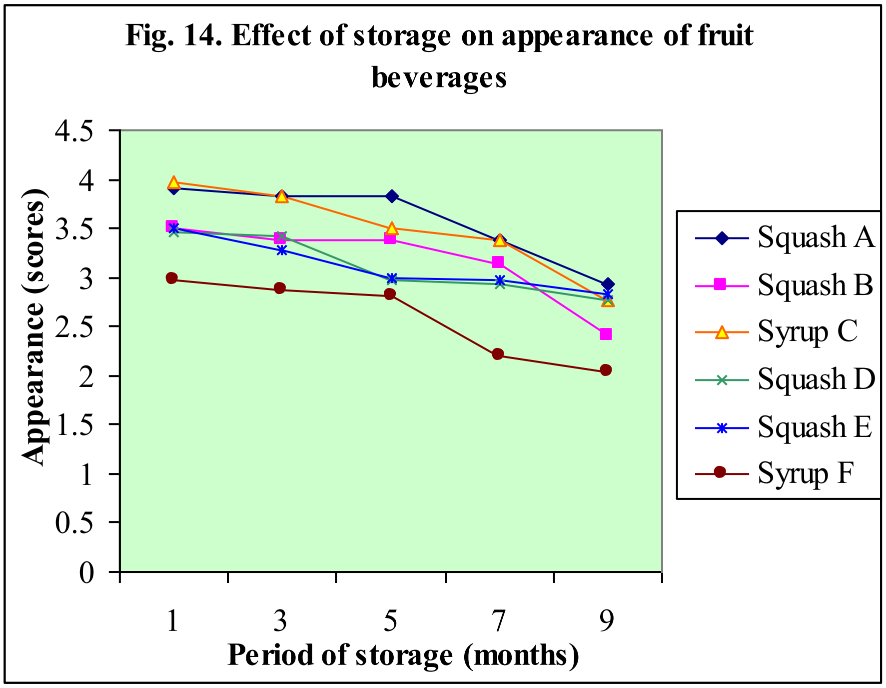


Fig. 14. Effect of storage on appearance of fruit beverages
Appearance (scores)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
3
5
7
9
Period of storage (months)
Squash A
Squash B
Syrup C
Squash D
Squash E
Syrup F

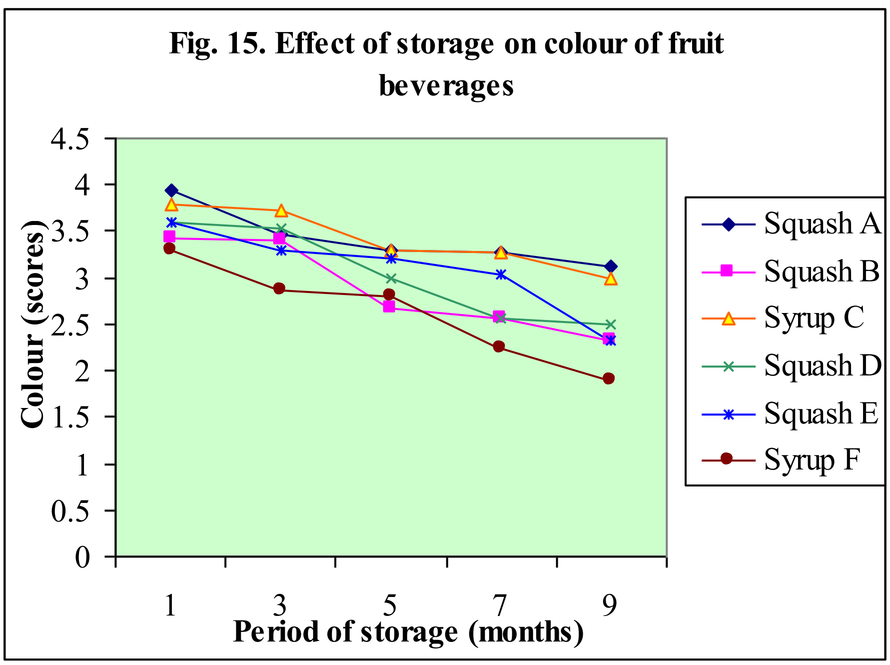


Fig. 15. Effect of storage on colour of fruit beverages
Colour (scores)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
3
5
7
9
Period of storage (months)
Squash A
Squash B
Syrup C
Squash D
Squash E
Syrup F

4.3.3. Flavour

The score for flavour in the most popular beverages varied from 3.3 (squash B_2) to 3.8 (squash A_2 and A_3). Squash A (3.70) had the highest mean score for flavour among the most popular beverages during first month followed by syrup C (3.50) and squash B (3.40) (Table 29). Among the three least popular beverages the score for flavour varied from 3.4 (squash D_2, D_3, E_1 and E_3) to 3.9 (syrup F_1) with a mean score of 3.47 (squash D), 3.43 (squash E) and 3.80 (syrup F) during first month. The variation between batches of all the beverages was found to be statistically insignificant (Table 29).

A decreasing trend in the flavour was observed for all the fruit beverages during storage (Fig 16). In case of most popular beverages the mean score for flavour decreased from 3.70 to 2.93 (squash A), 3.40 to 2.37(squash B) and 3.50 to 3.00 (syrup C) from first month to ninth month of storage. In case of least popular beverages the mean score decreased from 3.47 (squash D), 3.43 (squash E) and 3.80 (syrup F) during first month to 2.43 (squash D), 2.50 (squash E) and 2.63 (syrup F) during ninth month of storage.

Kendall's coefficient of concordance w (a) registered for appearance indicated a significant agreement among judges during third, fifth and seventh month of storage but the agreement among judges was not significant during first and ninth month of storage (Table 30).

Table 29. Flavour (scores) of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	3.5	3.5	3.5	3	2.9
	Squash A_2	3.8	3.7	3.5	3	3
	Squash A_3	3.8	3.8	3.5	3.1	2.9
	Mean	3.70	3.67	3.50	3.03	2.93
	CD ($p<0.05$)	NS				
2.	Squash B_1	3.4	3.43	3.3	2.39	2.3
	Squash B_2	3.3	3.2	3.1	2.8	2.4
	Squash B_3	3.5	3.4	3.4	2.7	2.4
	Mean	3.40	3.30	3.30	2.63	2.37
	CD ($p<0.05$)	NS				
3.	Syrup C_1	3.5	3.3	3.2	3	3
	Syrup C_2	3.4	3.3	3.3	3.1	3.1
	Syrup C_3	3.6	3.2	3.2	2.9	2.9
	Mean	3.50	3.27	3.23	3.00	3.00
	CD ($p<0.05$)	NS				
4.	Squash D_1	3.6	3.4	3.2	2.9	2.5
	Squash D_2	3.4	3.4	3.4	2.9	2.5
	Squash D_3	3.4	3.4	3.4	2.8	2.3
	Mean	3.47	3.40	3.33	2.87	2.43
	CD ($p<0.05$)	NS				
5.	Squash E_1	3.4	3.2	2.8	2.8	2.5
	Squash E_2	3.5	3.1	2.9	2.7	2.4
	Squash E_3	3.4	3.3	2.8	2.8	2.6
	Mean	3.43	3.20	2.83	2.77	2.50
	CD ($p<0.05$)	NS				
6.	Syrup F_1	3.9	3.3	3.2	2.8	2.6
	Syrup F_2	3.8	3.3	3.1	2.8	2.7
	Syrup F_3	3.7	3.4	3.4	2.6	2.6
	Mean	3.80	3.33	3.23	2.73	2.63
	CD ($p<0.05$)	NS				

NS – Not Significant

Table 30. Mean score for flavour of fruit beverages

Sl. No.	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1	Squash A	3.70 (3.70)	3.67 (3.25)	3.50 (3.78)	3.03 (3.48)	2.93 (3.78)
2	Squash B	3.40 (3.23)	3.30 (3.12)	3.30 (3.03)	2.63 (2.98)	2.37 (3.03)
3	Syrup C	3.50 (3.08)	3.27 (3.18)	3.23 (3.07)	3.00 (3.63)	3.00 (3.70)
4	Squash D	3.47 (3.48)	3.40 (3.73)	3.33 (3.33)	2.87 (3.50)	2.43 (3.20)
5	Squash E	3.43 (4.33)	3.20 (4.30)	2.83 (4.45)	2.77 (4.50)	2.50 (4.15)
6	Syrup F	3.80 (3.62)	3.33 (3.08)	3.23 (3.22)	2.73 (2.90)	2.63 (3.13)
	W (a)	0.069^{NS}	0.027*	0.104**	0.119**	0.073^{NS}

Figures in parenthesis are mean rank scores
W (a) Kendall's coefficient of concordance
** Significant at 1% level
* Significant at 5% level
NS - not significant

4.3.4. Taste

The score for taste in most popular beverages ranged from 2.9 (squash B_1 and B_3) to 3.8 (squash C_1). Syrup C had the highest mean score of 3.70 for taste initially followed by squash A (3.40) and squash B (2.93). Among the least popular beverages the scores varied from 3 (squash F_1 and F_3) to 3.7 (squash D_1). Squash D had the highest mean score for taste (3.60) during first month followed by squash E (3.43) and syrup F (3.03) (Table 31). The variation between batches of all beverages was found to be statistically insignificant.

