ENRICHMENT, PACKAGING AND STORAGE OF FRUIT BARS FROM *AONLA* (*Emblica officinalis* G.)

By

DEEPIKA
(2012-12-113)

THESIS

Submitted in partial fulfillment of
requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G)."** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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DECLARATION

Certified that the thesis entitled "Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G)." is a bonafide record of research work done independently by Ms. DEEPIKA (2012-12-113) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of **Ms. Deepika** (2012- 12- 113), a candidate for the degree of **Master of Science in Horticulture**, with major field in **Processing Technology**, agree that the thesis entitled **"Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G)."** may be submitted by **Ms. Deepika** in partial fulfillment of the requirement for the degree

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Introduction

INTRODUCTION

India is one of the leading fruit producing countries in the world. The production has been estimated to be around 76.4 million tonnes from an area of nearly 6.7 million hectares (NHB, 2013). In spite of the increase in production, about 30-40 per cent of the produce is lost due to improper post harvest management practices like inadequate storage, improper packaging and insufficient processing. Commercial role of fruits in contributing significantly to the country's economy, besides their nutritional and social importance, is being increasingly recognized. In order to minimize the loss in quality, to control microbial growth and to ensure product safety and convenience, proper post harvest management and value addition are required (Gajanana *et al.*, 2002).

India is blessed with a variety of agro-climatic conditions and therefore, our country produces a wide range of tropical, subtropical, temperate and arid zone fruits. Many minor fruits like *aonla*, bael, jamun, tamarind etc. are extensively cultivated in the arid zones of our country. *Aonla* or Indian gooseberry (*Emblica officinalis* G.) belongs to the family Euphorbiaceae. It is indigenous to tropical India and Southeast Asia. *Aonla* thrives well in dry and neglected areas. It is commonly cultivated in eastern Uttar Pradesh, Gujarat, Maharashtra, TamilNadu, Haryana and Rajasthan.

Aonla (*Emblica officinalis* G.) is valued for its nutritional qualities and pharmacological properties. It is a storehouse of vital antioxidants like ascorbic acid, polyphenols and is also a rich source of minerals like Fe, Ca, K etc. These qualities of *aonla* are utilized in the Ayurvedic and Unani systems of medicine. Though valued for its therapeutic role, *aonla* is still regarded as a minor and under exploited fruit crop. It is the richest source of ascorbic acid, next only to Barbados cherry. *Aonla* fruits can be used either fresh or in powdered form in various preparations like *Triphala, Arishtha, Chyavanprash* etc. The fruit is a potent antioxidant, hypolipidemic, antibacterial, antiviral, antacid, antidiabetic etc. (Khopde *et. al.*, 2001).

The acidity and astringency are two inherent characteristics of *aonla* that prevent consumers from relishing this fruit in the fresh form. Limited availability and high perishability are two major bottlenecks that demand its immediate post harvest utilization. In spite of the rapid strides made in the release of new varieties and expansion of area under cultivation, considerable losses are encountered in *aonla* due to lack of suitable post harvest management practices. The fruit cannot be stored beyond a week under ambient storage conditions. Therefore, suitable innovative techniques in packaging and storage are required to prolong the availability of this fruit (Kirtikar and Basu, 1993).

Increase in health consciousness of consumers and constant demand for healthful meals can be considered as opportunities before people working in the field of food science and technology. Value added products of *aonla* which are nutritious and delicately flavoured, can meet the demands of a health conscious population. Diversification of processed products of *aonla* with altered palatability and enhanced nutrition has been attempted to make them available throughout the year. However, excellent nutritive, antioxidant and therapeutic values of the fruit can be tapped for developing good quality products. Value added products can be prepared from *aonla* fruit by converting it into various processed products by employing different methods of preservation (Kadam, 2001).

Fruit bar or leather is a ready to eat product with soft gel like texture, obtained by dehydration of fruit purees into leathery sheets. The nutritional content varies with the extent of processing of the fruit, the selection of raw materials, the preservatives added and the packaging materials. Hence the present study deals with the preparation of a novel, value added and nutritious product from *aonla*. A suitable technique for enrichment in the development of fruit bars from *aonla,* with fruits that are good sources of provitamin A will result in enhanced nutrition and altered palatability. Hence the study 'Enrichment, packaging and storage of fruit bars from *aonla (Emblica officinalis* G.*)*' has been laid out with the following objectives:

1. To standardise optimum enrichment of *aonla* pulp to form fruit bars.
2. To evaluate the packaging materials to maintain quality during storage.

***

Review of Literature

REVIEW OF LITERATURE

Aonla fruits are highly perishable and it is very difficult to store and transport them over very long distances. Therefore, it needs immediate marketing and utilization. Moreover, the period of availability of *aonla* fruits is very limited (October-January).

The high acidity and astringency of *aonla* fruits make it undesirable to be cherished in the fresh form. Processing *aonla* fruits into excellent quality nutritious products can attract both internal and export markets (Singh and Kumar, 1995).

The information available with respect to storage, post harvest handling and pathology is scanty. Intermediate moisture products from *aonla* pulp and information pertaining to their processing and storage characteristics are also very limited. However, attempts have been made to prepare several other processed products like RTS, nectar, squash, syrup, preserve, candy etc. (Nath, 1999).

The literature available pertaining to the present study has been reviewed under the following heads:

2.1 Compositional changes

2.1.1 Total soluble solids (TSS)

2.1.2 Acidity

2.1.3 Ascorbic acid

2.1.4 Sugars

2.1.5 Polyphenols/tannins

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2.1 BIOCHEMICAL CHANGES

2.1.1 Total soluble solids (TSS)

Storage of cashew apples of different cultivars at room temperature, cool chamber and cold store revealed that the TSS decreased at the end of the storage, irrespective of varieties and storage conditions, the decrease being greater at higher storage temperature (Antarkar *et al.*, 1991).

Ojha and Pathak (1993) studied the changes in chemical composition of *aonla* fruits of different cultivars and reported that Banarasi showed maximum TSS throughout investigation as compared to other cultivars.

Storage studies in *aonla* fruits cv. Chakaiya showed that TSS increased with the increase in duration of storage, irrespective of storage condition. Among the different storage conditions, the maximum TSS content (8.96%) was recorded in fruits stored at room temperature and minimum in modified storage conditions on 24^{th} day of storage (Singh and Kumar, 1997).

2.1.2 Acidity

Antarkar *et al.* (1991) compared the storage performance of cashew apple at ambient temperature, cool chamber and low temperature. They reported that the acidity of cashew apple decreased at the end of storage period and the decrease was maximum at higher storage temperature.

Storage of aonla fruits of cv. Chakaiya under different conditions showed that acidity increased significantly with the increase in storage period, irrespective of the treatments. The maximum acidity was recorded at room temperature and minimum in modified storage (Singh and Kumar, 1997).

Effect of post harvest treatments on *aonla* fruits of cv. Chakaiya during storage revealed that the acidity increased with increase in storage period and the maximum acidity was recorded in fruits treated with diphenyl @ 0.5 g/box (Singh and Kumar, 1997).

2.1.3 Ascorbic acid

Aonla is particularly rich in vitamin C. A large amount of valuable work has been done by many researchers.

Singh and Pathak (1987) assessed the vitamin C content of different cultivars of *aonla* viz. Banarasi, Chakaiya, Francis, Kanchan and Krishna to be 659, 634.3, 434.3, 512.5 and 450.5 mg/100g, respectively.

Vitamin C content of *aonla* fruits of cv. Chakaiya was compared during storage at ambient temperature and cool chamber. The fruits stored under zero energy cool chamber retained higher vitamin C content (Kumar and Nath, 1993).

Vitamin C content of *aonla* as reported by Ojha and Pathak (1993) varied from 347.67 to 632.33 mg/100g pulp in different cultivars. Banarasi showed maximum content (632mg/100g) followed by Krishna (450.5mg/100g).

Storage studies on *aonla* cv. Desi indicated that vitamin C content in fruits decreased with the period of storage. GA_3 treatment (40 ppm) resulted in better retention of vitamin C (Patel and Sachan, 1995).

Ghorai and Sethi (1996) compared the ascorbic acid levels of *aonla* fruits of cvs. Desi and Banarasi at ambient and low temperatures. The ascorbic acid loss was 4.50 and 10.84 per cent in Desi against 4.88 and 13.06 per cent in Banarasi under low and ambient conditions, respectively at the end of 12 days of storage.

Aonla fruits of cv. Chakaiya when stored under different conditions revealed that the ascorbic acid content decreased with the duration of storage. The content was highest in modified storage conditions and diphenyl treatment @ 0.5 g/box retained maximum ascorbic acid (Singh and Kumar, 1997).

Premi *et al.* (1999) reported a considerable decrease in the ascorbic acid content of *aonla* fruits of cvs. Desi and Chakaiya during steeping preservation.

2.1.4 Sugars

Cashew apple when stored at ambient temperature (30.5-34.0^{0}C, 80.5% RH) cool chamber (26-27^{0}C, 99.0% RH) and low temperature (13^{0}C, 94.0% RH) showed a declining trend in the levels of total and reducing sugars and the decrease was greater at higher storage temperature (Antarkar *et al.*, 1991).

Evaluation of different *aonla* cultivars showed that cv. Krishna showed slightly higher total sugar and reducing sugar contents while maximum non reducing sugars were recorded in cv. Francis (Ojha and Pathak, 1993).

Performance of *aonla* fruits of cvs. Desi and Banarasi during storage at ambient (24-29^{0}C) and low temperature (2-5^{0}C) was studied by Ghorai and Sethi (1996). The total and reducing sugars were found to be more in Banarasi whereas, non reducing sugars were more in Desi. Both reducing and non reducing sugars decreased during 12 days of storage at both the temperatures.

2.1.5 Phenols/tannins

Singh and Pathak (1987) assessed the total phenols in different *aonla* cvs. to be 62.8, 56.3, 77.7, 67.1 and 66.2 mg/100g of Desi, Banarasi, Francis, Kanchan and Krishna, respectively.

Cashew apple when stored at ambient, cool chamber and low temperature conditions resulted in a decrease in tannin content during storage and the decrease was maximum in fruits stored at higher temperatures (Anarkar *et al.*, 1991).

Aonla fruits of cv. Desi and Banarasi under low (2-5^{0}C) temperature and ambient conditions (24-29^{0}C) showed a decrease from 2.93 to 2.84 and 2.78 per cent in cv. Desi whereas in cv. Banarasi, it decreased from 2.82 to 2.75 and 2.68 per cent under low and ambient conditions respectively, after 12 days of storage (Ghorai and Sethi, 1996).

Tannin content of *aonla* fruits of cv. Desi was higher than that of Chakaiya and steeping preservation of *aonla* fruits resulted in a decrease in tannin content considerably during storage (Premi *et al.*, 1999).

2.2 PROCESSING OF *AONLA*

Aonla is not consumed as fresh fruit in raw state as it is highly acidic and astringent. The fruit is consumed after processing into different products like preserve, pickle, juice, dehydrated *aonla* etc.

2.2.1 Preparation and preservation of pulp

Like other fruits, *aonla* can also be processed into good quality pulp which is used as base material for preparation of different products.

Aonla pulp was successfully extracted by addition of water equal to the weight of segments. Fruit segments and water ratio of 1:1 was found to be the optimum for easy extraction and better recovery of pulp with moderate total soluble solids, vitamin-C and acidity (Singh and Kumar, 1995). Addition of water for easy extraction of pulp has been also recommended in ber (Khurdiya and Singh, 1975) and bael (Roy and Singh, 1979).

Sethi (1986) reported that fresh *aonla* dried in the form of pulp gave better nutritive value as compared to whole blanched and unblanched fruits. Drying of raw *aonla* pulp yielded an organoleptically acceptable product for use in curries and soups preparation as a nutritional supplement. It took 5 days to dry raw *aonla* fruit pulp. Whereas, the whole fruits took 8 days. The blanched fruits took 7 days to dry.

Preservation of *aonla* pulp was done by heating at 75^0C and cooling to room temperature. Potassium metabisulphite (2g/kg of pulp) was mixed thoroughly and sealed (Singh and Pathak, 1987).

Among the chemical preservatives, KMS (potassium metabisulphite) in terms of sulphur dioxide is more commonly used in both storage of pulp and juice. Bisulphites are broad spectrum antimicrobial agents inhibiting moulds, bacteria and yeasts. Sulphur dioxide not only helps in reducing both enzymatic and non enzymatic browning of the pulp, but also helps in better retention of vitamin C and total carotenoids (Singh and Kumar, 1997).

Aonla pulp was prepared from fully mature fruits by blanching in boiling water for about 10 minutes to separate the segments from the stone. Equal quantity of water was added to the segments and passed it through a pulper to make pulp (Nath, 1999).

Pragati *et al.* (2000) prepared dehydrated *aonla* fruits of cv. Chakaiya by different methods like direct and indirect solar drying, hot air oven drying and osmo air drying. Ripe *aonla* fruits were blanched in boiling water for 10 minutes. After removing the pits, the pieces were dried by different methods till no further moisture loss occurred. The drying was accomplished in 3 days each in hot air oven drying and osmo air drying methods whereas, it took 6 and 11 days, respectively in direct and indirect heating models. The recovery of fruits was maximum in osmo air drying methods.

2.2.2 Biochemical changes during storage of pulp

2.2.2.1 Total Soluble Solids (TSS)

Shah and Masoodi (1994) reported that TSS of preserved apple pulp remained consistent during storage. Kalra (1982) also reported that there was no significant alteration in TSS of mango pulp during storage.

Singh and Kumar (1995) observed the TSS levels in *aonla* pulp prepared with different ratios of fruit segments and water. The highest TSS (7.0%) was observed in pulp prepared from fruit segment, water ratio of 1:05 and the lowest TSS (3.4%) was seen in 1:2.0 ratio.

2.2.2.2 Acidity

Tripathi *et al.* (1988) reported that pH of *aonla* products was found to be slightly higher than the fresh fruit and did not change during the storage period. *Aonla* juice and jam exhibited a rise in acidity during storage.

There was no significant change in pH and acidity during storage of peach and apricot pulp (Shah and Bains, 1992).

Shah and Masoodi (1994) found that there was an increase in acidity but without any appreciable change in pH of the stored apple pulp. Acidity increased in mango pulp when kept at room temperature but exhibited minor changes at low temperature (Kalra, 1982).

Singh and Kumar (1995) observed acidity of *aonla* pulp prepared from fruit segments and water ratio of 1:0.5 to be 1.3 per cent and that from 1:2.0 was 0.7 per cent.

2.2.2.3 Sugars

During storage of mango pulp, reducing sugars rose sharply due to break up of higher sugars when the total soluble carbohydrate remain unchanged (Kalra, 1982).

Tripathi *et al.* (1988) reported an increase in total sugar and reducing sugar contents in *aonla* jam and juice during storage.

2.2.2.4 Ascorbic acid

Shah and Bains (1992) reported that losses of ascorbic acid in canned peach and apricot pulp were more at ambient temperature storage than refrigerator storage.

Hong *et al.* (1994) reported that purees of peach, plum, pear and strawberry were heated at 70, 80 or 90^{0}C for 10 minutes and added with ascorbic acid at 60 mg/100g. Ascorbic acid concentration decreased with increasing temperature.

Singh and Kumar (1995) determined the vitamin C content of *aonla* pulp prepared by addition of water half to the weight of fruit segments to contain 242.3 mg/100g and that prepared by addition of water twice the quantity of fruit segment to be 88.9 mg/100g.

2.2.2.5 Tannins

During storage of apple pulp, tannin content was found to decrease (Shrestha and Bhatia, 1982).

Jain *et al.* (1983) reported that the retention of tannins was in the range of 26.16 per cent and 13.08 per cent in freshly prepared and six month old *aonla* preserves.

Kalra and Tandon (1985) observed that tannins decreased during storage of mango pulp. During storage of peach and apricot pulp, tannin content was in decreasing trend as reported by Shah and Bains (1992). There was decrease in the tannin content of guava pulp during storage (Tandon and Kalra, 1984).

Tripathi *et al.* (1988) reported that tannin content decreased in jam, preserve and candy while it was found to increase in *aonla* juice during 135 days of storage.