A decreasing trend was observed in taste for all beverages during storage (Fig.17). The mean score for taste decreased from 3.40 (squash A), 2.93 (squash B) and 3.70 (Syrup C) during first month to 2.80 (squash A), 2.30 (squash B) and 2.40 (Syrup C) during ninth month of storage. Similarly, in least popular beverages the decrease was from 3.60 (squash D), 3.43 (squash E) and 3.03 (syrup F) during first month to 2.73 (squash D), 2.70 (squash E) and 2.00 (syrup F) during ninth month of storage.

Table 31. Taste (scores) of fruit beverages during storage

Sl. No	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	3.3	3.3	3.3	2.9	2.8
	Squash A_2	3.3	3.3	3.3	2.9	2.8
	Squash A_3	3.6	3.5	3.4	2.9	2.8
	Mean	3.40	3.37	3.33	2.90	2.80
	CD ($p<0.05$)	NS				
2.	Squash B_1	2.9	2.9	2.9	2.6	2.3
	Squash B_2	2.99	2.9	2.7	2.6	2.3
	Squash B_3	2.9	2.9	2.89	2.6	2.3
	Mean	2.93	2.90	2.83	2.60	2.30
	CD ($p<0.05$)	NS				
3.	Syrup C_1	3.8	3.7	3.3	3.1	2.2
	Syrup C_2	3.7	3.6	3.5	3.1	2.5
	Syrup C_3	3.6	3.6	3.3	3	2.5
	Mean	3.70	3.63	3.37	3.07	2.40
	CD ($p<0.05$)	NS				
4.	Squash D_1	3.7	3.5	3.2	3.1	2.6
	Squash D_2	3.5	3.5	3.1	2.9	2.7
	Squash D_3	3.6	3.6	3.2	3.1	2.9
	Mean	3.60	3.53	3.17	3.03	2.73
	CD ($p<0.05$)	NS				
5.	Squash E_1	3.6	3.3	3.1	2.7	2.6
	Squash E_2	3.3	3.3	3.1	2.9	2.7
	Squash E_3	3.4	3.3	2.9	2.9	2.8
	Mean	3.43	3.30	3.03	2.83	2.70
	CD ($p<0.05$)	NS				
6.	Syrup F_1	3	3	2.3	2	2
	Syrup F_2	3.1	3	2.4	2	2
	Syrup F_3	3	3	2.3	2	2
	Mean	3.03	3.00	2.33	2.00	2.00
	CD ($p<0.05$)	NS				

NS – Not Significant

Fig. 16. Effect of storage on flavour of fruit beverages

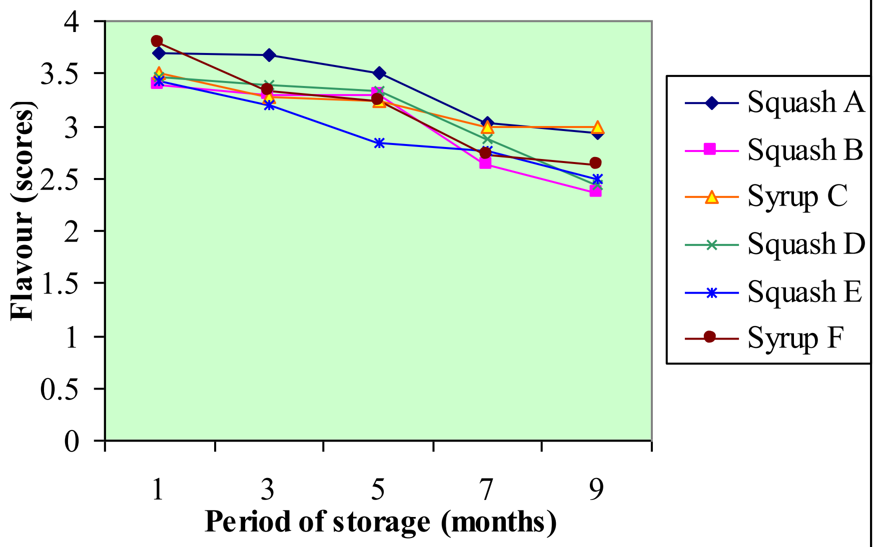


Fig. 16. Effect of storage on flavour of fruit beverages

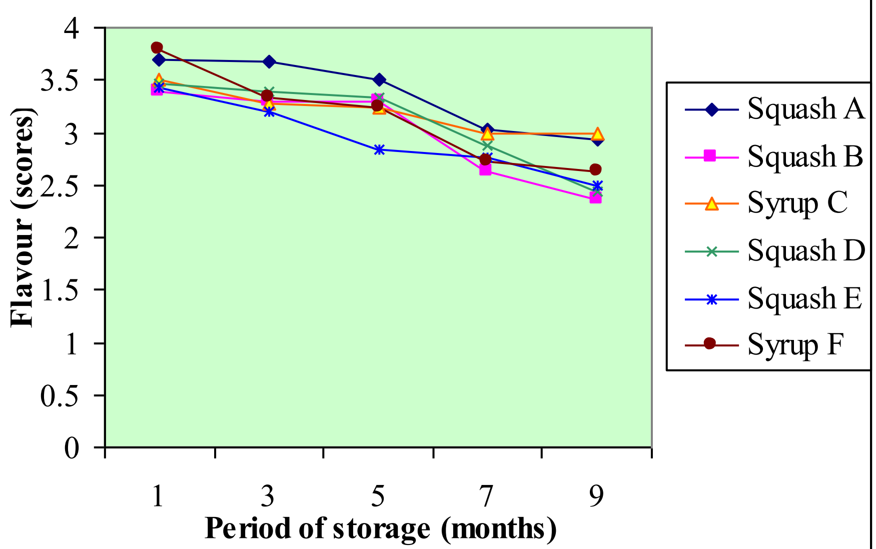


Table 32. Mean score for taste of fruit beverages

Sl. No.	Beverages	Period of storage in months				
		First	Third	Fifth	Seventh	Ninth
1	Squash A	3.40 (3.33)	3.37 (3.33)	3.33 (3.60)	2.90 (3.33)	2.80 (3.47)
2	Squash B	2.93 (2.63)	2.90 (2.880	2.83 (2.55)	2.60 (2.90)	2.30 (2.73)
3	Syrup C	3.70 (3.60)	3.63 (3.72)	3.37 (3.83)	3.07 (3.67)	2.40 (3.43)
4	Squash D	3.60 (4.27)	3.53 (3.70)	3.17 (3.92)	3.03 (3.78)	2.73 (3.63)
5	Squash E	3.43 (3.50)	3.30 (3.87)	3.03 (3.73)	2.83 (4.32)	2.70 (4.47)
6	Syrup F	3.03 (3.67)	3.00 (3.50)	2.33 (3.37)	2.00 (3.00)	2.00 (3.27)
	W (a)	0.095*	0.043*	0.091*	0.096*	0.114**

Figures in parenthesis are mean rank scores
W (a) Kendall's coefficient of concordance
** Significant at 1% level
* Significant at 5% level

Kendall's coefficient of concordance w (a) registered for taste indicated a significant agreement among judges during all periods of storage (Table 32).

4.4. Microbial enumeration of the fruit beverages and changes during storage

4.4.1. Bacteria

The bacterial population of fruit beverages was enumerated at bimonthly intervals and the results are presented in Table 33. The mean bacterial count of the most popular beverages during the initial period of storage was found to be 0.66 x 10^6 cfu ml^{-1} (squash A), 1.22 x 10^6 cfu ml^{-1} (squash B) and 0.11 x 10^6 cfu ml^{-1} (syrup C). The mean bacterial count of least popular beverages was found to be 0.66 x 10^6 cfu ml^{-1} (squash D), 0.44 x 10^6 cfu ml^{-1} (squash E) and 1.77 x 10^6 cfu ml^{-1} in syrup F.

The bacterial count of the different batches of different brands did not show much variation. However, the bacterial population of squash B_1 differed significantly from squash B_2 and B_3. In the case of less popular beverages significant variation in the bacterial count was observed between syrup F_1 and F_3.

Table 33. Effect of storage periods on bacterial population of fruit beverages.

SL. No.	Fruit beverages	Bacteria (x 10^6 cfu ml^{-1})				
		Storage periods in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	0.33 (0.92) ^{c}	1 (1.09) ^{bc}	3.66 (1.51) ^{bc}	3.66 (1.51) ^{bc}	5 (1.60) ^{b}
	Squash A_2	1 (1.03) ^{bc}	0.66 (1.02) ^{bc}	2 (1.30) ^{bc}	2.33 (1.36) ^{bc}	32 (2.64) ^{a}
	Squash A_3	0.66 (1.02) ^{bc}	0.33 (0.92) ^{c}	1.33 (1.48) ^{bc}	2 (1.32) ^{bc}	2.66 (1.40) ^{bc}
	Mean	0.66	0.66	2.33	2.66	13.22
2.	Squash B_1	3.33 (1.48) ^{bcd}	6 (1.75) ^{b}	7 (1.82) ^{ab}	7.66 (1.86) ^{ab}	12.66 (2.16) ^{a}
	Squash B_2	0 (0.81) ^{g}	1 (1.09) ^{defg}	2 (1.28) ^{cdef}	4.33 (1.59) ^{bc}	8.33 (1.89) ^{ab}
	Squash B_3	0.33 (0.92) ^{fg}	0.66 (0.98) ^{efg}	1.33 (1.13) ^{defg}	2.33 (1.33) ^{cde}	8.33 (1.87) ^{ab}
	Mean	1.22	2.55	3.44	4.77	9.77
3.	Syrup C_1	0 (0.81) ^{e}	1.66 (1.17) ^{bcde}	3.66 (1.47) ^{bcd}	4.66 (1.58) ^{bc}	5 (1.64) ^{b}
	Syrup C_2	0.33 (0.92) ^{de}	0.66 (1.03) ^{cde}	2.33 (1.36) ^{bcde}	3.33 (1.49) ^{bcd}	30.66 (2.59) ^{a}
	Syrup C_3	0 (0.81) ^{e}	0.66 (1.02) ^{cde}	1.33 (1.19) ^{bcde}	2 (1.30) ^{bcde}	2 (1.30) ^{bcde}
	Mean	0.11	0.99	2.44	3.33	12.55
4.	Squash D_1	1.66 (1.19) ^{de}	5.66 (1.72) ^{bc}	5.66 (1.68) ^{bc}	7 (1.82) ^{ab}	15.33 (2.29) ^{a}
	Squash D_2	0.33 (0.98) ^{e}	1.33 (1.13) ^{de}	1.66 (1.19) ^{de}	4.33 (1.59) ^{bcd}	8 (1.88) ^{ab}
	Squash D_3	0 (0.81) ^{e}	0.66 (0.98) ^{e}	1.33 (1.13) ^{de}	1.66 (1.25) ^{cde}	6.66 (1.75) ^{b}
	Mean	0.66	2.55	2.77	4.33	9.99
5.	Squash E_1	1 (1.09) ^{cde}	1.66 (1.25) ^{bcde}	4 (1.49) ^{bcd}	5.33 (1.62) ^{bc}	7.66 (1.78) ^{b}
	Squash E_2	0 (0.81) ^{e}	0.66 (1.02) ^{cde}	2 (1.30) ^{bcde}	2.33 (1.34) ^{bcde}	32.33 (2.61) ^{a}
	Squash E_3	0.33 (0.92) ^{de}	1 (1.13) ^{bcde}	1.33 (1.19) ^{bcde}	2 (1.30) ^{bcde}	4 (1.53) ^{bcd}
	Mean	0.44	1.11	2.44	3.22	14.66
6.	Syrup F_1	4.3 (1.56) ^{bcde}	7 (1.77) ^{abc}	8.66 (1.92) ^{ab}	9.33 (1.95) ^{ab}	14 (2.23) ^{a}
	Syrup F_2	1 (1.09) ^{def}	2 (1.23) ^{cdef}	2.66 (1.37) ^{cde}	4.66 (1.62) ^{bcd}	9.33 (1.92) ^{ab}
	Syrup F_3	0 (0.81) ^{f}	0.66 (1.02) ^{ef}	1 (1.09) ^{def}	2 (1.30) ^{cdef}	5.66 (1.64) ^{bc}
	Mean	1.77	3.22	4.11	5.33	9.66

Values with even alphabets do not differ significantly Figures in parentheses are transformed values (Power transformation) $(x + 0.5)^{\wedge 0.3}$

During storage an increase in bacterial count was observed in all the batches in all beverages. In most popular beverages the mean count increased from the initial value 0.66 x 10^6 cfu ml^{-1} to 13.22 x 10^6 cfu ml^{-1} in squash A, 1.22 x 10^6 cfu ml^{-1} to 9.77 x 10^6 cfu ml^{-1} in squash B and 0.11 x 10^6 cfu ml^{-1} to 12.55 x 10^6 cfu ml^{-1} in syrup C. The bacterial count of least popular beverages increased from the initial value of 0.66 x 10^6 cfu ml^{-1} to 9.99 x 10^6 cfu ml^{-1} in squash D, 0.44 x 10^6 cfu ml^{-1} to 14.66 x 10^6 cfu ml^{-1} in squash E and 1.77 x 10^6 cfu ml^{-1} to 9.66 x 10^6 cfu ml^{-1} in syrup F. Effect of storage on the bacterial population of different batches of beverages are illustrated in Fig 18.

4.4.2. Fungus

The mean fungal population in the three most popular beverages was found to be 0.11 x 10^3 cfu ml^{-1} (squash A), 0.33 x 10^3 cfu ml^{-1} (squash B) and 0.11 x 10^3 cfu ml^{-1} (syrup C). In the case of least popular beverages, the mean fungal count was 0.22 x 10^3 cfu ml^{-1} (squash D), 0.11 x 10^3 cfu ml^{-1} (squash E) and 0.33 x 10^3 cfu ml^{-1} (syrup F). The variation observed in the fungal count of different batches of beverages was found to be statistically insignificant (Table 34).

During storage, the fungal population increased in all fruit beverages. The fungal count increased from a mean value of 0.11 x 10^3 cfu ml^{-1}, 0.33 x 10^3 cfu ml^{-1}, and 0.11 x 10^3 cfu ml^{-1} during first month to 84.55 x 10^3 cfu ml^{-1}, 52.55 x 10^3 cfu ml^{-1} and 81.55 x 10^3 cfu ml^{-1} during ninth month of storage in squash A, B and syrup C respectively. The fungal level of least popular beverages increased from 0.22 x 10^3 cfu ml^{-1}, 0.11 x 10^3 cfu ml^{-1} and 0.33 x 10^3 cfu ml^{-1} during first month to 49 x 10^3 cfu ml^{-1}, 87.89 x 10^3 cfu ml^{-1} and 52.33 x 10^3 cfu ml^{-1} during ninth month of storage in squash D, E and syrup F respectively. The effect of storage on the fungal population is given in Fig. 19.

Yeast and *E. coli* were not detected in any of the beverage samples throughout the storage period.