2.2.2.6 Non Enzymatic Browning (NEB)

Non enzymatic browning in SO_2 preserved bael fruit pulp was considerably less compared to the canned one, due to the presence of SO_2 as it prevented the non enzymatic browning (Roy and Singh, 1979).

Sethi (1986) recommended blanching of *aonla* fruits for 4 minutes in boiling water to prevent non enzymatic browning and better colour retention of the processed product during storage because of higher degree of inactivation of polyphenol oxidase.

2.2.3 Microbial quality

Krishnamurthy *et al.* (1982) while studying the storage of mango pulp observed that heating alone was not adequate for complete inhibition of bacteria, although yeasts and moulds were inhibited and found that hot pulp with SO_2 preservative was able to inhibit bacteria, yeasts and moulds during storage. Microbial population could not be detected during the entire period of storage of mango pulp that was preserved with 1000 ppm SO_2 (Kalra and Tandon, 1985).

Microbiologically stable banana purees were obtained by the addition of 1000 ppm potassium sorbate or the application of high hydrostatic pressure (HHP) at 517 or 689 Mpa for 10 minutes. Standard plate as well as yeast and mould counts of HHP treated purees were less than 10 cfu/g throughout storage (Palou *et al.*, 1999).

2.2.4 Physico-chemical changes during storage of dehydrated fruits

2.2.4.1 Moisture

Sethi (1986) while studying the effect of blanching on drying of *aonla*, observed that residual moisture content was 3% in dried unblanched , blanched fruits and pulp.

Tripathi *et al.* (1988) evaluated dried *aonla* by using a solar dehydrator to a moisture content of 7.20 per cent and it showed a progressive decline in moisture during storage for 135 days.

Ukhun and Ukpebor (1991) observed that there were limited increases in the moisture content of the various plantain flour samples stored for 5 months and the changes were statistically insignificant.

2.2.4.2 Titratable acidity

Tripathi *et al.* (1988) reported that the pH of *aonla* products was found to be slightly higher than the fresh fruit and did not change during the storage period. There was a decreasing trend in the acidity of dehydrated *aonla* during storage.

Ukhun and Ukpebor (1991) reported that the pH of instant plantain flours did not change significantly during storage.

2.2.4.3 Sugars

Sethi (1986) compared the sugar content in dehydrated *aonla* prepared from un blanched, blanched and dried pulp. The reducing sugars were maximum in dried fruits pulp while the total sugar content was the same in all the products.

The total and non reducing sugars in dehydrated *aonla* decreased during storage period of 5 months (Tripathi *et al.*, 1988). Ukhun and Ukpebor (1991) reported that the total sugars in instant plantain flour decreased during 5 months storage period.

2.2.4.4 Ascorbic acid

Sethi (1986) compared the ascorbic acid content of dried *aonla* prepared from unblanched, blanched and dried fruit pulp. The best product was obtained with

KMS blanching and drying in solar dryer and the most acceptable product had ascorbic acid content of 298.3 mg/100 g.

Priya and Khatkar (2012) observed that TSS, pH, reducing sugars, total sugars and browning of the *aonla* preserves increased during storage irrespective of different methods employed for preparation of the preserves. Moisture, ascorbic acid, tannin and titratable acidity of the preserves decreased during storage for 90 days.

2.2.4.5 Tannins

Sethi (1986) reported that the tannin content in dried *aonla* pulp was higher than that of unblanched and blanched dried fruits and it retained 98.23 per cent tannins.

Tripathi *et al.* (1988) studied the changes in tannin content of dehydrated *aonla* and reported that there was an increase in tannin content during storage.

2.2.4.6 Non enzymatic browning (NEB)

Khurdiya and Roy (1986) reported that non enzymatic browning in dried potato chips was low in the solar drier with chimney and high in solar drier with plain glass.

Loschner *et al.* (1990) reported that during food processing operations, particularly on heating, L-ascorbic acid degraded, leading not only to loss of vitamin-C but also the formation of brown colour products.

Sawamura *et al.* (1991) reported that browning in citrus fruit juice increased with increase in storage temperature and it was intensely brown at 37^0C but no browning was seen in juice stored at 2^0C.

In guava RTS beverage, the browning (O.D value at 440 nm) increased from 0.00 to 0.09 during 6 months storage at ambient temperature (Pandey and Singh, 1999).

2.2.5 Microbial quality

Moulds can grow on food substrates with as little as 12 per cent moisture and some are known to grow in foods with less than 5 per cent moisture. Bacteria and yeasts require higher moisture levels, usually over 30 per cent (Desrosier, 1977).

Ukhun and Ukpebor (1991) did not detect moulds in instant plantain flour during storage and ascribed the good keeping quality of the product, largely to the very low moisture content attained and to the efficacy of the processing methods used in the production of the instant flours.

Menon (2000) reported low microbial counts in dehydrated fruits and vegetables, dried to moisture content less than 3 per cent after blanching and drying.

2.2.6 Blending of pulps and preparation of fruit bar

Possibility of making satisfactory and palatable products such as RTS, nectar, squash and shreds had been reported by many workers. Prasad *et al.* (1968) reported that acceptability of squash and ready to drink beverage prepared from *aonla* juice increased when flavouring agents such as ginger and sarsaparilla were blended with *aonla* juice.

All the mango varieties are not suited for the preparation of mango bar (Gahilod *et al.*, 1982). Thick pulpy varieties yielded superior product and thin pulps required blending with thick pulps of fruits like banana. The authors studied the suitability of mango for processing of mango leather, where the pulp of seven different varieties of mangoes were deaerated, adjusted to 20^0 brix and dehydrated in the form of sheets. The organoleptic scores indicated that varieties Amlet and Dilpasand were rated superior to Dori, Pairi, Totapuri, Mushadapedi and Neelum.

Premachandaran (1982) found that when apple and peach juices were blended in 1:2 ratio, formed the most acceptable nectar. Similarly, Begum *et al.*, (1983) prepared squash by mixing pineapple juice and mango pulp in different proportions and found 25 per cent juice/pulp, 45 per cent TSS and 1 per cent acidity to be acceptable.

Kalra *et al.*, (1991) reported that 25-53 per cent papaya pulp could be incorporated with mango without affecting the quality and acceptability of mango beverages.

The RTS beverage prepared from pineapple and guava juice (90:10) blend containing 16^0 brix and 0.2 per cent acidity secured highest score with respect to overall quality (Tripathi, *et al.*, 1992).

Singh and Kumar (1995) reported that RTS beverage prepared from 10 per cent *aonla* pulp +2 per cent lime juice + 1 per cent ginger juice having 12^0 brix and 0.3 per cent acidity had highest organoleptic score as compared to other recipies. Similarly, squash comprising of 25 per cent *aonla* pulp + 5 per cent lime juice + 2 per cent ginger juice with 50 per cent TSS and 1 per cent acidity had high score in terms of oganoleptic evaluation.

Inyang and Abah (1997) blended cashew apple juice with various proportions of sweet orange juice and reported that increase in orange juice proportions decreased the ascorbic acid content of the blend , since orange juice contains lesser ascorbic acid as compared to cashew apple.

2.2.6.1 Preparation of fruit bar

Mango fruit bar is a confectionery product prepared by mixing mango pulp with calculated amount of sugar and other ingredients, spreading on trays and drying in a drier, until the moisture content is reduced to the required level. The dried sheet is cut into suitable sizes and packed (Nanjundaswamy *et al.*, 1976). The pulp with or without sugar was spread over bamboo or date palm leaves in successive layers for drying in open sun. But the sun dried product was dark brown and the process was unhygienic and lengthy due to coincidence of rainy season with the ripening of mango fruits (Rameshwar, 1979).

The ideal sugar/acid composition for the preparation of mango sheet or leather of the mango cultivars Baneshan, Bombay Green and Dashehari were found to be 25^0 brix and 0.5 per cent acidity. Addition of pectin at the rate of 0.5 per cent in the cultivar Baneshan and 0.75 per cent in the cultivars of Bombay Green and Dashehari was found to improve the texture of leather. The ideal moisture for the storage stability was found to be 15 per cent or a little more with a relative humidity between 63 and 70 per cent (Rao and Roy, 1980).

Mango (*Mangifera indica*) and *aonla* (*Phyllanthus emblica* Linn.) were inoculated with *Phomopsis mangiferae* and incubated for 8 days. Fresh mango and *aonla* contained 98.2 and 402.7 mg/100 g of ascorbic acid before incubation. Ascorbic acid content was reduced by 19.5% in fresh and 97.5% in infected mango fruit. In *aonla* the ascorbic acid content was reduced by 6.6% in fresh and 87.0% in infected fruits. (Reddy *et al.*, 1984).

The methods for the preparation of fruit slabs with a soft gel texture, suitable for direct eating from several fruits using appropriate ingredients by simple cabinet drying were standardized by Jayaraman (1993). Mir and Nath (1995) optimized the cabinet drying process by adding additives like citric acid, KMS and cane sugar to mango pulp. They reported improved retention of colour and flavour.

To prepare mango fruit bar, the mango pulp was mixed with sugar to 25^0 brix. Two grams of citric acid per kilogram of pulp was added. The mixture was then heated for two minutes at 80^0 C, and partially cooled. Sulphur dioxide at the rate of 1000 ppm was added before drying the mixture for 10 hours by solar energy at about 55^0 C, and 16 hours by electric or steam power at 70^0 C. Dried bars were wrapped in cellophane paper packed in cartons and stored at ambient air temperature (Dauthy, 1995).

Mango fruit bar was prepared from cv. Alphonso by the addition of sugar (20%), citric acid (0.2%) and KMS (700ppm) individually or in different combinations. Drying in shade or tray drier gave good quality product in terms of better colour retention, texture and flavour leading to higher overall acceptability (Gowda *et al.*, 1995).

Man and Taufik (1995) prepared jack leather by blanching the edible portion of the fruit for three minutes at 84^0 C and by soaking it in 2.1 per cent sodium meta bisulphite for 30 minutes. To the purees were added 10 per cent sugar, 200 ppm sorbic acid and 500 ppm sulphur dioxide as sodium meta bisulphite. The mixture was dried over water bath at 45^0 C for 16 hours and 3 hours in an oven. It was cooled and packed in polypropylene pouches. Both types of jackfruit leathers were acceptable after 2 months of storage at both ambient temperature and at 8^0 C.

Premalatha and Manimegalai (1996) prepared jackfruit leather by using pulp, sugar and citric acid. The mixture was heated to about 60^0 C and dried in sunlight by spreading in trays. The dried leather was cut in to pieces of desired size and wrapped in butter paper. The jackfruit leather was found to be highly acceptable and scored more than 95 per cent for all quality attributes.

Man and Sin (1997) developed fruit leather from under fertilized floral parts of jackfruit. Attempts were made by Gazi *et al.* (1998) to replace the use of pectin in mango bar by corn flour, which also has setting properties. Mango pulp was dehydrated after fortifying with 1, 2, 3 and 4 per cent corn flour, maintaining TSS at 21^0 brix, acidity at 0.7 per cent and sulphur dioxide at 1000 ppm. Organoleptic evaluation showed that mango pulp fortified with 1 per cent corn flour gave a better sheet on drying and compared well with that of pectin added sample, showing the possibility of replacing pectin by a low cost ingredient.

Jack fruit bar was prepared from pulped jack fruit bulbs (carpel). Acidity and TSS were adjusted to 0.4 per cent and 50^0 brix, mixture spread evenly on a tray to a thickness of 1.0 cm and dried at 50 ± 2^0C for 12 hours by using cabinet dryer (Manimegalai *et al.*, 2001).

Sandhu *et al.* (2001) standardized the methods for preparation of guava pulp and guava leather in two cultivars, namely Allahabad Safeda and Banarsi Surkha. Guava leather prepared from pulp had good organoleptic acceptability and had a shelf life of 3 months under ambient conditions.

Fruit bar is an age old traditional fruit product acceptable by all age groups (Nanjundaswamy *et al.*, 1976; Rao and Roy, 1980). Fruit bar or leather is a ready to eat product with soft gel like texture obtained by dehydration of fruit purees into leathery sheets. These products are shelf stable for about 6 months in flexible laminate pouches. They have great potential in supplying nutrients to military persons, mountaineers and astronauts, besides growing children (Kalsi, 2002).

Gill *et al.* (2004) studied the effects of sodium alginate and drying temperature on colour, texture and sensory properties of 'Dashehari' mango leather. Fruit pulp was concentrated to 20, 25 and 30^0 brix and dried at 50, 60 and 70^0 C with sodium alginate concentration at 0, 0.5 and 1 per cent respectively. Results indicated that highly acceptable mango bars could be prepared using 25^0 brix pulp with 0.5 per cent sodium alginate at a drying temperature of 60^0 C.

Ready to eat food bars provide nutrition as snacks, meal supplements, or meal substitutes. The ingredients are selected and processed for desired food bar in the form of cylindrical or rectangular shapes, finally processed and packaged to provide portable convenience in handling and eating (Kemeny *et al.*, 2003).

Kumar *et al.* (2012) observed that the protein content of sapota-papaya bar was increased gradually from 1.17% to 1.85% with increasing amount of skim milk powder whereas the protein content of fruit bar without addition of skim milk powder was found to be 0.87%.

2.2.7 Enriched fruit bars

Khalil *et al.* (1984) fortified date bars with yeast protein and dry skim milk in different proportions and the fortified bars showed higher amounts of protein, fat, fibre, ash and minerals than that of control or unfortified bars. Sensory evaluation scores showed that all the bars were equally acceptable and could be stored up to 6 months at ambient temperature of 25^0C without significant loss of quality attributes. Ruales *et al.* (1990) evaluated the nutritional value of flakes made of banana pulp and full fat soy flour incorporated with pulp of ripe bananas (60:40 dry basis), which contained protein 19.7 g, fat 7.6 g, carbohydrate 60.09 g and digestibility was found to be 83.1 per cent.

The preparation of protein enriched apricot fruit and soy flour was standardized by Chauhan *et al.* (1993). Apricot pulp and soy slurry were mixed with sugar syrup to raise the TSS to 33^0 brix and 50 ppm of sulphur dioxide was also added to the mixture. The content was spread on tray and dehydrated at 65 ± 1^0C in a mechanical cabinet drier for 14 hours. Dried product was packed in polyethylene sheets. The product having 70 per cent apricot pulp and 30 per cent soy slurry with

15.3 per cent moisture, 7.8 per cent protein and 16.5 mg per 100 g ascorbic acid was found to be the best in sensory qualities. Mir and Nath (1993) prepared fortified mango bars by adding desiccated coconut powder (2%) and soy protein concentrate (4.5%) into the Langra mango pulp.

Kalamgh and Unde (1996) developed khoa bar and milk powder bar from wood apple. The bar was prepared by mixing pulp with sugar. The mixture was heated for half an hour. At this stage, khoa or milk powder was added at the ratio of 4:1 and heated to mix the ingredients thoroughly. It was moulded, cooled, sealed and packed in plastic polyethylene wrappers and stored in a cool place. They were highly acceptable. Chauhan *et al.* (1997) developed protein enriched mango fruit bar. The mango pulp supplemented with soy slurry, sucrose and skim milk powder at levels of 4.5 percent each resulted in mango leather with the highest acceptability.

Protein enriched mango fruit bar having 70 % mango pulp and 30 % soy slurry with 16.5 % moisture, 11.35 % protein and 50.0 mg/100 g ascorbic acid content was adjudged to be the best in sensory qualities like flavour, texture and taste (Chauhan *et al.*, 1997).

Good quality fruit leather samples from mango/ guava/ papaya and fig pulp were obtained from the treatment standardized by Mixing thoroughly with sugar 20^0 brix, liquid glucose 5.0 per cent, pectin 0.2 per cent and emulsifying agent 0.5 per cent (Naikare *et al.*, 1998).

The study showed that the value of acidity, reducing sugar and TSS increased, while the value for the pH and ascorbic acid decreased in *aonla* preserves during the two month storage with different preservatives at different temperatures (Kumar *et al.*, 1998).

A process for preparation of protein rich tamarind leather was developed by Vashishtha and Mittal (2003). The product having 40 per cent jaggery, 0.1 per cent salt, 3 per cent soy protein isolate and 2 per cent coconut powder was adjudged to be the best organoleptically. Fortified papaya fruit bar was standardized by Kushwaha and Verma (2003) by raising TSS of extracted pulp from 9^0 brix to 30^0 brix by adding different proportions of cane sugar, gram flour and skimmed milk powder. Fortified papaya fruit bar prepared by adding pulp (82%), sugar (13.6%), pectin

(0.6%), citric acid (0.7%) and skimmed milk powder (3.25%) was found to be the best.

A study was conducted by Shanthi *et al.* (2003) to develop protein enriched mango bar from mango variety Totapuri with pulse protein. Protein supplementation of bar resulted in increased protein, fat, ash and crude fibre contents, whereas total sugar, vitamin C and beta carotene showed lesser values than control sample.

Mixing of *aonla* and guava pulp with different formulations were analysed for their chemical composition, which was stored at ambient temperature for a period of 2 months. The proportion of 50:50 was found to be optimum with respect to acidity (0.4%) and sugar (10%), compared to other formulations (Mishra *et al.*, 2012).

Mango and *aonla* blended RTS beverages were subjected to storage studies at room temperature. The chemical, microbiological and sensory qualities viz., colour, flavour, taste, texture, appearance and overall acceptability were assessed for a storage period of 2 months (Rastagi and Kumar, 2013).

2.3 SIGNIFICANCE OF PACKAGING ON FRUIT BARS

Gahilod *et al.* (1982) observed a reduction in reducing sugars, ascorbic acid and carotenoid contents and increase in acidity and non enzymatic browning in mango leather packed in polythene bags stored for 70 days at 10 ± 1^{0}C. The chemical changes that commonly occurred during storage of fruit products were absorption or loss of moisture, increase in acidity or decline in pH, increase in reducing sugars and decrease in total sugars (Mitra and Bose, 1984).

A package intended for confectionary items has to perform several functions during storage and sales. The functional packaging requirements for confectionary include protection against dust, contaminants, moisture pick up or losses, colour and flavour losses, resistance to impact, ease of opening, size, shape, weight limitations, appearance, printability and low cost (Potter, 1989).

Packaging has a "techno-economic function" aimed to maintain the quality of food stuff packed, with a view to retain the quality for a reasonable period (Thangaraj and Jaiswal, 1998). Packaging is indispensable in the modern food industry. It acts as a barrier to oxygen, moisture, light and smells depending upon the sensitivity of a particular food to the prevailing environment. Thus it helps to retain the sensory characteristics of food products. The sensory quality of a packed food is the result of a complex interaction between the food, the package and the environment (Alam and Kaur, 2002). Packaging is and has been an integral part of our daily lives. It protects the commodities during transportation and storage (Chaudhari *et al.*, 2005).

Metallised poly laminate is an ideal packaging material for all products, which require critical protection from moisture, oxygen and other degrading substances. Metallised plastics have been partially replaced not only by aluminium foil but also cellophane for wrapping confectionary products (Veeraraju and Rangarao, 1990). Laminates find extended use in food packaging due to their performance properties. A bilayer structure comprising polyethylene offers barrier and seal chareteristics. The residual solvents used for adhesion may pose problem resulting in tainting of packed product (Kumar *et al.*, 2003).

2.4 SENSORY QUALITY OF FRUIT BARS ON STORAGE

Rao and Roy (1980) observed that mango sheets with added sulphur dioxide were organoleptically acceptable at all storage temperatures of 20°C, 30 °C and 40 °C even after three months of storage. A higher initial sensory score for colour, texture, aroma and taste for mango bar fortified with desiccated coconut powder (DCP) was observed by Mir and Nath (1993) during 90 days of storage at 18^0C, 27 ± 3^0C and 38 ± 1^0C. The overall acceptability decreased in both types of bars stored up to 6 months. The sensory evaluation score of mango bars packed in flexible packaging materials showed that the product was not acceptable after 5 months, due to the development of undesirable colour (Nadanasabapathi *et al.*, 1993).

Nadanasabapathi *et al.* (1993) evaluated the indigenously available packaging materials such as paper/aluminium foil/low density polyethylene of 40, 20 and 12 micron, metallised polyester / high density – low density polyethylene and nylon / ionomer for packing ready to eat commercially available mango bar. Aluminium foil based materials were found necessary for long term storage of mango bar supplied to armed forces.

Gowda *et al.* (1995) prepared mango bars by different methods of drying and stored for 6 months. The fruit bar prepared by drying in shade or tray drier gave good quality product in terms of better colour, texture and flavour leading to higher overall acceptability.

Man and Taufik (1995) observed a decrease in colour and texture values of jackfruit leather during storage of two months. Sensory evaluation showed that jackfruit leather was acceptable after two months of storage at both ambient temperature and at 8^0C. The organoleptic quality of osmotically dehydrated papaya stored at 0^0C was unchanged and little changes in colour, flavour and texture at room temperature (27^0C) and at elevated temperature (37^0C) were observed by Ahmed and Chaudhary (1995).

Jeyarani *et al.* (1997) found that cereal pulse based sweet bars packed in pouches of polypropylene (50 micron) and metallised polyester / polyethylene had a shelf life up to 150 days at ambient (65% RH and 27^0C) condition. While at accelerated condition (90% RH and 38^0C), the products kept well for 90 days in polypropylene pouches and 150 days in metallised PET/PE pouches.

Aruna *et al.* (1999) observed a significant difference in colour and appearance of papaya fruit bars during storage and organoleptic scores decreased 29.02 (initially) to 24.93, 24.93, 22.13 and 19.80 when stored at 5^0C - 8^0C, 9^0C - 24^0C, 25^0C - 34^0C and 35^0C - 45^0C, respectively. Krishnaveni *et al.* (1999) studied the organoleptic score values of jack fruit bars during storage and found that the sensory attributes like colour, flavour, texture and taste of the samples were highly acceptable up to 90 days of storage at room temperature.

Overall organoleptic score of guava bar reduced from 8.33 to 7.13 after 3 months of storage (Sandhu *et al.*, 2001). The freshly prepared jackfruit bar samples had firm texture, which changed to mild to moderate hardness during 6 months of storage (Manimegalai *et al.*, 2001).

Sensory score studies in relation to period of storage by Babalola *et al.* (2002) showed that guava leather gave better result in overall acceptability at zero, one and two months of storage at 8 ± 1^0C. Guava leather also gave better sensory qualities in fruitiness, smell, chewiness, toughness, colour, and overall acceptability when varietal influence is considered. At the end of storage, a decreasing trend in organoleptic score values of protein enriched mango bars was observed (highly acceptable to acceptable) by Shanthi *et al.* (2003).

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Materials and Methods

MATERIALS AND METHODS

MATERIALS

The present investigation "Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G.)" was carried out with *aonla* fruits of the local variety, Neelam variety of mango, Red Lady variety of papaya and Then Varikka variety of jackfruit procured from the fruit market, Thrissur. The investigation was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara.

METHODS

The study was conducted under two experiments *viz.* (3.1) Effect of enrichment on quality of *aonla* fruit bars. (3.2) Effect of packaging on quality of enriched fruit bars during storage. To support the aforesaid aspects of the investigation, various physico-chemical parameters were analysed. All the results were analysed statistically.

3.1 EFFECT OF ENRICHMENT ON QUALITY OF *AONLA* FRUIT BARS

3.1.1 Preparation of pulp from fresh *aonla* fruits

Standardization of method for pulp making was carried out using *aonla* fruits with water, in a pressure cooker. The product was checked for pulp formation after time intervals of 15 minutes. The cooked fruits were pulped in a grinder, after removing the seeds.

Fruits
↓
Washing
↓
Addition of water (1:1)
↓
Pressure cooking
↓
Removal of seeds
↓

Pulping

↓

Addition of KMS

↓

Filling in jars

↓

Sealing

↓

Storage

3.1.2 Blending of *aonla* pulp with pulps of provitamin A rich fruits and preparation of fruit bars

3.1.2.1 Blending of *aonla* pulp provitamin A rich fruit pulps

Aonla pulp was blended with pulp of tropical fruits rich in provitamin A viz. mango, papaya and jackfruit in different ratios as given below.

Treatments

T1- *Aonla* pulp (100%)

T2- *Aonla* (75%) + Mango (25%)

T3- *Aonla* (50%) + Mango (50%)

T4- *Aonla* (25%) + Mango (75%)

T5- *Aonla* (75%) + Papaya (25%)

T6- *Aonla* (50%) + Papaya (50%)

T7- *Aonla* (25%) + Papaya (75%)

T8- *Aonla* (75%) + Jackfruit (25%)

T9- *Aonla* (50%) + Jackfruit (50%)

T10- *Aonla* (25%) + Jackfruit (75%)

3.1.2.2 Preparation of fruit bars from pure *aonla* pulp and blended pulp

Fruit bars were prepared from pure *aonla* fruit and also from blended fruit pulp in which pulp of *aonla* was mixed in different ratios with mango, papaya and jackfruit pulp. The fruit pulp thus prepared was mixed with powdered cane sugar, which was ground in a grinder. The total soluble solids content of the pulp was raised to 35 ^{0} Brix and the acidity of the pulp was adjusted to 0.6 per cent. Clean stainless steel trays, smeared with vegetable oil were taken and the prepared pulp was spread on these trays to a thickness of 10mm. These trays were loaded into a cabinet drier maintained at 58 ± 2 ^{0}C. The pulp was dried to a thickness of 5mm. After drying to optimum moisture content, the dried pulp was cut into bars. Organoleptic evaluation was conducted among a panel of judges of different age groups to determine the best treatments. The following flow chart shows the procedure involved in the preparation of fruit bars.

Aonla pulp/blended pulp

↓

Increasing TSS (35 ^{0}B)

↓

Addition of KMS (1000 ppm)

↓

Regulation of acidity

↓

Spreading pulp on trays (1.0 cm)

↓

Dehydration (58 ± 2 ^{0}C)

↓

Staking into layers

↓

Formation of bars

3.1.3 Lay out

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

3.1.4 Observations

Observations on both physico-chemical and biochemical changes during blending of *aonla* pulp with other fruit pulps were taken as detailed below.

3.1.4.1 Physico- chemical characteristics

3.1.4.1.1 Moisture

The moisture content was determined by drying a known weight of the sample at 50-60 ^{0} C to a constant weight and expressed as per cent (Ranganna, 1997)

$$\text{Moisture (\%)} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

3.1.4.2 Biochemical parameters

3.1.4.2.1 Titratable acidity

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

3.1.4.2.2 Total Soluble Solids (TSS)

TSS was measured /recorded directly using a digital refractometer (range 0-32°brix) and expressed in degree brix (^{0} Brix).

3.1.4.2.3 Reducing sugars

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

$$\text{Reducing sugar (\%)} = \frac{\text{Fehling's Factor} \times \text{dilution} \times 100}{\text{Titre value} \times \text{weight of sample}}$$

3.1.4.2.4 Non reducing sugars

Non reducing sugars were estimated by deducting reducing sugars from total sugars (% total sugars - % reducing sugars)

3.1.4.2.5 Total sugars

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

1. % total sugars = calculated by making use of the titre value obtained in the determination of total sugars after inversion
2. % sucrose = (% total sugars - % reducing sugars x 0.95)
3. Total sugars = (% reducing sugars + % sucrose)

3.1.4.2.6 Ascorbic acid

Ascorbic acid was determined by titrating a known weight of sample with 2, 6-dichlorophenol indophenol dye, using metaphosphoric acid as stabilizing agent (Ranganna, 1997).

In the case of *aonla* fruits, known weight of sample was ground in pestle and mortar with 3 per cent metaphosphoric acid. The volume was made up to 100 ml. After filtration, 10 ml of aliquot was titrated against 2, 6-dichlorophenol indophenol dye. The dye factor was calculated by titrating standard ascorbic acid solution against dye and ascorbic acid content of sample was expressed as

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

3.1.4.2.7 Tannins

Tannin content was determined by colorimetric method (Ranganna, 1997) using a standard curve of tannic acid. Standard tannic acid (1ml = 0.1mg of tannic acid) solution of 0 to 10ml was pipetted into 100ml volumetric flasks containing 75 ml of distilled water. Five ml of Folin- Denis reagent and 10ml of saturated Na_2CO_3

solutions were added into each of the volumetric flasks and the volume was made up to 100ml with distilled water. The solutions were mixed well and kept for 30 minutes. After filtration, the absorbance was measured at 760nm in a spectrophotometer (Model EC) using an experimental blank (5 ml Folin- Denis reagent + 10ml Na_2CO_3 +85 ml distilled water) for zero setting. The absorbance was plotted against the known concentration of tannic acid on a graph paper.

A known volume of diluted sample was mixed with 50-75ml of distilled water in a 100ml volumetric flask. Five ml of Folin- Denis reagent and 10ml of Na_2CO_3 solution were added and volume was made up to 100ml with distilled water, mixed well by shaking and kept for 30 minutes. After filtration, absorbance was measured as in case of standard curve, the values were matched with the standard curve and per cent tannin content of the sample was determined using the following formula:

$$\text{Tannin as tannic acid (\%)} = \frac{\text{mg of tannic acid x dilution x 100}}{\text{ml of sample taken for estimation x wt. of sample taken}} \times 100$$

3.1.4.2.8 Total carotenoids

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

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

3.1.4.3 Sensory evaluation

The products were judged by a panel of judges of different age groups for appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability, based on a 9 point hedonic scale rating (Amerine *et al.*, 1965). A score of 5.5 and above was considered acceptable

3.2 EFFECT OF PACKAGING ON QUALITY OF ENRICHED FRUIT BARS DURING STORAGE

Best combination from each category of enrichment, along with pure *aonla* bar were wrapped in vegetable parchment paper (VPP), followed by enclosing them in different types of packaging materials. Packaged fruit bars were stored at ambient temperature for six months and bio-chemical observations were carried out at bimonthly intervals.

3.2.1 Treatments

T1-*Aonla* bar in LDPE

T2-*Aonla* bar in APCF

T3-*Aonla* bar in HIPS

T4-*Aonla*+Mango in LDPE

T5-*Aonla*+Mango in APCF

T6- *Aonla*+Mango in HIPS

T7- *Aonla*+Papaya in LDPE

T8- *Aonla*+Papaya in APCF

T9- *Aonla*+Papaya in HIPS

T10- *Aonla*+ Jackfruit in LDPE

T11- *Aonla* + Jackfruit in APCF

T12-Aonla +Jackfruit in HIPS

(LDPE: Low Density Polyethylene; APCF: Areca Plate overwrapped with Cling Film; HIPS: High Impact Polystyrene Box)

3.2.2 Observations

Observations on both physical and biochemical changes during storage were taken as detailed below.

3.2.2.1 Physical parameters

3.2.2.1.1 Moisture

Moisture content was estimated as in 3.1.4.1.1

3.2.2.2 Biochemical parameters

3.2.2.2.1 Titratable acidity

Titratable acidity was estimated as in 3.1.4.2.1

3.2.2.2.2 Total Soluble Solids (TSS)

TSS were estimated as in 3.1.4.2.2

3.2.2.2.3 Reducing sugars

Reducing sugars were estimated as in 3.1.4.2.3

3.2.2.2.4 Non-reducing sugars

Non-reducing sugars were estimated as in 3.1.4.2.4

3.2.2.2.5 Total sugars

Total sugars were estimated as in 3.1.4.2.5

3.2.2.2.6 Ascorbic acid

Ascorbic acid was estimated as in 3.1.4.2.6

3.2.2.2.7 Tannins

Tannins were estimated as in 3.1.4.2.7

3.2.2.2.8 Total carotenoids

Total carotenoids were estimated as in 3.1.4.2.8

3.2.2.2.9 Non-enzymatic browning

To a known volume of sample, 30ml of 60 per cent alcohol was added and mixed thoroughly. After keeping overnight, the contents were filtered through Whatman's No.1 filter paper. The colour was measured at 440nm in a spectrophotometer (model.EC) using 60 per cent alcohol as blank. The results were reported as absorbance (Optical density) value (Ranganna, 1997).