Table 34. Effect of storage periods on fungal population of fruit beverages

Sl. No.	Fruit beverages	Fungus (x 10^3 cfu ml^{-1})				
		Storage periods in months				
		First	Third	Fifth	Seventh	Ninth
1.	Squash A_1	0 (0.81) ^{d}	0 (0.81) ^{d}	1 (1.09) ^{d}	6.66 (1.75) ^{cd}	86.66 (3.65) ^{ab}
	Squash A_2	0.33 (0.92) ^{d}	1 (1.09) ^{d}	1.66 (1.25) ^{d}	3 (1.45) ^{d}	89.33 (3.65) ^{a}
	Squash A_3	0 (0.81) ^{d}	0 (0.81) ^{d}	1 (1.09) ^{d}	19.3 (2.44) ^{bc}	77.66 (3.69) ^{a}
	Mean	0.11	0.33	1.22	9.65	84.55
2.	Squash B_1	0.66 (0.98) ^{gh}	0.66 (0.98) ^{gh}	2 (1.30) ^{fg}	52.66 (3.25) ^{b}	119.66 (4.19) ^{a}
	Squash B_2	0 (0.81) ^{h}	0.66 (0.98) ^{gh}	2 (1.30) ^{fg}	9.66 (1.96) ^{de}	15 (2.25) ^{cd}
	Squash B_3	0.33 (0.92) ^{gh}	0.33 (0.92) ^{gh}	2.33 (1.35) ^{fg}	4.66 (1.60) ^{ef}	23 (2.57) ^{c}
	Mean	0.33	0.55	2.11	22.32	52.55
3.	Syrup C_1	0 (0.81) ^{d}	0 (0.81) ^{d}	1.66 (1.25) ^{d}	7.66 (1.80) ^{cd}	86.66 (3.30) ^{ab}
	Syrup C_2	0.33 (0.92) ^{d}	1 (1.09) ^{d}	1.33 (1.15) ^{d}	4 (1.55) ^{cd}	84.33 (3.51) ^{a}
	Syrup C_3	0 (0.81) ^{d}	0 (0.81) ^{d}	1.33 (1.15) ^{d}	18.33 (2.39) ^{bc}	73.66 (3.64) ^{a}
	Mean	0.11	0.33	1.44	9.99	81.55
4.	Squash D_1	0.33 (0.92) ^{fg}	0.66 (0.98) ^{fg}	2.33 (1.34) ^{def}	53.66 (3.26) ^{b}	110.66 (4.18) ^{a}
	Squash D_2	0 (0.81) ^{g}	1 (1.09) ^{efg}	2 (1.30) ^{defg}	7 (1.75) ^{d}	14.66 (2.23) ^{c}
	Squash D_3	0.33 (0.92) ^{fg}	0.33 (0.92) ^{fg}	2 (1.30) ^{defg}	3.66 (1.53) ^{de}	23.66 (2.60) ^{c}
	Mean	0.22	0.66	2.11	21.44	49
5.	Squash E_1	0.33 (0.92) ^{c}	0.66 (0.98) ^{c}	2 (1.30) ^{c}	5.66 (1.68) ^{c}	88 (3.45) ^{a}
	Squash E_2	0 (0.81) ^{c}	0.33 (0.92) ^{c}	1 (1.09) ^{c}	3 (1.43) ^{c}	94.33 (3.76) ^{a}
	Squash E_3	0 (0.81) ^{c}	0 (0.81) ^{c}	1.66 (1.20) ^{c}	21 (2.51) ^{b}	81.33 (3.74) ^{a}
	Mean	0.11	0.33	1.55	9.89	87.89
6.	Syrup F_1	0.66 (0.98) ^{efg}	1 (1.09) ^{efg}	2.33 (1.34) ^{def}	51.66 (3.23) ^{b}	119.66 (4.19) ^{a}
	Syrup F_2	0 (0.81) ^{g}	1 (1.09) ^{efg}	2.66 (1.41) ^{de}	13 (2.15) ^{c}	13.66 (2.21) ^{c}
	Syrup F_3	0.33 (0.92) ^{fg}	0.33 (0.92) ^{fg}	2.33 (1.34) ^{def}	6 (1.70) ^{d}	23.66 (2.59) ^{c}
	Mean	0.33	0.78	2.44	23.55	52.33

Values with even alphabets do not differ significantly Figures in parentheses are transformed values (Power transformation) $(x + 0.5)^{\wedge 0.3}$

Fig. 18. Effect of storage on bacterial population of fruit beverages

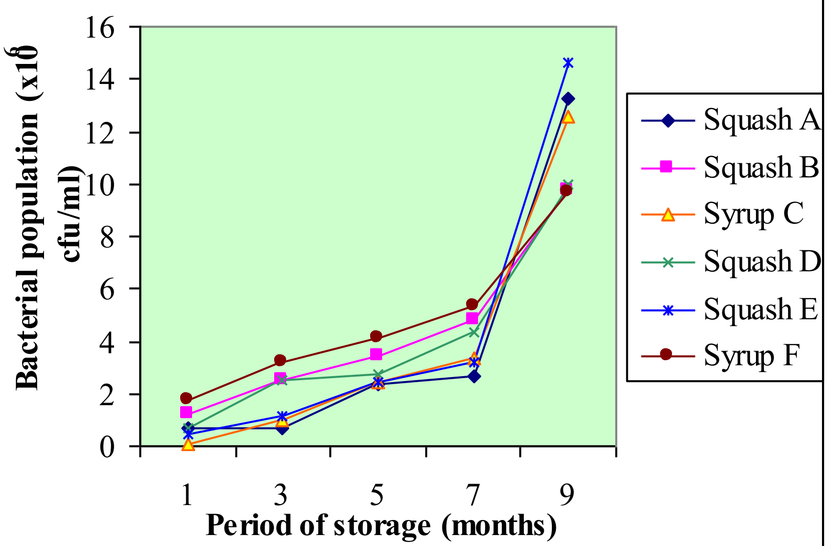
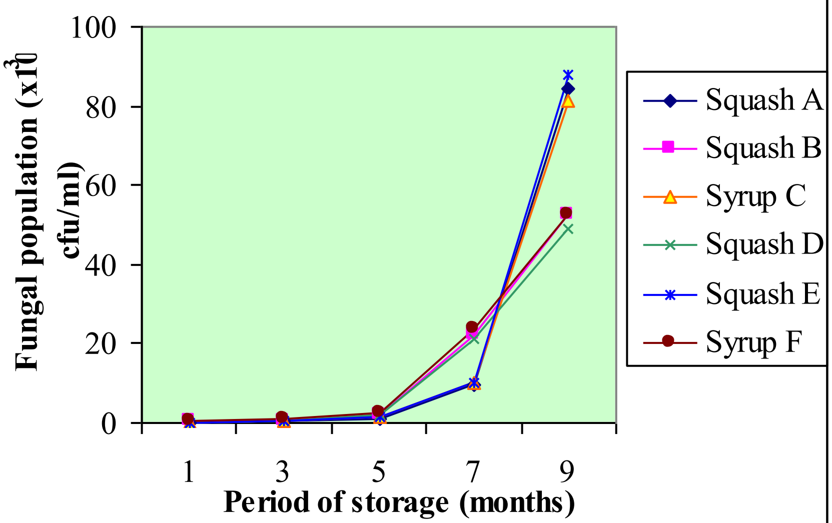


Fig. 19. Effect of storage on fungal population of fruit beverages



DISCUSSION

5. DISCUSSION

The results of the study entitled "Quality evaluation of fruit beverages" are discussed in this chapter.

5.1. Chemical constituents of fruit beverages during storage

The acidity of fruit beverages varied from 0.64 per cent to 1.28 per cent with a mean acidity of 1.15 per cent in squash A and 0.85 per cent in Squash B and 0.64 per cent in syrup C, during the first month. In the case of least popular beverages the mean acidity varied from 0.64 per cent in syrup F to 0.96 per cent in squash D and E. The acidity of different batches of squash and syrup were found to be lower than the acidity of not less than 1.5 per cent suggested by FPO. Similar findings were observed in apricot squash (Manan *et al*., 1992) and in pineapple squash (Sudhagar, 2001) in which the authors observed 1.2 per cent and 1.08 per cent acidity respectively.

In the case of different batches of beverages, the acidity of squash A_1 and A_3 and squash A_2 and A_3 and squash B_1 and B_3 and squash B_2 and B_3 varied significantly. In syrup C and in all the least popular beverages the variation in acidity between the different batches of beverages was statistically insignificant.

During the storage period, an increase in the acidity of beverages was observed in all the beverages. The increase was found to be significant in all the beverages except squash B and C.

During the initial period of storage, maximum increase was observed in most of the beverages and then the increase was found to be at a lower rate with advancement of storage period. The increase in acidity observed in the beverages may be due to the interaction of organic acid present in the beverages. Joy, (2003) also observed an increase in acidity of fruit beverages during storage and indicated that the increase was due to the interaction of organic acids. Palaniswamy and Muthukrishnan (1974), Hema (1997) and Sudhagar (2001) also observed an increase in total acidity in mango, jamun and pear squash respectively.

The mean TSS of squash A and B was found to be 50.67^0 brix and 40.5^0 brix respectively where as in syrup C the TSS was found to be 75^0 brix. In case of least popular beverages the mean TSS of squash D and E was found to be 42^0 and 51^0 brix respectively where as in the case of syrup F, the TSS was found to be 74.33^0 brix during initial period of storage. All the beverages satisfied the standards suggested by FPO both for squashes (not less than 40%) and syrup (not less than 65%). Sheeja (1994) and Gothwal *et al*. (1998) observed a TSS of 56.80^0 brix and 45^0 brix in pineapple and plum squashes respectively.