3.2.2.3 Sensory evaluation

Sensory evaluation of fruit bars was conducted as in 3.1.4.3

3.2.2.4 Microbiological analysis

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

The processed products were subjected to microbiological analysis initially and also at specific intervals during their storage. The samples were analysed for the population of bacteria and fungi in standard plate count nutrient agar and Martin Rose Bengal agar media, respectively and the results were expressed in cfu/g of sample.

3.2.2.4.1 Estimation of bacterial population

Bacterial population was estimated using 10^{-5} dilution on nutrient agar medium. One ml of 10^{-5} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of the melted and cooled Standard Plate Count Agar (SPCA) media was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petridishes were kept as replicate for each sample. The petriplates were incubated at room temperature for 48 hours. The bacterial colonies developed were counted and expressed as cfu/g of sample.

3.2.2.4.2 Estimation of fungal population

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

3.3 TABULATION AND STATISTICAL ANALYSIS

Observations under each experiment were tabulated and analyzed statistically in a completely randomized design (CRD) as proposed by Panse and Sukhatme (1976). The treatments were ranked according to Duncan's Multiple Range Test (DMRT) as suggested by Duncan (1955). Data pertaining to organoleptic evaluation were analysed using Kendall's coefficient of concordance.

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Results

RESULTS

The results obtained in the present investigation entitled "Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G.)" are presented below

4.1 EFFECT OF ENRICHMENT ON QUALITY OF *AONLA* FRUIT BARS

4.1.1 Physico- chemical characteristics

4.1.1.1 Moisture

The moisture content of the bars was recorded immediately after preparation and also at an interval of two months during storage. The data are presented in Table 1. The result revealed that the treatment T_4 (25 % *aonla*+ 75 % mango) had the highest moisture content (17.17 %) and the lowest moisture content (13.23 %) was observed in the treatment T_1 (100 % *aonla*).

4.1.2 Biochemical parameters

4.1.2.1 Titratable acidity (%)

Titratable acidity of enriched fruit bars is presented in Table 1. Enrichment of *aonla* fruit pulp with fruit pulps of mango, papaya and jackfruit resulted in a decline in titratable acidity. The treatment T_1 (100 % *aonla*) recorded highest acidity (0.313 %) and which was on par with the treatment T_8 (0.297 %) and T_5 (0.296 %) and significantly different from all other treatments and the lowest acidity (0.15 %) was recorded in T_{10} (25 % *aonla* + 75 % jackfruit).

4.1.2.2 TSS (^{0} B)

Enrichment of *aonla* pulp with fruit pulps of mango, papaya and jackfruit increased the TSS content of fruit bars (Table 1). The maximum TSS (53.33^0 Brix) was observed in the treatment T_4 (25 % *aonla* + 75 % mango) while the treatment T_1 (100 % *aonla*) had the minimum TSS (45.23^0 Brix). However, the TSS content in all the enriched fruit bars was significantly superior as compared to that of fruit bar from pure *aonla*.

Table 1. Moisture content, titratable acidity and TSS content of enriched *aonla* fruit bars

Treatments	Moisture (%)	Titratable acidity (%)	TSS (^{0}B)
T_1. *Aonla* pulp (100%)	13.23	0.31	45.23
T_2. *Aonla* (75%) + Mango (25%)	13.73	0.29	50.77
T_3 - *Aonla* (50%) + Mango (50%)	14.40	0.26	51.30
T_4 - *Aonla* (25%) + Mango (75%)	17.17	0.22	53.33
T_5 - *Aonla* (75%) + Papaya (25%)	15.70	0.29	50.53
T_6 - *Aonla* (50%) + Papaya (50%)	15.17	0.23	51.73
T_7 - *Aonla* (25%) + Papaya (75%)	16.60	0.19	52.27
T_8 - *Aonla* (75%) + Jackfruit (25%)	14.13	0.29	50.43
T_9 - *Aonla* (50%) + Jackfruit (50%)	15.33	0.28	51.40
T_{10} - *Aonla* (25%) + Jackfruit (75%)	16.10	0.15	52.27
SE	1.055	0.004	0.077
CD	3.114	0.013	0.226

4.1.2.3 Sugars (%)

Blending of *aonla* pulp with fruit pulps of mango, papaya and jackfruit resulted in an increase in reducing, non reducing and total sugar content of fruit bars (Table 2). Treatment T_4 (25 % *aonla* + 75 % mango) had the highest reducing sugar content (37.80 %) and the lowest (30.07 %) was in T_1 (100 % *aonla*). Non reducing sugar content was maximum (14.84 %) in T_6 (50 % *aonla* + 50 % papaya) and minimum (10.30 %) in T_1 (100 % *aonla*). Blending 25 % *aonla* pulp with 75 % jackfruit pulp (T_{10}) resulted in maximum total sugars (50.5 %) and the minimum (40.24 %) was in fruit bar from pure *aonla* pulp (T_1).

Table 2. Reducing, non reducing and total sugars of enriched *aonla* fruit bars

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
T_1- *Aonla* pulp (100%)	30.07	10.17	40.24
T_2- *Aonla* (75%) + Mango (25%)	31.27	11.88	43.15
T_3 - *Aonla* (50%) + Mango (50%)	34.50	13.14	47.64
T_4 - *Aonla* (25%) + Mango (75%)	37.80	12.62	50.42
T_5 - *Aonla* (75%) + Papaya (25%)	30.25	10.20	40.45
T_6 - *Aonla* (50%) + Papaya (50%)	32.74	14.84	47.58
T_7 - *Aonla* (25%) + Papaya (75%)	37.07	12.97	50.04
T_8 - *Aonla* (75%) + Jackfruit (25%)	31.03	12.03	43.06
T_9 - *Aonla* (50%) + Jackfruit (50%)	31.69	11.96	43.65
T_{10} - *Aonla* (25%) + Jackfruit (75%)	36.64	13.86	50.50
SE	0.029	0.019	0.007
CD	0.085	0.059	0.023

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

Ascorbic acid content of fruit bars from *aonla* showed a declining trend when enriched with fruit pulps of mango, papaya and jackfruit (Table 3). Maximum ascorbic acid content (85.34 mg) was observed in fruit bar from pure *aonla* (T_1), which was significantly higher than that of the enriched fruit bars. Lowest ascorbic acid (21.79 mg) was observed in the treatment T_{10} (25 % *aonla* + 75 % jackfruit).

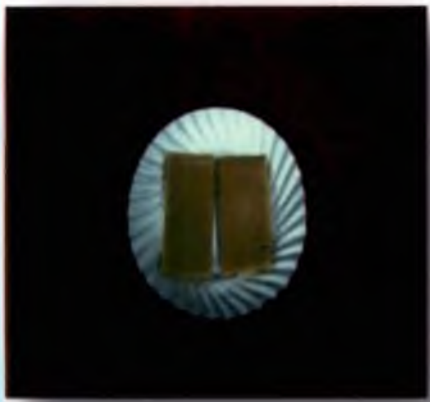
Pure *aonla* (100 %)

75 % *aonla* + 25 % mango

50 % *aonla* + 50 % mango

25 % *aonla* + 75 % mango

Plate. 1 Fruit bars from pure and enriched pulp of *aonla* and mango



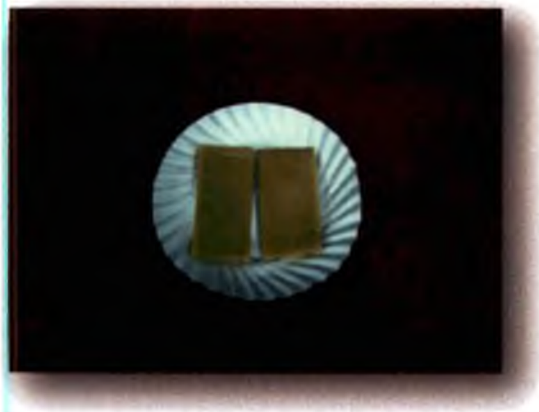
Pure *aonla* (100%)

75 % *aonla* + 25 % papaya

50 % *aonla* + 50 % papaya

25 % *aonla* + 75 % papaya

Plate 2 Fruit bars from pure and enriched pulp of *aonla* and papaya



Pure *aonla* (100%)

75 % aonla + 25 % jackfruit

50 % aonla + 50 % jackfruit

25 % aonla + 75 % jackfruit

Plate 3. Fruit bars from pure and enriched pulp of *aonla* and jackfruit

4.1.2.5 Tannins (%)

Tannin content of enriched fruit bars showed a decreasing trend when *aonla* pulp was enriched with mango, papaya and jackfruit (Table 3). Tannin content of fruit bar prepared from pure *aonla* pulp (T_1) was the highest (7.34 %) as compared to all other treatments. Lowest tannin content (1.56 %) was observed in the fruit bar in which *aonla* pulp was enriched with 75 % papaya (T_7).

Table 3. Ascorbic acid, tannins and total carotenoids of enriched *aonla* fruit bars

Treatments	Ascorbic acid (mg 100 g^{-1})	Tannins (%)	Total carotenoids (mg 100 g^{-1})
T_1- *Aonla* pulp (100%)	85.34	7.34	0.22
T_2- *Aonla* (75%) + Mango (25%)	72.90	6.10	0.34
T_3 - *Aonla* (50%) + Mango (50%)	58.77	5.08	0.69
T_4 - *Aonla* (25%) + Mango (75%)	50.87	3.01	0.89
T_5 - *Aonla* (75%) + Papaya (25%)	64.41	5.08	0.27
T_6 - *Aonla* (50%) + Papaya (50%)	50.22	3.06	0.94
T_7 - *Aonla* (25%) + Papaya (75%)	31.00	1.56	1.33
T_8 - *Aonla* (75%) + Jackfruit (25%)	56.00	5.11	0.21
T_9 - *Aonla* (50%) + Jackfruit (50%)	54.17	4.06	0.34
T_{10} - *Aonla* (25%) + Jackfruit (75%)	21.79	2.05	0.69
SE	0.383	0.008	0.009
CD	1.130	0.024	0.027

4.1.2.6 Total carotenoids (mg 100 g^{-1})

Enrichment of *aonla* fruit bars with carotenoid rich fruit pulps (mango, papaya and jackfruit) resulted in an increase in the levels of total carotenoids in the enriched fruit bars (Table 3). The increase was significantly superior in all the treatments with increase in the proportion of mango, papaya and jackfruit. Enriched fruit bar containing 25 % *aonla* and 75 % papaya pulp (T_7) had the highest total carotenoids (1.33 mg). Total carotenoid content was the lowest (0.21 mg) in the fruit bar containing 75 % *aonla* and 25 % jackfruit pulp (T_8) which was on par with the fruit bar prepared from pure *aonla* pulp (T_1), which contained 0.22 mg of total carotenoids.

4.1.2.9 Sensory evaluation

Based on the results obtained from sensory evaluation of fruit bars, best treatment was selected in accordance with the maximum score obtained for fruit bar from each combination of enrichment.

Enrichment of *aonla* pulp with fruit pulps of mango, papaya and jackfruit resulted in enhanced acceptability (Table 4). Increase in the proportion of fruit pulps of mango, papaya and jackfruit in *aonla* pulp in the preparation of enriched fruit bars resulted in higher scores for sensory properties. Of all the treatments, enriched fruit bar containing 25 % *aonla* and 75 % mango (T_4) scored the highest values (8.60) for overall acceptability, which was on par with the treatment T_7 (25 % *aonla* + 75 % papaya) which had a score of 8.55. Enrichment of *aonla* with jackfruit, in the preparation of fruit bar, was found inferior, based on scores observed in the organoleptic evaluation of the product. Fruit bar prepared from pure *aonla* pulp was also found unacceptable to the panel of judges.

Pure *aonla* 100% (T_1)

Aonla 25%+ Mango 75% (T_2)

Aonla 25 % + papaya 75% (T_3)

Aonla 75% + Jackfruit 25 % (T_4)

Plate 4. Fruit bars from pure *aonla* pulp and enriched pulp of *aonla* with mango, papaya and jackfruit selected for storage studies

Table 4. Mean sensory scores for the pure and enriched *aonla* fruit bars

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1-*Aonla* pulp (100%)	6.40	3.95	3.80	4.70	4.50	6.50	3.55	4.35	37.75
T_2-*Aonla* (75%) + Mango (25%)	4.65	4.95	5.00	5.75	5.20	6.00	4.75	5.75	42.05
T_3- *Aonla* (50%) + Mango (50%)	5.45	7.10	6.20	6.80	5.35	6.70	5.65	5.80	49.05
T_4- *Aonla* (25%) + Mango (75%)	8.60	8.30	8.70	6.35	8.40	9.05	8.10	8.60	66.10
T_5- *Aonla* (75%) + Papaya (25%)	2.75	3.60	4.55	5.30	4.55	5.05	5.45	4.90	36.15
T_6- *Aonla* (50%) + Papaya (50%)	5.80	5.80	5.80	4.85	5.60	4.00	5.25	5.35	42.45
T_7- *Aonla* (25%) + Papaya (75%)	8.00	8.70	8.00	7.50	7.65	6.65	9.10	8.55	64.15
T_8- *Aonla* (75%) + Jackfruit (25%)	5.10	4.50	3.75	5.55	5.50	3.95	4.70	4.15	37.20
T_9- *Aonla* (50%) + Jackfruit (50%)	3.85	3.70	3.10	3.95	3.60	3.50	3.25	2.90	27.85
T_{10}- *Aonla* (25%) + Jackfruit (75%)	4.40	4.40	6.10	4.25	4.20	3.60	5.20	4.65	36.80
Kendal's W test	0.827	0.454	0.403	0.159	0.516	0.397	0.405	0.416	

4.2 Effect of packaging on quality of enriched fruit bars during storage

Enriched fruit bars from best combination of *aonla* with different proportion of mango, papaya and jackfruit, selected based on scores obtained in sensory evaluation, were chosen for storage studies. Enriched fruit bars made from pulps of *aonla* (25 %) and mango (75 %) (T_4), *aonla* 25 % and papaya 75 % (T_7), *aonla* 75 % and jackfruit 25 % (T_8) along with fruit bar from pure *aonla* were evaluated at ambient temperature for changes in their quality during storage. The four types of fruit bars were initially wrapped in vegetable parchment paper (VPP), followed by enclosing them in different packaging materials. The packaging materials were LDPE (Low Density Polyethylene) pouches, APCF (Areca Plate overwrapped with Cling Film) and HIPS (High Impact Polystyrene) boxes. Observations were recorded at an interval of 2 months during storage.

4.2.1 Physico- chemical characteristics

4.2.1.1 Moisture (%)

Moisture content of fruit bars from pure *aonla* and that from enriched *aonla* pulp showed a decreasing trend during storage, irrespective of packaging materials (Table 5). However, all the 4 types of fruit bars packaged in High Impact Polystyrene boxes retained maximum moisture content of 1.96 (%), 2.26 (%) and 5.06 (%) after 2, 4 and 6 months of storage, respectively. Minimum moisture retention was recorded in the fruit bars packed in LDPE pouches which showed a decrease of 2.04 (%), 6.04 (%) and 8.84 (%) after 2, 4 and 6 months of storage, respectively.

4.2.2 Biochemical parameters

4.2.2.1 Titratable acidity (%)

All the fruit bars showed a significant decline in titratable acidity up to 2 months of storage, irrespective of packaging materials (Table 6). Thereafter, the decline was insignificantly slow in all the fruit bars at four and six months intervals during storage. However, packaging materials did not have any significant influence on retention of titratable acidity of fruit bars during the entire storage period. Titratable acidity of enriched fruit bar from *aonla* and mango (0.04 %) was on par with that of

VPP (Vegetable Parchment Paper)

LDPE (Low Density Polyethylene)

APCF (Areca Plate overwrapped
with Cling Film)

HIPS (Polystyrene) box

Plate 5. Packaging materials used for enclosing fruit bars- 1. VPP 2. LDPE bag
3. APCF and 4. HIPS box

enriched bar from *aonla* and papaya (0.05 %), after six months of storage. Fruit bar from pure *aonla* pulp had maximum titratable acidity (0.14 %) at the end of storage.

4.2.2.2 Total Soluble Solids (^{0}Brix)

TSS content of all types of fruit bars showed an upward trend (Table 7). However, this increase in TSS was not significant with regard to storage period and type of packaging materials used. However, fruit bars packaged in High Impact Polystyrene boxes retained maximum total soluble solids than those packaged in LDPE pouches and areca plate overwrapped with cling film, even though the retention was not significant. Enriched fruit bars prepared from pulp of *aonla* and mango had maximum TSS (52.67 – 53.70 ^{0}B), than the one from *aonla* pulp alone (45.63 – 45.67 ^{0}B). TSS content of enriched fruit bar from *aonla* and papaya was on par (52.63 – 53.79 ^{0}B) with that of enriched fruit bar from *aonla* and mango.

4.2.2.3 Reducing sugars (%)

An upward trend was noticed in reducing sugar content of all the fruit bars during storage (Table 8). However, the increase was not significant during the entire storage period of 6 months and type of packaging materials also did not have any significant influence in reducing sugar content of fruit bars. Enriched fruit bar containing *aonla* and mango had maximum reducing sugars (37.94 – 38.93 %), which was significantly higher than the reducing sugar content of fruit bar from *aonla* pulp alone (30.37 %), after six months of storage.

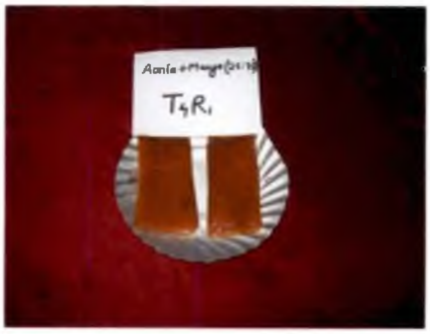
4.2.2.4. Non reducing sugars (%)

Non reducing sugar content of fruit bar from pure *aonla* and enriched *aonla* pulp showed a declining trend throughout the storage period (Table 9). However, there was no significant difference in reducing sugar content of the fruit bars with respect to the various packaging materials. Enriched fruit bar containing *aonla* and papaya had maximum non reducing sugars (12.64 – 12.66 %) over a period of six months, which was significantly higher than the non reducing sugar content in fruit bar from pure *aonla* pulp (9.0 – 9.10 %).

2 months after storage

2 months after storage

4 months after storage



4 months after storage

6 months after storage

6 months after storage

Plate 6. Quality of fruit bar from pure aonla pulp and enriched pulp of *aonla* and mango, after 2, 4 and 6 months of storage

Table 5. Effect of packaging materials on moisture content (%) of enriched *aonla* fruit bars during storage

Treatments	Moisture content (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	13.23	12.96	12.83	12.97	12.43	12.80	12.93	12.06	12.30	12.56
T_2	17.17	16.70	16.63	16.53	16.26	16.63	16.53	15.93	16.10	16.30
T_3	16.60	16.26	16.12	16.26	15.90	15.43	16.26	15.30	15.13	16.03
T_4	14.13	13.80	13.73	13.73	13.30	13.60	13.70	13.06	13.06	13.13
SE	0.05	0.11	0.10	0.07	0.12	0.08	0.08	0.09	0.07	0.13
CD	0.65	0.322	0.288	0.217	0.335	0.243	0.249	0.282	0.224	0.377

Table 6. Effect of packaging materials on titratable acidity (%) of enriched *aonla* fruit bars during storage

Treatments	Titratable acidity (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	0.31	0.15	0.16	0.15	0.15	0.16	0.15	0.14	0.14	0.14
T_2	0.22	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04
T_3	0.19	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
T_4	0.29	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.11	0.11
SE	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.001	0.001
CD	0.01	0.002	0.003	0.004	0.002	0.003	0.004	0.348	0.003	0.004

MAS – Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%), **T_4**- *Aonla* (75%) + Jackfruit (25 %)

Table 7. Effect of packaging materials on Total Soluble Solids (^{0}B) of enriched *aonla* fruit bars during storage

Treatments	Total Soluble Solids (^{0}B)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	45.23	45.26	45.25	45.29	45.73	45.83	45.83	45.63	45.67	45.67
T_2	53.33	53.35	53.36	53.38	53.47	53.63	53.77	53.70	53.73	53.79
T_3	52.27	52.29	52.29	53.00	52.73	52.87	52.90	52.63	52.63	52.67
T_4	50.43	50.48	50.46	50.49	50.73	51.20	51.27	50.73	50.70	50.73
SE	0.072	0.072	0.072	0.072	0.072	0.064	0.091	0.119	0.057	0.060
CD	0.236	0.238	0.239	0.237	0.237	0.210	0.298	0.388	0.188	0.195

Table 8. Effect of packaging materials on reducing sugars (%) of enriched *aonla* fruit bars during storage

Treatments	Reducing sugars (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	30.07	30.17	30.17	30.17	30.27	30.27	30.27	30.37	30.37	30.37
T_2	37.80	37.83	37.83	37.87	37.93	37.84	37.93	38.92	37.94	38.93
T_3	37.07	37.17	37.18	37.17	37.27	37.28	37.27	37.67	37.48	37.37
T_4	31.03	31.13	31.14	31.15	31.23	31.24	31.25	31.43	31.34	31.44
SE	0.029	0.018	0.017	0.017	0.008	0.010	0.007	0.008	0.010	0.007
CD	0.096	0.059	0.057	0.056	0.027	0.032	0.024	0.026	0.032	0.024

MAS- Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%)

T_4- *Aonla* (75%) + Jackfruit (25%)

2 months after storage

2 months after storage

4 months after storage

4 months after storage

6 months after storage

6 months after storage

Plate 7. Quality of fruit bar from pure aonla pulp and enriched pulp of *aonla* and papaya, after 2, 4 and 6 months of storage

2 months after storage

2 months after storage

4 months after storage

4 months after storage

6 months after storage

6 months after storage

Plate 8. Quality of fruit bar from pure aonla pulp and enriched pulp of *aonla* and jackfruit, after 2, 4 and 6 months of storage

Table 9. Effect of packaging materials on non reducing sugars (%) of enriched *aonla* fruit bars during storage

Treatments	Nonreducing sugars (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	10.30	10.00	10.00	10.00	9.60	9.50	9.63	9.03	9.10	9.00
T_2	12.72	12.62	12.61	12.62	12.52	12.54	12.53	12.42	12.44	12.43
T_3	12.95	12.85	12.85	12.83	12.75	12.75	12.76	12.65	12.64	12.66
T_4	12.04	12.00	12.00	12.00	11.80	11.80	11.73	11.03	11.06	11.00
SE	0.029	0.006	0.007	0.010	0.064	0.041	0.068	0.024	0.044	0.005
CD	0.097	0.020	0.022	0.034	0.211	0.134	0.225	0.079	0.144	0.019

MAS- Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%)

T_4- *Aonla* (75%) + Jackfruit (25%)

4.2.2.5 Total sugars (%)

An increase in total sugar content was observed in all the fruit bars during the entire storage period (Table 10). Type of packaging materials did not have any significant influence on total sugar content of fruit bars during storage. However, enriched fruit bar from *aonla* and mango had highest total sugars (50.69 - 50.77 %), which was significantly higher than the total sugar content of fruit bar from *aonla* pulp alone (40.64 – 40.68 %), after six months of storage. Total sugar content of enriched fruit bar from *aonla* and papaya was on par with that of the bar from *aonla* and mango (50.47 – 50.54 %).

4.2.2.6 Ascorbic acid (mg 100 g^{-1})

Ascorbic acid content of all fruit bars decreased throughout the storage period. Packaging materials did not have any significant influence on ascorbic acid content of fruit bars during storage (Table 11). Maximum ascorbic acid content was observed in fruit bar from pure *aonla* pulp (45.37 mg), which was on par with that of the enriched fruit bar from *aonla* and jackfruit (44.53 mg), after 6 months of storage. Ascorbic acid content of enriched fruit bar containing *aonla* and mango (25.20 mg) and that from *aonla* and papaya (26.05 mg) was significantly lower than that of the fruit bar from pure *aonla* pulp and enriched fruit bar containing *aonla* and jackfruit, at the end of storage period.

4.2.2.7 Tannins (%)

Tannins rose in all fruit bars during storage. Fruit bars from enriched *aonla* pulp contained significantly lower levels of tannins as compared to the fruit bar from pure *aonla* pulp (Table 12). Tannin content of all fruit bars packaged in High Impact Polystyrene (HIPS) boxes was significantly lower as compared to the fruit bars in LDPE and Areca Plate overwrapped with Cling Film, after 2 months of storage. However, with the advancement of storage period, there was no significant difference in tannin content of fruit bars with respect to packaging materials. Enriched fruit bar from *aonla* and papaya contained significantly lower tannin content (2.15 – 2.19 %) as compared to all other treatments throughout the storage period.

Table 10. Effect of packaging materials on total sugars (%) of enriched *aonla* fruit bars during storage

Treatments	Total sugars (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	40.24	40.48	40.55	40.57	40.54	40.55	40.58	40.64	40.65	40.68
T_2	50.42	50.51	50.65	50.65	50.59	50.64	50.66	50.69	50.75	50.77
T_3	50.04	50.24	50.44	50.34	50.27	50.44	50.44	50.47	50.54	50.54
T_4	43.06	43.26	43.46	43.26	43.37	43.46	43.36	43.47	43.57	43.46
SE	0.008	0.011	0.015	0.012	0.009	0.015	0.010	0.009	0.016	0.010
CD	0.029	0.036	0.051	0.040	0.031	0.051	0.033	0.031	0.051	0.033

Table 11. Effect of packaging materials on ascorbic acid content (mg 100 g^{1})of enriched *aonla* fruit bars during storage

Treatments	Ascorbic acid content (mg 100 g^{-1})									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	85.34	74.53	74.50	74.41	55.37	55.36	55.35	45.37	45.37	45.37
T_2	50.87	45.47	45.39	45.42	35.20	35.20	35.21	25.20	25.21	25.20
T_3	31.00	29.47	29.48	29.49	27.05	27.05	27.04	26.05	26.05	26.05
T_4	56.00	50.08	50.15	50.15	46.53	46.54	46.54	44.53	44.53	44.52
SE	0.040	0.034	0.042	0.029	0.002	0.003	0.006	0.002	0.005	0.001
CD	1.32	0.109	0.139	0.095	0.007	0.010	0.020	0.007	0.015	0.004

MAS- Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%)

T_4- *Aonla* (75%) + Jackfruit (25%)

Table 12. Effect of packaging materials on tannins (%) of enriched *aonla* fruit bars during storage

Treatments	Tannins (%)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	7.34	7.53	7.57	7.33	7.73	7.75	7.76	7.93	7.95	7.96
T_2	3:01	3.21	3.22	3.01	3.41	3.44	3.43	3.61	3.64	3.63
T_3	1.56	1.76	1.78	1.56	1.96	1.96	1.97	2.15	2.17	2.19
T_4	5.11	5.34	5.34	5.11	5.54	5.55	5.56	5.74	5.77	5.76
SE	0.007	0.014	0.008	0.007	0.014	0.015	0.009	0.014	0.011	0.008
CD	0.024	0.045	0.026	0.024	0.045	0.048	0.030	0.045	0.036	0.029

MAS- Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%)

T_4- *Aonla* (75%) + Jackfruit (25%)

4.2.2.8 Total carotenoids (mg 100 g^{-1})

Total carotenoids of all fruit bars decreased during storage. However, packaging materials did not have any significant effect on the retention of total carotenoids during the entire period of storage. Enriched fruit bar from *aonla* and papaya contained maximum total carotenoids (1.16-1.20 mg), which was significantly higher than that of the fruit bar from *aonla* and mango (0.78 mg), after 6 months of storage. Total carotenoid content of enriched fruit bar from *aonla* and jackfuit (0.16 mg) was on par with that of the fruit bar from pure *aonla* pulp (0.18 mg), at the end of the storage period.

4.2.2.9 Non enzymatic browning (absorbance)

Non enzymatic browning increased in all fruit bars during storage. Packaging materials did not have any significant effect on non enzymatic browning of fruit bars during the entire storage period (Table 14). However, enriched fruit bar containing *aonla* and papaya showed maximum non enzymatic browning throughout the storage period. After 6 months of storage, non enzymatic browning in enriched fruit bar from *aonla* and papaya was in the range of 1.181-1.182 (absorbance), which was significantly higher than that in the fruit bar from pure *aonla* pulp (0.206-0.208). Non enzymatic browning in enriched fruit bar from *aonla* and mango (0.192-0.194) was on par with that of the fruit bar from *aonla* and jackfruit (0.194).

Table 13. Effect of packaging materials on total carotenoids (mg 100 g^{-1}) of enriched *aonla* fruit bars during storage

Treatments	Total carotenoids (mg 100 g^{-1})									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	0.22	0.20	0.20	0.23	0.19	0.19	0.19	0.18	0.18	0.18
T_2	0.89	0.80	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78
T_3	1.33	1.23	1.26	1.26	1.21	1.21	1.21	1.20	1.20	1.16
T_4	0.21	0.18	0.18	0.17	0.17	0.17	0.17	0.16	0.16	0.16
SE	0.013	0.014	0.01	0.007	0.012	0.011	0.012	0.012	0.012	0.003
CD	0.042	0.046	0.032	0.025	0.041	0.037	0.042	0.040	0.039	0.011

Table 14. Effect of packaging materials on non enzymatic browning (absorbance) of enriched *aonla* fruit bars during storage

Treatments	Non enzymatic browning(absorbance)									
		2 MAS			4 MAS			6MAS		
	Initial	LDPE	APCF	HIPS	LDPE	APCF	HIPS	LDPE	APCF	HIPS
T_1	0.158	0.168	0.168	0.166	0.187	0.188	0.186	0.207	0.208	0.206
T_2	0.142	0.154	0.153	0.152	0.174	0.173	0.172	0.194	0.193	0.192
T_3	1.130	1.142	1.142	1.141	1.162	1.162	1.161	1.182	1.182	1.181
T_4	0.140	0.154	0.154	0.154	0.174	0.174	0.174	0.194	0.194	0.194
SE	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CD	0.003	0.004	0.004	0.003	0.004	0.004	0.003	0.004	0.004	0.003

MAS-Months after storage

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

T_1- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%),**T_3**- *Aonla* (25%) + Papaya (75%)

T_4- *Aonla* (75%) + Jackfruit (25%)

4.3 SENSORY EVALUATION

Mean sensory score of all fruit bars showed a declining trend throughout the storage period, irrespective of the packaging materials in which they were enclosed. Among all the treatments, enriched fruit bar containing *aonla* and mango showed significantly higher total score (62.95) after 6 months of storage, followed by the one in which *aonla* was enriched with papaya (61). With respect to packaging materials, all fruit bars packaged in High Impact Polystyrene (HIPS) boxes had maximum scores.

4.4 MICROBIAL LOAD (cfu/g)

Bacterial population was not detected in any of the fruit bars, irrespective of the packaging material, up to 2 months of storage (Table 16a and 16b). However, bacterial population was detected in all fruit bars packaged in LDPE (1.0-2.0 x 10^4) and Areca Plate overwrapped with Cling Film (1.0 x 10^4), after 4 months of storage. There was no growth of bacteria in any of the fruit bars packaged in High Impact Polystyrene (HIPS) boxes up to 4 months of storage. After 6 months of storage, bacterial population was observed in all fruit bars, irrespective of the packaging materials, even though their growth was low in fruit bars packaged in HIPS (High Impact Polystyrene) boxes.

Fungal population was not detected in any of the fruit bars packaged in APCF and HIPS during the entire storage period. However, fungi was detected in all fruit bars except the one from pure *aonla* pulp, after 4 months of storage in LDPE bag.