Significant variation in the TSS content of different batches of beverages were not observed except in case of squash A_2 and A_1 and squash A_2 and A_3.

The TSS content remained constant throughout the storage period in different batches of squash A and D. Similar findings was observed by Kalra *et al*. (1991) and Hema (1997) in papaya mango blended beverages and in jamun squash respectively. In the case of squash B and E, and syrup C and F, an increase in the TSS content was observed. Wasker and Khurdiya (1982), Mehta and Bajaj (1983), Jain *et al* (1984), Garande *et al*. (1995), Joy (2003) and Kotecha and Kodam (2003) also reported an increase in the TSS of different fruit beverages like phalsa squash, kiwi fruit squash, orange, lemon and beal squash, jamun squash, rose apple squash and tamarind syrup during storage.

The increasing trend observed in squash B and E were found to be more during the initial period of storage. After seventh month of storage till the expiry date no change in TSS content was observed in the case of squash B. In squash E, no change in TSS content was observed between fifth and seventh month of storage while, after seventh month a slight increase of 0.5 per cent in TSS content was observed in different batches.

Total sugar content of fruit beverages was found to be 32.05 per cent (squash A), 31.26 per cent (squash B) and 52.08 per cent (syrup C). In least popular beverages the total sugar was 30.79 per cent (squash D), 35.31 per cent (squash E) and 54.82 per cent (syrup F). Almost similar total sugar content of 35.05 to 35.19 per cent was observed in pineapple squash by Sudhagar (2001). Joy (2003) indicated a high total sugar content of 41.20 per cent in rose apple squash. No variation in total sugar content of different batches of squash A and E, syrup C and F was observed during the initial period. However, the variation in the total sugar content between the batches squash B_1 and B_3, squash B_2 and B_3, squash D_1 and D_2 and squash D_1 and D_3 was found to be statistically significant.

The total sugar content of all fruit beverages increased during storage. The increase in total sugar was found to be statistically significant in all beverages except squash B and D. Jain *et al.* (1988), Joy (2003) and Kotecha and Kodam (2003) reported an increase in total sugar during storage in litchi squash, rose apple squash and tamarind syrup.

Though, a faster increase in total sugar was noticed during the initial period of storage in most of the fruit beverages, the rate of increase slowed down during third to fifth month of storage in almost all the beverages. Again, an increase in the total sugar content was noticed during fifth to seventh month of storage for all beverages and rate decreased during the final phase of storage in almost all the beverages except syrup C and syrup F.

The mean reducing sugar content of most popular beverages during the first month of storage was found to be 24.51 per cent in squash A, 19.24 per cent in squash B and 34.20 per cent in syrup C. In least popular beverages the reducing sugar content was found to be 22.83 per cent in squash D, 23.81 per cent in squash E. The reducing sugar content observed in beverages selected for the present study was found to be lower than the reducing sugar content of 26.77 per cent observed in rose apple squash by Joy (2003). The reducing sugar content of syrup F was 35.91 per cent initially.

The variation observed in the reducing sugar content of different batches of beverages was statistically insignificant in almost all brands except in the case of squash B and D in which, the content of squash B_3 varied significantly from squash B_1 and B_2 and squash D_1 from D_2 and D_3.

A gradual increase in the reducing sugar content of the beverages was observed during storage except in squash A, D and E. The reducing sugar content of squash B increased from 19.24 to 21.80 per cent and in syrup C it increased from 34.20 to 41.25 per cent. In syrup F, the increase observed was from 35.91 to 41.25 per cent. The maximum increase in reducing sugar content was noticed during later part i.e. in syrup C and syrup F after seventh month of storage.

The increase in reducing sugar content noticed during storage could be attributed to the gradual inversion of non-reducing sugar. Jain *et al.* (1988) and Joy (2003) also observed an increase in reducing sugar content of litchi and rose apple squash respectively. Similar findings of increase in reducing sugar were also reported by Wasker and Khurdiya (1987) and Hema (1997) in phalsa and jamun squashes respectively. Contrary to this a decreasing trend in the reducing sugar content was observed in squash A, D and E was reported by Hilda and Manimegalai (1996) and Sudhagar (2001) in amla and pear squash respectively during storage at room temperature.

Initially, a non-reducing sugar content of 7.77 per cent (squash A), 12,11 per cent (squash B) and 17.88 per cent (syrup C) was observed in case of three most popular beverages where as in case of least popular beverages the non-reducing sugar content was found to be 7.29 per cent (squash D), 11.5 per cent (squash E) and 18.91 per cent (syrup F). Joy (2003) also reported a non-reducing sugar content of 14.43 per cent in rose apple squash.

The variation observed in the non-reducing sugar content between the batches of syrup C, squash E and syrup F was statistically insignificant. The increase in non-reducing sugar content observed in different beverages during storage was found to be statistically significant in different brands except squash B. In the case of syrup F, no change in the non-reducing sugar content was observed in between fifth and seventh month of storage. Contrary to this finding Jain *et al.* (1984) observed a decrease in non-reducing sugar in orange, lemon and beal squash when stored at low temperature.

A fast increase in non-reducing sugar content in all the beverages was noticed during the earlier period of storage. During the later period of storage though there was an increase in non-reducing sugar content of most beverages, it was at a slower rate especially during seventh to ninth month of storage.

The mean vitamin C content of fruit beverages varied from 64.4 mg100 ml^{-1} squash B and syrup C to 92.8 mg 100 ml^{-1} in squash A during first month. The mean vitamin C content of squash E was 116 mg 100 ml^{-1} followed by 69.6 mg 100 ml^{-1}in squash D and 64.4 mg 100 ml^{-1} in syrup F initially. Yamane and Ogawa (1998) also observed a vitamin C content in the range of 34 to 47 mg 100 ml^{-1} in lime juice, citrus juice, and orange juice and apple juice respectively. Vitamin C content in the range of 13.7 to 121.7 mg 100 ml^{-1} was found in cashew apple juice, nectar and RTS by Assuncao and Mercadante (2003). Significant variation in the vitamin C content of different batches of beverages was not observed.

During storage, upto expiry date the vitamin C content decreased with advancement of time in which a loss of 42.89 per cent in squash A, 37.07 per cent in squash B and 37.07 per cent in syrup C was noticed. Similarly, the loss of vitamin C was found to be 38.41 per cent in squash D, 45.09 per cent in squash E and 38.76 per cent in syrup F from first month to ninth month of storage. Hilda and Manimegalai (1996) also observed a decrease in the vitamin C content of papaya-mango blended beverages from 87.6 to 43.58 mg 100 ml^{-1}. Kotecha and Kodam (2003) observed a decrease in vitamin C content of tamarind syrup during storage. The decrease in vitamin C content was due to the oxidation of vitamin C.

The decrease in the vitamin C content of beverages during different months of storage was found to be statistically significant in all brands of beverages except squash D. The decrease in vitamin C content of almost all beverages was maximum during the later part of storage.

Among the most popular beverages analysed, higher β-carotene content was noticed in Squash A (112.82 µg 100 ml^{-1}) followed by syrup C (90.09 µg 100 ml^{-1}) and lowest in squash B (89.63 µg 100 ml^{-1}). In the least popular beverages the β-carotene content was highest in squash E (115.31 µg 100 ml^{-1}) followed by syrup F (99.88 µg 100 ml^{-1}) and squash D (98.96 µg 100 ml^{-1}). Almost similar β-carotene content in cashew apple juice and RTS was observed by Assuncao and Mercadante (2003). The variation observed in the β-carotene content of different brands of beverages is mainly due to the variation in the β-carotene content of the fruits selected to prepare the beverages.

A significant variation in the β-carotene content of different batches of all beverages was noticed except in syrup F, where the variation observed in the β-carotene content of syrup F_2 and F_3 was statistically insignificant.

During storage, the β-carotene content decreased in all the beverages. The loss was found to be from 112.82 to 62.55 µg 100 ml^{-1} (squash A), 89.63 to 58.03 µg 100 ml^{-1} (squash B) and 90.09 to 51.00 µg 100 ml^{-1} (syrup C) from first month of storage to ninth month of storage. In the case of least popular beverages the decrease was found to be from 98.96 to 62.97 µg 100 ml^{-1} in squash D, 115.31 to 80.20 µg 100 ml^{-1} in squash E and 99.88 to 55.35 µg 100 ml^{-1} in syrup F from first month of storage to ninth month of storage. A decrease in the β-carotene content of mango RTS beverages during storage was observed by Beerh *et al*. (1989). The decrease in β-carotene content may be due to non-oxidative or oxidative changes and such changes may alter the colour of the product and lower the flavour and nutritive value of the product.