Table 15a. Mean sensory scores for pure and enriched *aonla* fruit bars at 2 months after storage in packaging material LDPE (Low Density Polyethylene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.30	3.85	3.80	4.70	4.50	6.40	3.45	4.25	37.25
T_2	8.50	8.20	8.70	6.35	8.40	8.95	8.00	8.50	65.6
T_3	7.90	8.60	8.00	7.50	7.65	6.55	9.00	8.45	63.65
T_4	5.00	4.40	3.75	5.55	5.50	3.85	4.60	4.05	36.7

Table 15b. Mean sensory scores for pure and enriched *aonla* fruit bars at 4 months after storage in packaging material LDPE (Low Density Polyethylene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.20	3.75	3.40	4.30	4.10	6.30	3.35	4.15	35.55
T_2	8.40	8.10	8.30	5.95	8.00	8.85	7.90	8.40	63.9
T_3	7.80	8.50	7.60	7.10	7.25	6.45	8.90	8.35	61.9
T_4	4.90	4.30	3.35	5.15	5.10	3.75	4.50	3.95	35

Table 15c. Mean sensory scores for pure and enriched *aonla* fruit bars at 6 months after storage in packaging material LDPE (Low Density Polyethylene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.00	3.55	3.30	4.20	4.00	6.20	3.25	3.95	34.45
T_4	8.20	7.90	8.20	5.85	7.90	8.75	7.80	8.20	62.8
T_7	7.60	8.30	7.50	7.00	7.15	6.35	8.80	8.15	60.85
T_8	4.70	4.10	3.25	5.05	5.00	3.65	4.40	3.75	33.9

Table 15d. Mean sensory scores for pure and enriched *aonla* fruit bars at 2 months after storage in packaging material APCF (Areca Plate overwrapped with Cling Film)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.30	3.85	3.80	4.70	4.50	6.40	3.45	4.25	37.25
T_4	8.50	8.20	8.70	6.35	8.40	8.95	8.00	8.50	65.6
T_7	7.90	8.60	8.00	7.50	7.65	6.55	9.00	8.45	63.65
T_8	5.00	4.40	3.75	5.55	5.50	3.85	4.60	4.05	36.7

Table 15e. Mean sensory scores for pure and enriched *aonla* fruit bars at 4 months after storage in packaging material APCF (Areca Plate overwrapped with Cling Film)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.20	3.75	3.40	4.30	4.10	6.30	3.35	4.15	35.55
T_4	8.40	8.10	8.30	5.95	8.00	8.85	7.90	8.40	63.9
T_7	7.80	8.50	7.60	7.10	7.25	6.45	8.90	8.35	61.95
T_8	4.90	4.30	3.35	5.15	5.10	3.75	4.50	3.95	35

Table 15f. Mean sensory scores for pure and enriched *aonla* fruit bars at 6 months after storage in packaging material APCF (Areca Plate overwrapped with Cling Film)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.00	3.55	3.30	4.20	4.00	6.20	3.25	3.95	34.45
T_4	8.20	7.90	8.20	5.85	7.90	8.75	7.80	8.20	62.8
T_7	7.60	8.30	7.50	7.00	7.15	6.35	8.80	8.15	60.85
T_8	4.70	4.10	3.25	5.05	5.00	3.65	4.40	3.75	33.9

Table 15g. Mean sensory scores for pure and enriched *aonla* fruit bars at 2 months after storage in packaging material HIPS (High Impact Polystyrene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.30	3.85	3.80	4.70	4.50	6.40	3.45	4.25	37.25
T_4	8.50	8.20	8.70	6.35	8.40	8.95	8.00	8.50	65.6
T_7	7.90	8.60	8.00	7.50	7.65	6.55	9.00	8.45	63.65
T_8	5.00	4.40	3.75	5.55	5.50	3.85	4.60	4.05	36.7

Table 15h. Mean sensory scores for pure and enriched *aonla* fruit bars at 4 months after storage in packaging material HIPS (High Impact Polystyrene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.15	3.70	3.40	4.30	4.10	6.30	3.35	4.10	35.4
T_4	8.35	8.05	8.30	5.95	8.00	8.85	7.90	8.35	63.75
T_7	7.75	8.45	7.60	7.10	7.25	6.45	8.90	8.30	61.8
T_8	4.85	4.25	3.35	5.15	5.10	3.75	4.50	3.90	34.85

Table 15i. Mean sensory scores for pure and enriched *aonla* fruit bars at 6 months after storage in packaging material HIPS (High Impact Polystyrene)

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T_1	6.05	3.60	3.30	4.20	4.00	6.20	3.25	4.00	34.6
T_4	8.25	7.95	8.20	5.85	7.90	8.75	7.80	8.25	62.95
T_7	7.65	8.35	7.50	7.00	7.15	6.35	8.80	8.20	61
T_8	4.75	4.15	3.25	5.05	5.00	3.65	4.40	3.80	34.05

Table 16a. Bacterial population in the enriched fruit bars during storage

Treatments	Bacterial population (cfu/g)									
		LDPE (10^4)			APCF (10^4)			HIPS (10^4)		
	Initial	2MAS	4MAS	6 MAS	2MAS	4MAS	6 MAS	2MAS	4MAS	6 MAS
T_1	ND	ND	1	1	ND	ND	ND	ND	ND	ND
T_2	ND	ND	2	3	ND	1	2	ND	ND	1
T_3	ND	ND	2	3	ND	1	2	ND	ND	1
T_4	ND	ND	1	2	ND	1	1	ND	ND	1

Table 16b. Fungal population in the enriched fruit bars during storage

Treatments	Fungal population (cfu/g)								
	LDPE (10^3)			APCF (10^3)			HIPS (10^3)		
	2MAS	4MAS	6 MAS	2MAS	4MAS	6 MAS	2MAS	4MAS	6 MAS
T1	ND	ND	ND	ND	ND	ND	ND	ND	ND
T2	ND	ND	1	ND	ND	ND	ND	ND	ND
T3	ND	ND	1	ND	ND	ND	ND	ND	ND
T4	ND	ND	2	ND	ND	ND	ND	ND	ND

(**LDPE**-Low Density Polyethylene, **APCF**- Areca Plate overwrapped with Cling Film and **HIPS**- High Impact Polystyrene)

(**T_1**- *Aonla* pulp (100%), **T_2**- *Aonla* (25%) + Mango (75%), **T_3**- *Aonla* (25%) + Papaya (75%), **T_4**- *Aonla* (75%) + Jackfruit (25%)

ND- Not detected

***

Discussion

DISCUSSION

Aonla or Indian gooseberry is indigenous to India. It is well known for its nutritional qualities and pharmacological properties. It is the richest and cheapest source of ascorbic acid, next only to Barbados cherry. *Aonla* fruits are widely used in various Ayurvedic preparations, such as *Chyavanprash, Triphala* and *Arishtha.* Due to high acidity and astringency, the fruit is not relished in the fresh form. There is always demand from consumers all over the world for new products which are nutritious. Value added products can be prepared from *aonla* fruits by processing them into various products. Hence, the study on "Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G.)" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara during 2013-14. The discussion pertaining to the study is presented under the following heads.

5.1 Effect of enrichment on quality of *aonla* fruit bars

5.2 Effect of packaging on quality of enriched fruit bars during storage

5.1 EFFECT OF ENRICHMENT ON QUALITY OF *AONLA* FRUIT BARS

Enriched fruit bars were prepared by blending *aonla* pulp with pulp of fruits that are good sources of provitamin A, viz. mango, papaya and jackfruit in increasing proportions of 25, 50 and 75%, along with the fruit bar prepared from pure *aonla* pulp. Quality of these fruit bars was evaluated based on their acceptability through organoleptic evaluation and biochemical/nutritional constitution.

5.1.1 Physico- chemical characteristics

5.1.1.1 Moisture (%)

The moisture content ranged from 13.23 % in fruit bar prepared from pure *aonla* pulp to 17.17 % in *aonla* pulp enriched with mango pulp. Similar trend in moisture content was observed by Mir and Nath (2000) in mango bar enriched with desiccated coconut powder and soy protein concentrate, which contained 18.7 and 18.4 % moisture, respectively. However, Hemakar *et al.* (2000) reported a moisture

Fig. 1a Moisture content of fruit bars from *aonla*

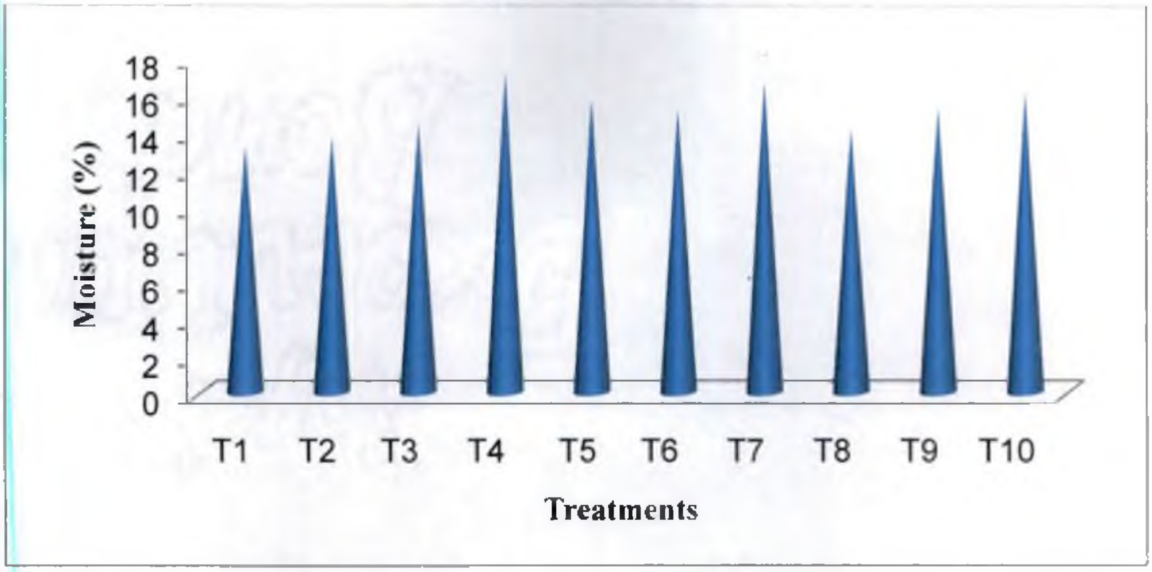


Fig. 1b Titratable acidity of fruit bars from *aonla*

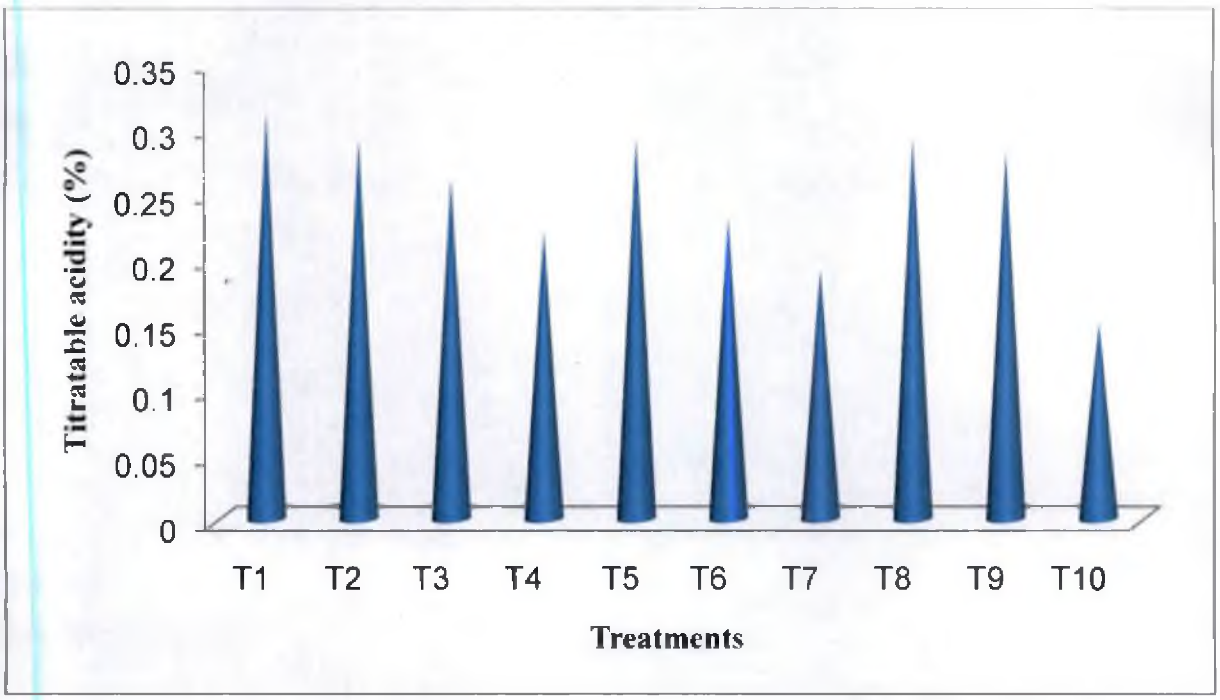


Fig. 2 TSS content of fruit bars from *aonla*

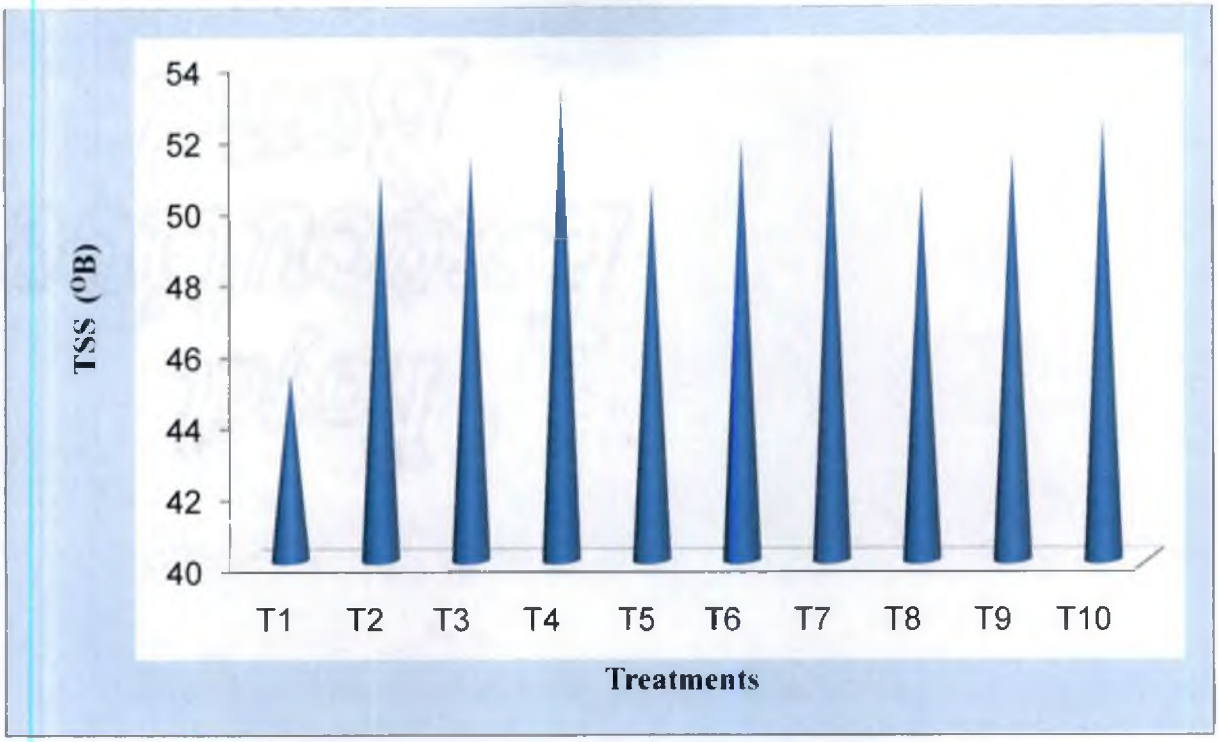
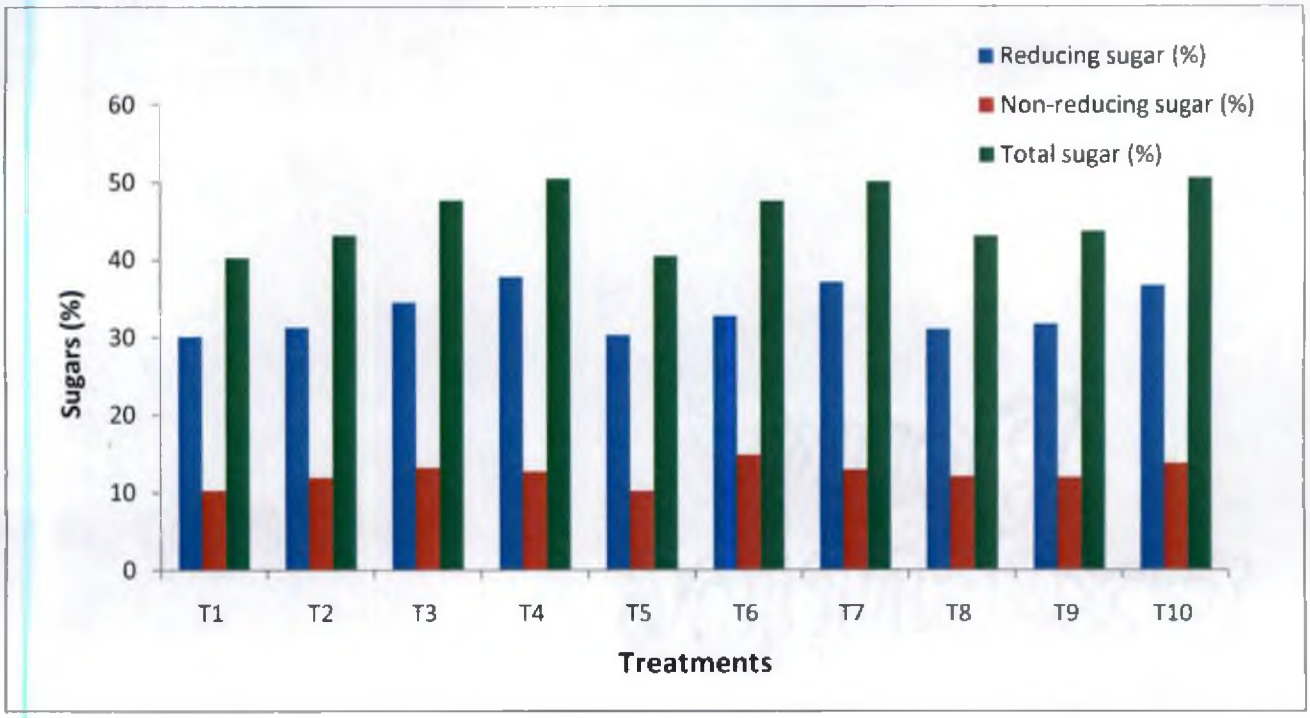


Fig. 3 Reducing, non reducing and total sugars of fruit bars from *aonla*



content of 11.0 per cent in mango bars. Take *et al.* (2012) also reported moisture content in the range of 14.64-15.91 per cent in fortified sapota-papaya fruit bar.

5.1.2 Biochemical parameters

5.1.2.1 Titratable acidity (%)

Blending of *aonla* pulp with fruit pulp of mango, papaya and jackfruit resulted in reduction of titratable acidity in all enriched fruit bars as compared to that from pure *aonla* pulp. Fruit bar from pure *aonla* pulp had maximum titratable acidity (0.313 %) and the minimum (0.15 %) in fruit bar from enriched pulp of *aonla* (25 %) and jackfruit (75 %). The decline in acidity of enriched fruit bars may be due to higher content of TSS and sugars and lower acidity in the pulp of fruits used for enrichment. Mishra *et al.* (2012) recorded 0.4 % titratable acidity in enriched fruit bar from pulp of *aonla* and guava. Shanthi (2000) reported an acid content of 0.43 per cent in green gram enriched mango bar. Bhardwaj and Mukherjee (2011) observed similar reduction in acidity from 0.72 to 0.51 %, when kinnow juice was blended with juice of pomegranate and ginger.

Decrease in acidity of *aonla* juice was also reported by Jain and Khurdiya (2004) when *aonla* juice was blended with fruit juices of apple, grapes and pomegranate in the preparation of RTS beverages.

5.1.2.2 Total Soluble Solids (^{0}B)

Enrichment of *aonla* pulp with pulp of mango, papaya and jackfruit increased the TSS content of resultant fruit bars. Enriched fruit bar from *aonla* and mango had maximum TSS (53.33 ^{0}B) while the fruit bar from pure *aonla* pulp had minimum TSS (45.23 ^{0}B). Increase in proportion of fruit pulp with higher TSS than *aonla* may have increased the TSS content of the final fruit bar. Increase in TSS was reported by Jain and Khurdiya (2004) when *aonla* juice was blended with fruit juices of apple, grapes and pomegranate in the preparation of RTS beverages. Sandhu *et al.* (2001) reported a TSS content of 50.6 ^{0}B in guava bar, whereas Shanthi (2000) reported a TSS content of 55.0 ^{0}B in soy protein enriched mango bar. Bhardwaj and Mukherjee (2011) also reported an increase in TSS when kinnow fruit juice was blended with juice of pomegranate.

5.1.2.3 Sugars (%)

Blending of *aonla* pulp with fruit pulp of mango, papaya and jackfruit increased the reducing, non- reducing and total sugar content of fruit bars. Maximum reducing sugars were found in enriched fruit bar from *aonla* and mango in 1:3 proportion (37.80 %), while non- reducing sugars were maximum (14.84 %) in enriched fruit bar from *aonla* and papaya (50:50) and the maximum total sugars (50.5 %) were in fruit bar containing *aonla* and jackfruit (25:75). Reducing, non-reducing and total sugars were minimum in fruit bar from pure *aonla* pulp. Enrichment of *aonla* pulp with fruit pulp of mango, papaya and jackfruit, which contain more sugar as compared to *aonla*, may have raised the sugar levels in the enriched fruit bars. Mir and Nath (2000) reported a reducing sugar content of 21.8 per cent in mango bar containing desiccated coconut powder. Hemaker *et al.* (2000) reported a total sugar content of 60.0 per cent in plain mango bar. Increase in total sugar content was also reported by Bhardwaj and Mukherjee (2011) in kinnow juice blended with pomegranate juice. Minimum levels of reducing, non-reducing and total sugars in fruit bar from pure *aonla* pulp may be due to the naturally low level of sugars in fresh *aonla* fruit.

5.1.2.4 Ascorbic acid (mg 100 g^{-1})

Ascorbic acid content declined in all the fruit bars prepared from *aonla* pulp enriched with mango, papaya and jackfruit. Fruit bar from pure *aonla* pulp had the maximum ascorbic acid content (85.34 mg/100g). Ascorbic acid content of enriched fruit bars decreased with increase in proportion of fruit pulp from mango, papaya and jackfruit. Decline in ascorbic acid content of enriched fruit bars may be due to the lower initial ascorbic acid content in the pulp of these fruits, as compared to pure *aonla* pulp. Similar trend in decline of ascorbic acid content was observed in *aonla* based blended RTS beverages by Jain and Khurdiya (2004). Inyang and Abah (1997) also observed that with increase in proportion of orange juice, the ascorbic acid content of cashew apple juice decreased, when blended with orange juice. Maximum ascorbic acid retention in kinnow juice was reported by Bhardwaj and Mukherjee (2011) when it was blended with *aonla* juice.

Fig. 4 Ascorbic acid content of fruit bars from *aonla*

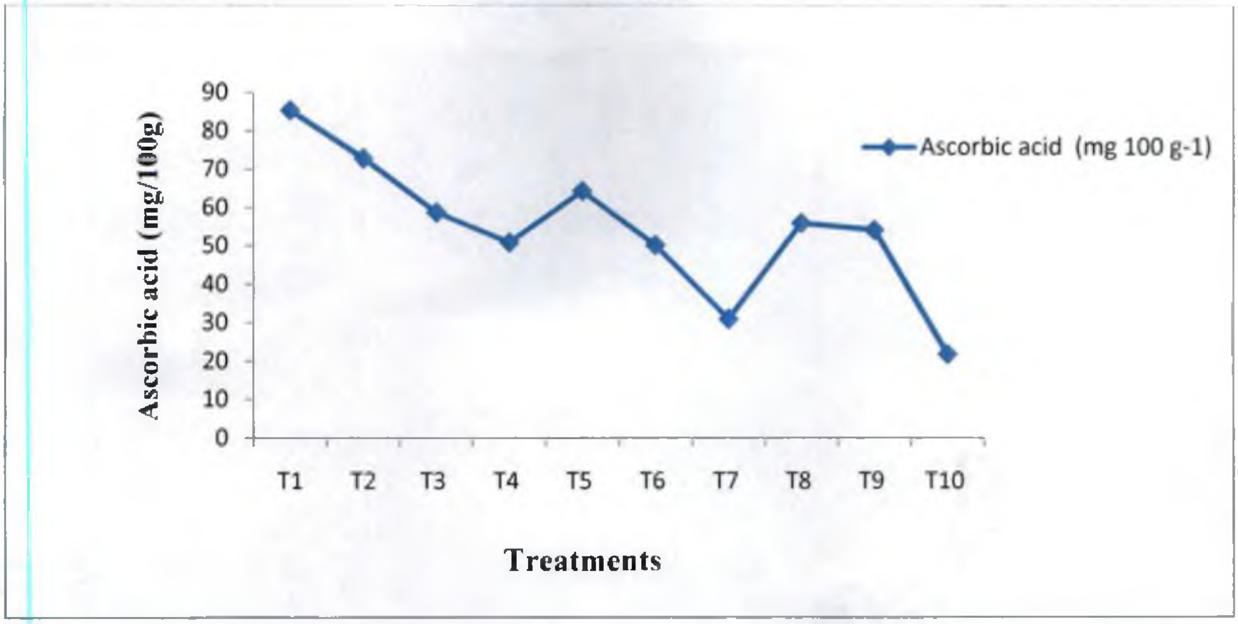
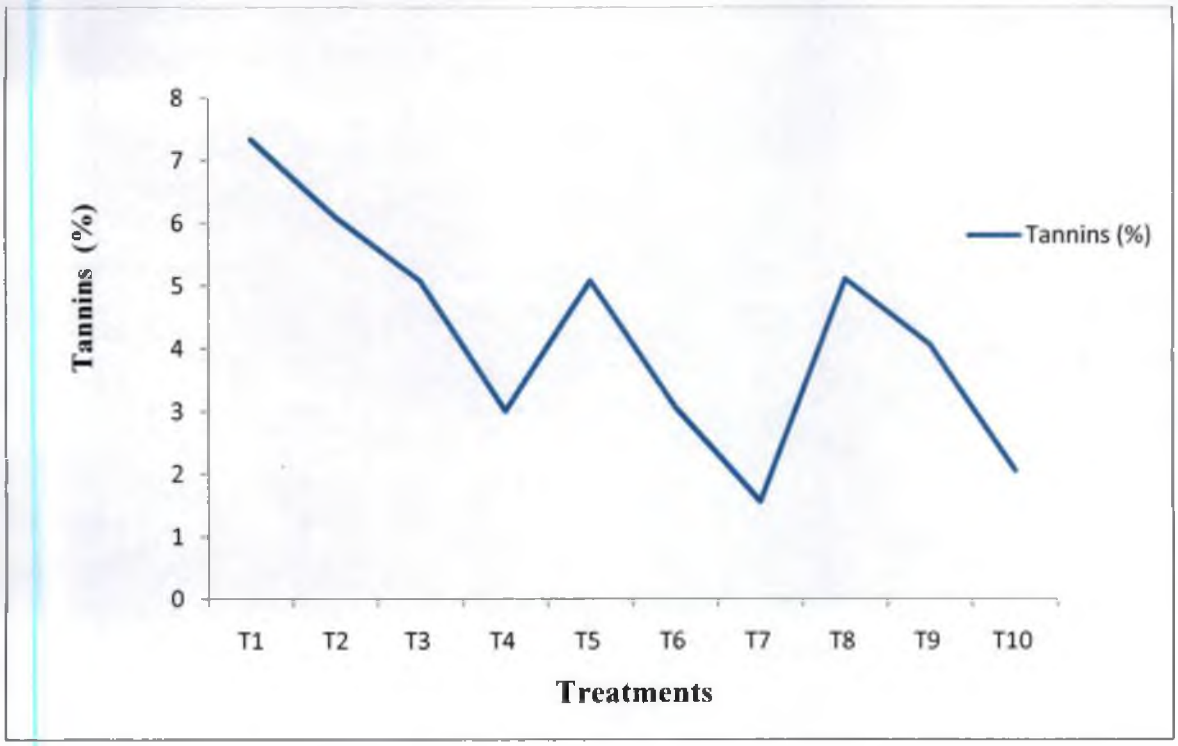


Fig. 5 Tannin content of fruit bars from *aonla*



5.1.2.5 Tannins (%)

Tannin content of enriched fruit bars decreased as compared to the fruit bar from pure *aonla* pulp. Maximum tannin content (7.34 %) was observed in fruit bar from pure *aonla* pulp. Blending of *aonla* pulp with fruit pulp of mango, papaya and jackfruit reduced the tannin content of the resultant fruit bars, the reduction being higher with increase in proportion of pulp from these fruits. Decline in tannin content in enriched fruit bars may be due to the lower initial tannin content in the pulp of these fruits, compared to pure *aonla* pulp. Reduction in tannin content of cashew apple juice was reported by Inyang and Abah (1997), when it was blended with orange juice. Similar trend in decline of tannin was also observed by Mishra *et al.* (2012) when pulp of *aonla* and guava fruits was blended in 50:50 proportion.

5.1.2.6 Total carotenoids

An increase in total carotenoids was observed in all the enriched fruit bars. The increase was higher with proportionate increase in fruit pulp of mango, papaya and jackfruit. Enriched fruit bar from *aonla* (25 %) and papaya (75 %) had the highest total carotenoids (1.33 mg/100g). Rise in total carotenoid content of enriched fruit bars may be due to higher level of carotenoids in these fruits as compared to pure *aonla* pulp. Similar trend in total carotenoids was observed by Mir and Nath (2000) in mango bar enriched with desiccated coconut powder and soy protein concentrate and Shanthi (2000) in mango bar enriched with green gram. Increase in carotenoid content in fortified sapota-papaya fruit bar was reported by Take *et al.* (2012).

5.2 EFFECT OF PACKAGING ON QUALITY OF ENRICHED FRUIT BARS DURING STORAGE

Three enriched fruit bars prepared from pulp of *aonla* and mango in 1:3, *aonla* and papaya in 1:3 and *aonla* and jackfruit in 3:1 proportions, along with the fruit bar from pure *aonla*, were selected based on their organoleptic acceptability and biochemical/nutritional constitution. These four types of fruit bars were wrapped initially in Vegetable Parchment Paper, followed by enclosing them in three types of packaging materials viz. Low Density Polyethylene (LDPE) bags, areca plate overwrapped with cling film (APCF) and High Impact Polystyrene (HIPS) boxes. Quality of the packaged fruit bars was evaluated at an interval of every two months, for a period of six months, under ambient storage conditions.

5.2.1 Physico- chemical and biochemical characteristics

5.2.1.1 Moisture

Moisture content of fruit bars from pure *aonla* and that from enriched *aonla* pulp showed a decreasing trend during storage. Packaging materials did not have any significant influence on moisture content of fruit bars. Reduction in moisture content of all fruit bars may be due to loss of moisture through evaporation. Moisture loss in fruit bars was maximum in LDPE bags and minimum in High Impact Polystyrene boxes. Loss in moisture content of mango bar during storage was observed by Nanjundaswamy *et al.* (1976). Higher moisture loss in mango bar packed in polyethylene terephthalate was reported by Nadanasabapathi *et al.* (1993). Manimegalai *et al.* (2001) reported that moisture content of jackfruit bar reduced during storage of six months when it was packed in polypropylene bag.

5.2.2 Biochemical parameters

5.2.2.1 Titratable acidity (%)

All the fruit bars showed a decline in titratable acidity throughout storage. Packaging materials did not show any significant variation in retention of acidity during storage. Fruit bar from pure *aonla* pulp had maximum titratable acidity. Decline in acidity may be due to increase in sugar content as a result of conversion of polysaccharides into sugars. Decline in acidity of *aonla* candy and preserve was reported by Tripathi *et al.* (1988). Priya and Khatkar (2013) also observed reduction in acidity of *aonla* preserve during storage. Ramalingam *et al.* (2010) found slight increase in titratable acidity of tropical fruit bars during storage when packed in polyethylene bags, whereas it remained constant in aluminium foil and industrial packaging material.