The decrease observed in the β-carotene content of beverages was statistically significant during the initial phases of storage. In the case of squash E, a significant decrease in β-carotene was observed during all periods of storage while in squash A, syrup C, and squash D, the decrease observed was statistically insignificant during the later part of storage.

The mean sodium content in the most popular beverages was 81.6 mg 100 ml^{-1} in squash A followed by 26.4 mg 100 ml^{-1} in squash B and 11.2 mg 100 ml^{-1} in syrup C. Similarly, mean sodium content in the least popular beverages was 37.8 mg 100 ml^{-1} in squash E, 34.47 mg 100 ml^{-1} in syrup F and 16 mg 100 ml^{-1} in squash D.

A significant variation in the sodium content was observed in different batches of beverages except squash E and the sodium content of all beverages remained constant through out the storage period.

The mean potassium content of most popular beverages was 58 mg 100 ml^{-1} in syrup C, followed by 55.67 mg 100 ml^{-1} in squash A and 31.67 mg 100 ml^{-1} in squash B where as in least popular beverages the content was 54 mg 100 ml^{-1} in syrup F followed by 41.33 mg 100 ml^{-1} in squash E and 27 mg 100 ml^{-1} in squash D.

The variation in potassium content of different batches of beverages was statistically insignificant except in squash B in which, the variation in the potassium content of three batches was found to be statistically significant. The potassium content of fruit beverages remained constant through out the storage period.

The mean pectin content of fruit beverages was found to be 0.90 per cent in syrup C and 0.97 per cent in squash A and B. In the case of least popular beverages, the pectin content was found to be 1.01 per cent (squash D), 1 per cent (syrup F) and 0.78 per cent (squash E). The variation observed in the pectin content of different batches of each brand was found to be statistically insignificant except in squash B and syrup C. Tejinder *et al.* (1999) also indicated almost similar pectin content of 0.64 per cent in pasteurized grape juice.

During storage, the pectin content decreased gradually in all the beverages. The decrease was from a mean content of 0.97 per cent, 0.97 per cent and 0.90 per cent to 0.63 per cent, 0.83 per cent and 0.69 per cent in squash A, B and syrup C respectively from first to ninth month of storage. In case of squash D the pectin content decreased from 1.01 to 0.79 per cent, 0.78 to 0.56 per cent (squash E) and 1 to 0.8 per cent in syrup F from first to ninth month of storage. A decrease in pectin content was observed by Kaushik and Nath (1991) in mango beverages and by Chahal and Saini (1999) in watermelon juice during storage. Mayer and Harel (1960) found that this decrease might be due to conversion of protopectin into pectinic acid and pectic acid and further to D-galacturonic acid during storage.

The decrease observed in the pectin content of beverages during all storage periods was statistically significant in squash A, B, E and syrup F where as in squash D, the decrease observed was statistically insignificant. The decrease observed in the pectin content was not systematic in any of the beverages. In case of squash A and syrup F the maximum decrease was observed during the last period of storage. In squash B and E highest decrease was noted during the third phase of storage (fifth to seventh month) where as in squash C and D the highest degradation was during the second and first phases respectively.

The sulphur dioxide content of all the beverages was found to be within the limits prescribed by FPO. The mean highest sulphur dioxide content was observed in squash A (256 ppm) followed by syrup C (204 ppm) and squash B (202.67 ppm). In case of least popular beverages maximum sulphur dioxide was found in squash E (230.4 ppm) followed by syrup F (198.4 ppm) and squash D (172.8 ppm).

With respect to the different batches of each brand the variation observed in the sulphur dioxide content was found to be statistically insignificant except in squash B where significant variation in the sulphur dioxide content of different batches was observed.

During the storage period, a decrease in the sulphur dioxide content of fruit beverages was observed. In the case of most popular beverages the decrease of 50 to 76 per cent in the sulphur dioxide content was observed at the end of storage. In the case of squash A and C, sulphur dioxide content decreased to 50 per cent of the initial value where as in squash B, a drastic decrease of 76 per cent was noticed during the ninth month of storage. In the case of least popular beverages also a decrease of 66, 33 and 61 per cent was observed in squash D, E and syrup F respectively during storage.

In most of the squashes, except in squash B, maximum decrease in the sulphur dioxide content of different batches was statistically content was observed after third month of storage. Though, there was a decrease in the sulphur dioxide content of different batches was statistically content after this, the rate of decrease was found to be at a lower rate.

Similar findings of decrease in the sulphur dioxide content were observed by Alex *et al*. (2003) in processed litchi juice and by Kaushik and Nath (1991) in mango beverages during storage. The loss of in the sulphur dioxide content of different batches was statistically during storage may be partially due to diffusion and oxidation (Ingram, 1949).

All the fruit beverages contained synthetic food colours. The main colours detected were sunset yellow and tartrazine. In the case of the most popular beverages, in squashes quantity of sunset yellow was 136.5 ppm in squash A and tartrazine was 133.2 ppm in squash B. All beverages except squash B_2 exceeded the permissible limit of 100 ppm for colour prescribed by FPO for fruit beverages. In case of syrup C_1, a combination of two colours i.e. sunset yellow (7.2 ppm) and tartrazine (24.6 ppm) was found but the quantity added was within the permissible level.

In the case of least popular beverages, also the sunset yellow and tartrazine were the predominant colours present and the mean content of sunset yellow in squash E was 42.3 ppm and mean tartrazine content in squash D was 28.6 ppm, which were within the permissible limit. But, in case of syrup F, combinations of colours were used i.e., a mean content of sunset yellow 74.3 ppm (within the permissible limit) and a mean tartrazine content of 310.9 ppm was detected. The colour used in syrup F exceeded the permissible limit. The addition of illegal colours was not detected in any of the beverages. A similar finding of absence of illegal colours was reported by Chou *et al.* (2002) in different samples of soft drinks.

Jannalagadda *et al*. (2004) also observed tartrazine and sun set yellow as the widely used permitted colours in ready to eat foods.

The level of colour added to the soft drinks analyed was within the statutory limits of 100 mg per litre for total colour (Food Standard Agency, UK, 2004). However, Food Standard Agency, UK (2004) indicated higher level of sunset yellow and carmosine in soft drinks. In the present study also in syrup C, squash D and squash E the quantity of synthetic colour added was found to be within the permitted level. However, in squash A, B and F the synthetic colour added exceeded the permissible level.

The mean lead content of most popular beverages was found to be 5.37 ppm (squash B) followed by 3.93 ppm (syrup C) and 2.93 ppm (squash A). In case of least popular beverages the highest level was detected in syrup F (3.77 ppm) followed by squash D (2.97 ppm) and squash E (2.77 ppm). Lead content observed in the beverages was slightly higher then the level of 2.5 ppm prescribed by PFA (NIN, 2004). The lead content noted in the beverages may be due to the use of lead pipes in the processing plant, which is used to supply water to the plant. Similar result of lead contamination was reported by Choudhary (1999) in different market samples of musambi juice.

Significant difference in the lead content of all batches of squash B was observed. In the case of squash A, the variation was significant between squash A_1 and A_2 and between squash A_1 and A_3. In case of syrup C, the variation was significant between syrup C_1 and C_2 and also in C_1 and C_3. Similarly, in least popular beverages, the variation in lead content between batches of squash D was statistically significant.

During storage, the lead content remained constant through out the storage period. Contrary to this Arvanitoyannis (1990) reported an increase in the lead content of canned peach, pear, apricot and apple juice during two years of storage, which might be from the container used for storage.

The mean cadmium content of most popular beverages was found to be 0.16 ppm in squash B followed by 0.15 ppm in syrup C as well as in squash A. The cadmium content of least popular beverages was 0.15 ppm in syrup F, squash

D and squash E. The cadmium content in the beverages were far below the level of 1.5 ppm prescribed by PFA (NIN, 2004). However, the cadmium content observed might be due to the contaminated soil where the fruit plant has grown and the contaminated water used for processing (Moore and Ramamoorthy, 1984). Similar result of cadmium contamination was detected in market musambi juice by Choudhary (1999).

Cadmium content of the beverages remained constant through out the storage period. Arvanitoyannis (1990) also indicated no change in the cadmium content of canned peach, pear, apricot and apple juice even after two years of storage.

5.2**. Acceptability of fruit beverages**

The initial mean score for appearance of most popular beverages ranged from 3.5 (squash B_1, B_2 and B_3) to 4.1 (squash C_1) with a mean value of 3.97 (syrup C), 3.9 (squash A) and 3.5 (squash B) where as, in least popular beverages the score ranged from 2.9 (syrup F_3) to 3.6 (squash D_3) with a mean value of 3.47 (squash D), 3.50 (squash E) and 2.97 (syrup F) initially. The variation between batches of all the beverages was found to be statistically insignificant.

During storage, the mean score for appearance decreased to 2.93, 2.40 and 2.77 for squash A, B and syrup C respectively and in least popular beverages the decrease was 2.77, 2.83 and 2.03 during ninth month. The decrease in appearance of the squash may be due to the deterioration of the pigment. Joy (2003) also observed a decrease in appearance of rose apple squash during storage. However, Wasker and Khurdiya (1987) noted maximum retention of anthocyanin pigment in phalsa squash stored at cool temperature.

In the case of colour also, the mean score decreased during the storage period. The decrease was from 3.93 to 3.13 (squash A), 3.43 to 2.33 (squash B) and 3.80 to 3.00 (syrup C) in case of most popular beverages where as in least popular beverages, the decrease was from 3.60 to 2.50 (squash D), 3.60 to 2.33 (squash E) and 3.30 to 1.90 (syrup F) from initial to final month of storage. Since, the appearance and colour are interrelated, the decrease in the colour obtained during storage may be attributed to the bleaching of the colour by light rays, which passed through the glass bottles, which are colourless. Hema (1997) also indicated a decrease in colour of jamun squash during storage.

A decreasing trend in the flavour was also observed in all the fruit beverages during storage. The mean score of the beverages decreased from an initial value of 3.70, 3.40, 3.50, 3.47, 3.43 and 3.80 to a final value of 2.93, 2.37, 3.00, 2.43, 2.50 and 2.63 respectively in squash A, B, syrup C, squash D, E and syrup F during storage. Joy (2003) reported a decrease in flavour of rose apple squash, which was due to the loss of volatile aromatic substances. A loss in flavour in kiwi fruit squash during storage was observed by Thakur and Barwal (1999).

In case of taste also a decreasing trend was observed in all the fruit beverages. The decrease was from an initial value of 3.40, 2.93 and 3.70 to 2.80, 2.30 and 2.40 in squash A, B and syrup C respectively. In least popular beverages the decrease was from 3.60, 3.43 and 3.03 to 2.73, 2,70 and 2.00 in squash D, E and syrup F. The decrease in taste may be due to change in chemical constituents and volatile aromatic substances. Thakur and Barwal (1999) and Joy (2003) also noted a decrease in taste during storage in kiwi fruit squash and rose apple squash respectively.

5.3. Microflora in fruit beverages

The bacterial count of most popular beverages during the initial period of storage was found to be 0.66 x 10^6 cfu ml^{-1} (squash A), 1.22 x 10^6 cfu ml^{-1} (squash B) and 0.11 x 10^6 cfu ml^{-1} (syrup C) where as the bacterial count of the least popular beverages found to be 0.66 x 10^6 cfu ml^{-1} (squash D), 0.44 x 10^6 cfu ml^{-1} (squash E) and 1.77 x 10^6 cfu ml^{-1} (syrup F). Similar bacterial count of 2.3 x 10^8 cfu ml^{-1} and 3.9 x 10^5 cfu ml^{-1} was observed by Daw *et al.* (1994) in commercially prepared sobia and tamarind drinks.

The bacterial count of the different batches of different brands didn't show much variation. However, in squash B_1 and B_2, B_1 B_3 and syrup F_1 and F_3 significant variation in the bacterial count was observed.

An increase in bacterial count was observed in all the batches of all the beverages. In case of most popular beverages the increase was from 0.66 x 10^6 cfu ml^{-1} to 13.22 x 10^6 cfu ml^{-1} (squash A), 1.22 x 10^6 cfu ml^{-1} to 9.77 x 10^6 cfu ml^{-1} (squash B) and 0.11 x 10^6 cfu ml^{-1} to 12.55 x 10^6 cfu ml^{-1} (syrup C) from first month to ninth month of storage. The bacterial count in least popular beverages increased from the initial value of 0.66 x 10^6 cfu ml^{-1} to 9.99 x 10^6 cfu ml^{-1} (squash D), 0.44 x 10^6 cfu ml^{-1} to 14.66 x 10^6 cfu ml^{-1} (squash E) and 1.77 x 10^6 cfu ml^{-1} to 9.66 x 10^6 cfu ml^{-1} (syrup F) in ninth month of storage. A bacterial count of 5.0 x 10^6 cfu g^{-1} was detected in strawberry squash by Saravanakumar (1997) after 180 days of storage. A bacterial count of 4 x 10^6 cfu g^{-1} were detected in clarified banana squash by Chitra (2000) after 300 days of storage. Sudhagar (2001) also observed a bacterial count of 7-9 x 10^6 cfu g^{-1} in pear and pear-blended squash after six months of storage at ambient temperature.

Squash B had the highest fungal count of 0.33 x 10^3 cfu ml^{-1} followed by squash A and syrup C i.e. 0.11 x 10^3 cfu ml^{-1}. In the case of least popular beverages, the mean fungal count was 0.22 x 10^3 cfu ml^{-1} in squash D, 0.11 x 10^3 cfu ml^{-1} in squash E and 0.33 x 10^3 cfu ml^{-1} in syrup F. The variation observed in the fungal count of different batches of beverages was found to be statistically insignificant. A fungal count of 9.2 x 10^3 cfu 100 ml^{-1} was detected in apple juice by Hassan *et al.* (1992).

During storage of fruit beverages the fungal population increased from an initial value of 0.11 x 10^3 cfu ml^{-1}, 0.33 x 10^3 cfu ml^{-1} and 0.11 x 10^3 cfu ml^{-1} to 84.55 x 10^3 cfu ml^{-1}, 52.55 x 10^3 cfu ml^{-1} and 81.55 x 10^3 cfu ml^{-1} in squash A, B and syrup C respectively. In case of least popular beverages the mean fungal count increased to 49 x 10^3 cfu ml^{-1}, 87.89 x 10^3 cfu ml^{-1} and 52.33 x 10^3 cfu ml^{-1} during ninth month from 0.22 x 10^3 cfu ml^{-1}, 0.11 x 10^3 cfu ml^{-1} and 0.33 x 10^3 cfu ml^{-1} during first month in squash D, E and syrup F respectively. An increase in the fungal count was detected by Sudhagar (2001) in pear and pear-blended squashes after six months of storage at room temperature. Chitra (2000) observed a fungal count of 13 x 10^4 cfu g^{-1} in the clarified banana RTS after 300 days of storage.

Yeast count was not detected in any of the beverages through out the storage period. This may be due to the antimicrobial property of sulphur dioxide added to the beverages. Similarly, Thakur *et al.* (2000) also indicated no yeast count in kinnow juice concentrate stored with the addition of sulphur dioxide. *E. coli* count was also not observed in any of the beverage sample through out the storage period. This may be due to the use of sterilized and purified water in the processing plant.

SUMMARY

6. SUMMARY

The present study entitled "Quality evaluation of fruit beverages " was conducted to evaluate the quality attributes of commercial fruit beverages and the changes during storage up to the expiry date. The fruit beverages were evaluated for chemical constituents, heavy metal contamination, acceptability and microbial quality at bimonthly intervals.

After conducting a market survey in the super markets and bakeries of Trichur Corporation area, three most popular and three least popular beverages were selected for the study. Chemical constituents such as acidity, TSS, total sugar, reducing sugar, non reducing sugar, β-carotene, vitamin C, pectin, sulphur dioxide, coloring agents, sodium, potassium, lead and cadmium were evaluated in the selected beverages.

The acidity of the fruit beverages varied from a lowest value of 0.64 per cent (syrup C) to 1.15 per cent (squash A) in most popular beverages and from 0.64 per cent (syrup F) to 0.96 per cent (squash D and E) in least popular beverages. A increase in acidity of beverages was noticed during storage.

Squash A and B had the TSS content of 50.67^0 brix and 40.5^0 brix respectively where as syrup C had a TSS of 75^0 brix. In case of least popular beverages the mean TSS of squash D and E were found to be 42^0 and 51^0 brix respectively where as in the case of syrup F the TSS was found to be 74.33^0 brix. During storage an increase in the TSS content was observed in most beverages.

In the case of most popular beverages the total sugar content varied from 31.26 per cent in squash B to 52.08 per cent in syrup C while in least popular beverages the content varied from 30.79 per cent in squash D to 54.82 per cent in syrup F. A significant increase in the total sugar content of most of the beverages was noticed during storage.

The reducing sugar content of most popular fruit beverages varied from 24.52 per cent in squash A to 34.20 per cent in syrup C and from 23.81 per cent in squash D and E to 35.91 per cent syrup F in least popular groups.

Among the most popular beverages non-reducing sugar content of syrup C was found to be the highest (17.88%) and squash A had the (7.77%) lowest. Syrup F had the highest (18.91%) and squash D (7.29%) had the lowest non-reducing sugar contents respectively among the least popular fruit beverages. The non-reducing sugar increased gradually during storage.

Vitamin C content of the three most popular beverages was found to be 92.8 mg 100 ml^{-1} in squash A, 64.4 mg 100 ml^{-1} in squash B as well as syrup C. In case of least popular beverages highest vitamin C content was found in squash E (116 mg 100 ml^{-1}) followed by squash D (69.6 mg 100 ml^{-1}) and lowest in syrup F (64.4 mg 100 ml^{-1}).

Among the most popular beverages highest β-carotene content was noticed in squash A (112.82 μg 100 ml^{-1}) followed by syrup C (90.09 μg 100 ml^{-1}) and squash B (89.63 μg 100 ml^{-1}). The β-carotene content of least popular beverages varied from 98.96 μg 100 ml^{-}1 in squash D to (115.31 μg 100 ml^{-1}) in squash E.

A decrease in the vitamin C content and β-carotene contents of the beverages was noticed during storage.

The sodium content of most popular beverages varied from the highest value of 81.6 mg 100 ml^{-1} (squash A) to a lowest value of 11.2 mg 100 ml^{-1} (syrup C) where as highest sodium content was observed in squash E (37.8 mg 100 ml^{-1}) and lowest was observed in squash D (16 mg 100 ml^{-1}) in case of least popular beverages.

Among the most popular beverages the potassium content varied from the highest value of 58 mg 100 ml^{-1} (syrup C) to a lowest value of 31.7 mg 100 ml^{-1} (squash B) where as it varied from a highest value of 54 mg 100 ml^{-1} (syrup F) to a lowest value of 27 mg 100 ml^{-1} (squash D) in case of least popular beverages.

The sodium and potassium contents of the beverages remained constant throughout the storage period.

The pectin content of fruit beverages varied from 0.97 per cent (squash A and B and 0.90 per cent in syrup C in most popular beverages. The pectin content of least popular beverages varied from 1.01 per cent in squash D, 0.78 per cent in squash E and 1 per cent in syrup F, which gradually decreased during storage.

SO_2 content of 256 ppm (highest) in squash A and 202.67 ppm (lowest) in squash B was detected in most popular beverages where as it was highest in squash E (230.4 ppm) and lowest in squash D (172.8 ppm) among the least popular group. A gradual decrease was noticed in the sulphur dioxide content of beverages during storage.

The synthetic food colour added to the beverages exceeds the FPO limit in squash A (104.4 ppm sunset yellow), squash B (170.6 ppm tartrazine) and syrup F (301.8 ppm tartrazine) but the other beverages contained the colours within the permissible limit.

The fruit beverages were contaminated with heavy metals like lead and cadmium. The lead content varied from 3.93 ppm in syrup C to 2.93 ppm in squash A in the most popular beverages and in the least popular beverages the lead content varied from 2.77 ppm to 3.77 ppm. In most popular beverages the cadmium content was found to be 0.15 ppm, 0.16 ppm and 0.15 ppm in squash A, B and syrup C respectively and in least popular beverages the content was found to be 0.15 ppm, 0.15 ppm and 0.15 ppm in squash D, E and syrup F respectively. The lead and cadmium content also remained constant during storage.

With regard to organoleptic quality squash A had the highest mean score throughout the storage period for appearance and colour where as syrup F secured the highest score for flavour and taste. A gradual decrease in the different organoleptic qualities was also noticed during storage of all beverages.

Regarding the microbial population, the bacterial count gradually increased with storage period. The initial bacterial count was highest in squash B (1.22 x 10^6 cfu ml^{-1}) and lowest in syrup C (0.11 x 10^6 cfu ml^{-1}) in most popular beverages where as in case of least popular beverages the highest count of 1.77 x 10^6 cfu $ml^{-1}$was found in syrup F and a lowest count of 0.44 x 10^6 cfu $ml^{-1}$was found in squash E. Similarly, fungal count also increased with increase in storage time. Squash B and syrup F had the highest fungal count of 0.33 x 10^3 cfu $ml^{-1}$and syrup C and squash E had the lowest fungal count of 0.11 x 10^3 cfu ml^{-1} initially in most popular and least popular beverages respectively. There was no traces of yeast and *E. coli* in both types of beverages through out the storage period.

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* Originals not seen.

APPENDIX

APPENDIX – I

SCORE CARD FOR ORGANOLEPTIC EVALUATION
OF FRUIT BEVERAGES

No.	Character	Description	Score	1	2	3	4	5

I	Appearance	Excellent Good Fair Poor Very poor	5 4 3 2 1					
II	Colour	Excellent Good Fair Poor Very poor	5 4 3 2 1					
III	Flavour	Excellent Good Fair Poor Very poor	5 4 3 2 1					
IV	Taste	Excellent Good Fair Poor Very poor	5 4 3 2 1					

Name

Date Signature

APPENDIX – II

Questionnaire

1. Name of the shop or super market :
2. Name of the locality :

3. What are the different types of brands of fruit beverages kept for sale in the shop

Sl. No.	Name of the beverages	Brand names

4. Can you list the beverages according to the preference of the consumer?

Preference level		
High	Medium	Low

5. Can you list the beverages/items sold more frequently from this list?

Sl. No.	Name of the beverages	Brand names

6. Can you list the beverages/items sold less frequently from this list?

Sl. No.	Name of the beverages	Brand names

QUALITY EVALUATION OF FRUIT BEVERAGES

By
SUJATA SETHY

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN HOME SCIENCE

(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture
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ABSTRACT

The present study on “Quality evaluation of fruit beverages” was undertaken to evaluate the quality attributes of commercially available fruit beverages with respect to chemical constituents, acceptability and microbial contamination.

Three most popular beverages and three least popular beverages were selected for the study after conducting a market survey in the different super markets and bakeries of Thrissur Corporation area. Both the most popular and least popular beverages were analysed for chemical constituents like acidity, TSS, total sugar, reducing sugar, non-reducing sugar, sodium, potassium, vitamin C, β-carotene, pectin, sulphur dioxide, colouring agents and heavy metals.

The mean acidity of beverages varied from 0.64 per cent to 1.15 per cent and the acidity of beverages increased during storage. None of the beverages satisfied the FPO specification for acidity. The TSS of the beverages was in accordance with the FPO specifications suggested for squash and syrup. In squash A and D, the TSS content remained constant where as in other beverages it increased with storage time.

An increase in the total sugar and non-reducing sugar contents of all beverages was noticed while the reducing sugar content of squash A, D and E decreased with advancement of storage period.

Highest vitamin C and β-carotene content were observed in squash E and the vitamin C and β-carotene contents decreased in all the beverages during storage. The highest sodium content was observed in squash A and lowest in syrup C. But, the potassium content was highest in syrup C and lowest in squash D. Sodium and potassium contents remained constant during storage.

Among the six beverages studied pectin content was highest (1.01%) in squash D and lowest in squash E (0.78%). The sulphur dioxide content was highest in squash A and lowest in squash D. Both pectin and sulphur dioxide contents of all beverages decreased during storage. The sulphur dioxide content was found to be within the permissible limit in all beverages.

Tartrazine and sunset yellow were found to be the predominant colours added to the beverages. In syrups a combination of two colours were present. The quantity of colour added to syrup C, squash D and E were found to be within the permitted level. However, in squash A, B and syrup F, the quantity exceeded the level permitted by FPO.

The beverages were contaminated with heavy metals like lead and cadmium. However, the quantity of cadmium was found to be very low. The highest lead content was detected in squash B and the lowest in squash E. Highest cadmium content was detected in squash E.

Though the beverages were found to be acceptable initially the organoleptic qualities degraded during storage. Bacteria and fungi were detected in beverages, which increased during storage, and the count was highest in the later part (seventh to ninth month) of storage. However, yeast or *E. coli* were not detected in the beverages during the storage period.