5.2.2.2 Total Soluble Solids (^{0}B)

TSS content of all fruit bars increased during storage. The increase in TSS was not significant with respect to storage period and packaging materials used. Fruit bars packaged in High Impact Polystyrene boxes retained maximum TSS as compared to the ones in LDPE bags and areca plate overwrapped with cling film. Increase in TSS might be due to conversion of polysaccharides into sugars. Increase in TSS was also observed in guava bar during storage by Khan et al. (2014). Similar

Fig. 6 Effect of packaging materials on moisture content (%) of enriched *aonla* fruit bars during storage

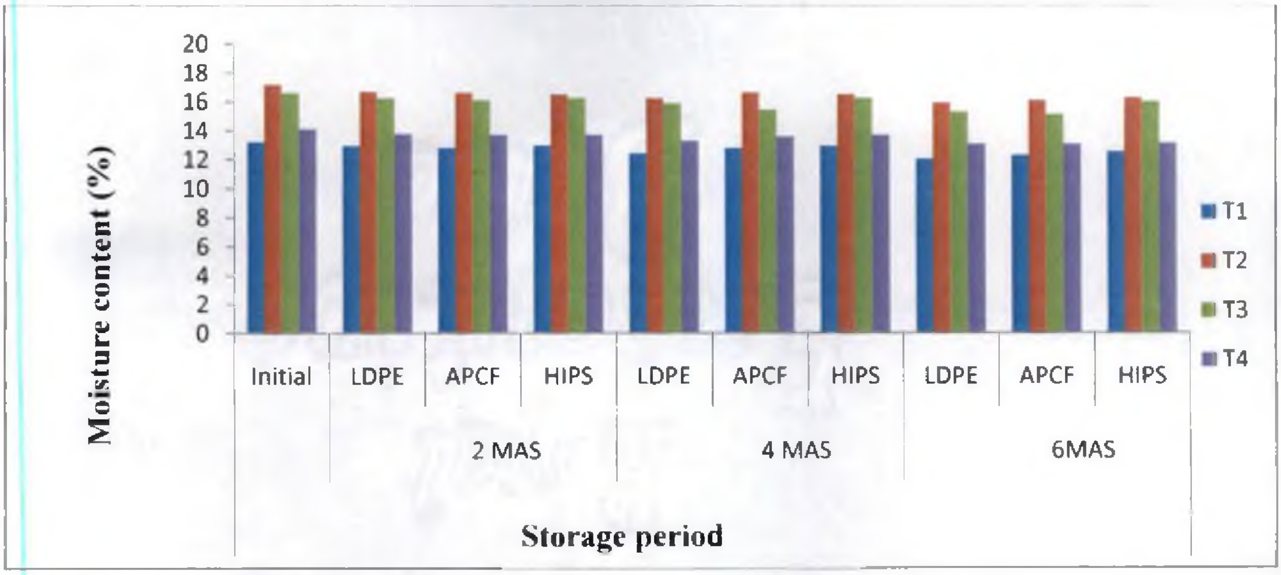


Fig. 7 Effect of packaging materials on titratable acidity (%) of enriched *aonla* fruit bars during storage

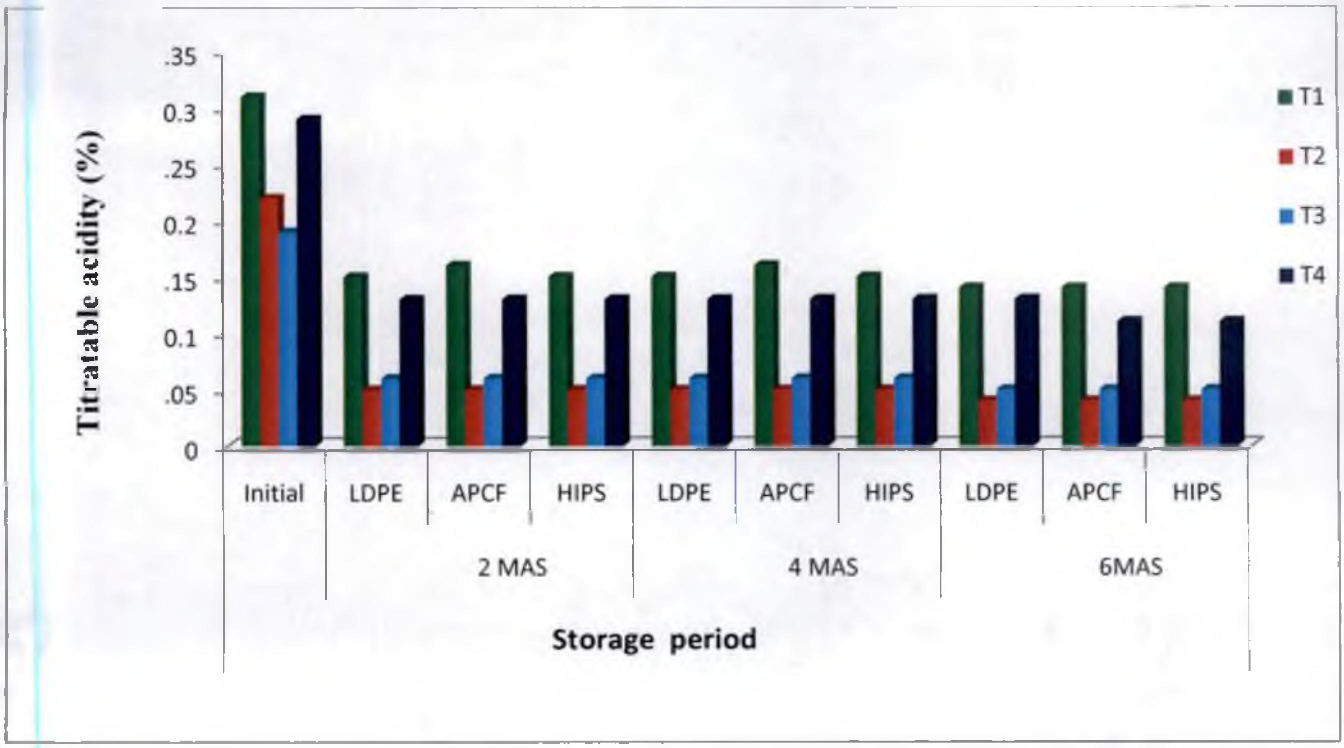


Fig. 8 Effect of packaging materials on Total Soluble Solids (^{0}B) of enriched *aonla* fruit bars during storage

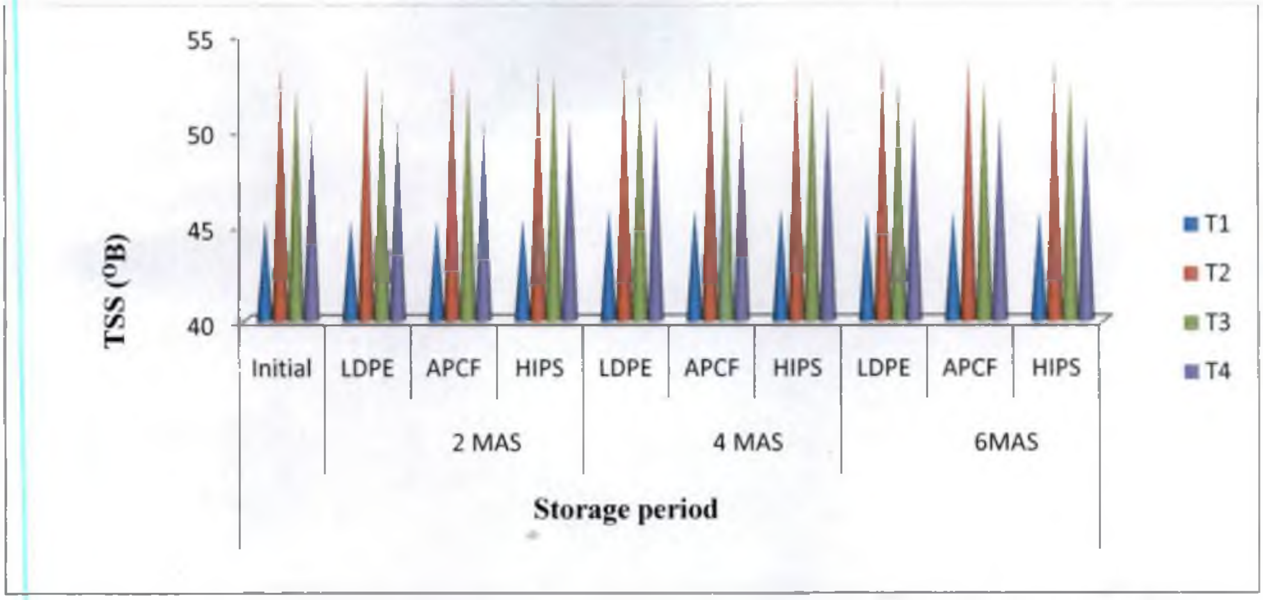
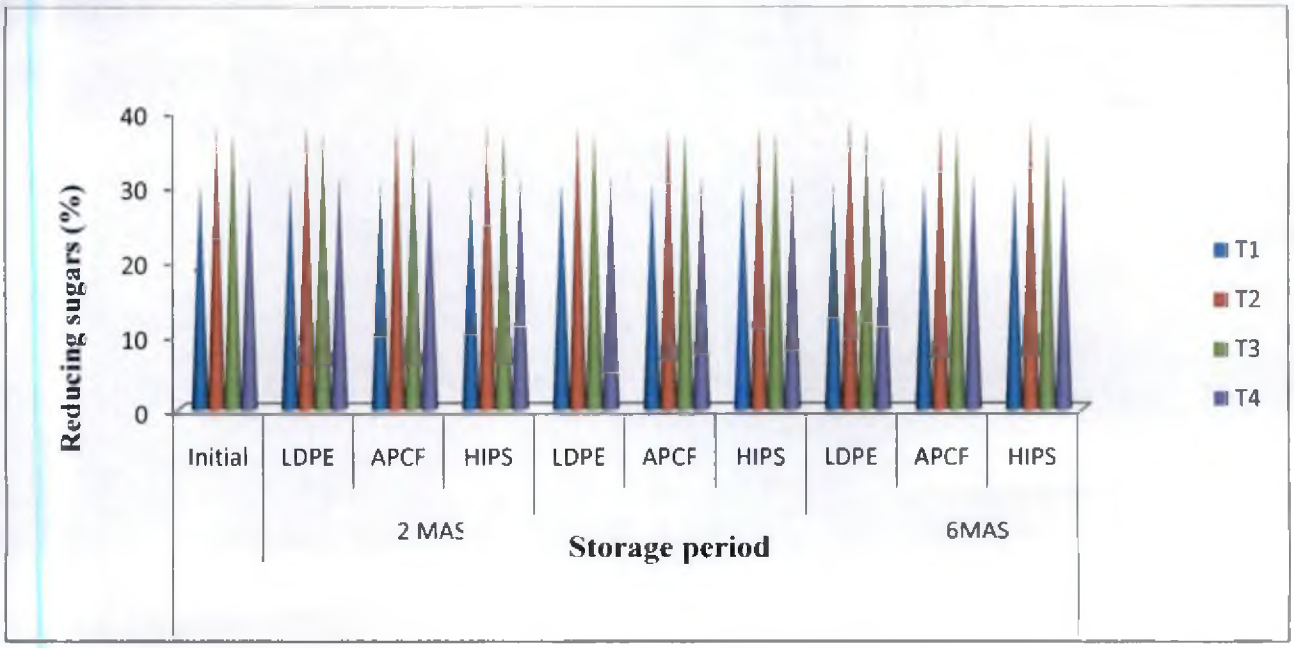


Fig. 9 Effect of packaging materials on reducing sugars (%) of enriched *aonla* fruit bars during storage



trend was reported by Tripathi *et al.* (1988) in *aonla* candy and preserve. Vidhya and Narain (2011) also did not find any significant increase in TSS of wood apple bar and jam during storage up to 90 days. Ramalingam *et al.* (2010) found slight decrease in concentration of sugar, when tropical fruit bars were packed in polyethylene bags, but remained constant in aluminium foil and industrial packaging material, when held at 55 ^{0}C and 60 % RH for a period of one month.

5.2.2.3 Sugars (%)

Blending of *aonla* pulp with pulp of mango, papaya and jackfruit increased the reducing, non-reducing and total sugar content of fruit bars. Maximum reducing sugars were found in enriched fruit bar from *aonla* and mango, while non-reducing sugars were maximum in enriched fruit bar from *aonla* and papaya. Total sugar content was maximum in fruit bar containing *aonla* and jackfruit. Reducing sugar content of all fruit bars increased during storage. Packaging materials did not show any significant variation in sugar retention of fruit bars. Increase in reducing sugar content of fruit bars during storage may be due to acid hydrolysis of sucrose. Chauhan *et al.* (1997) reported an increasing trend in reducing sugar content of fruit bar from mango pulp and also the one enriched with soy flour. An increasing trend in reducing sugar content during storage was also reported by Aruna *et al.* (1999) in papaya bar, Manimegalai *et al.* (2001) in jackfruit leather and Sandhu *et al.* (2001) in fruit bar from guava and sapota.

Non-reducing sugar content of all fruit bars decreased during storage. The reduction may be due to increase in reducing sugars by acid hydrolysis and subsequent inversion of non reducing sugars. Aruna *et al.* (1999) reported that non-reducing sugar of papaya fruit bar decreased significantly during storage. Similar reduction in non-reducing sugars was reported by Rao and Roy (1980) in mango bar and Manimegalai *et al.* (2001) in jackfruit leather. In pure *aonla* bar, significant reduction in non reducing sugar was observed during 6 months of storage. Nadanasabapathi *et al.* (1993) reported that mango bar packed in different packaging materials did not show any change in non reducing sugar content, even after 6 months of storage.

Fig. 10 Effect of packaging materials on total sugars (%) of enriched *aonla* fruit bars during storage

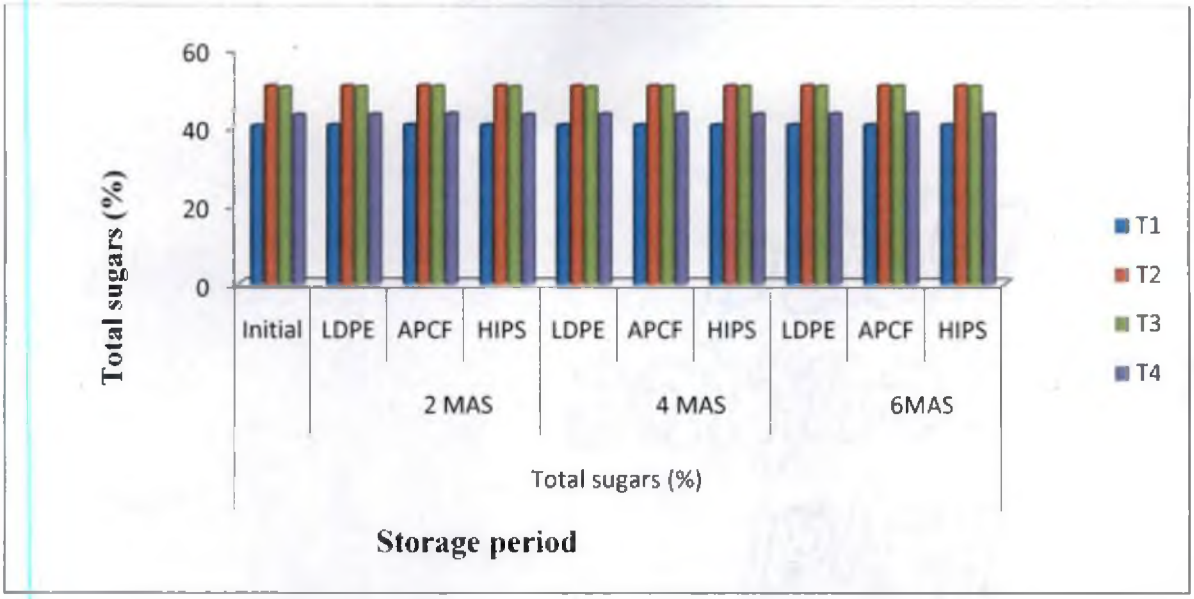
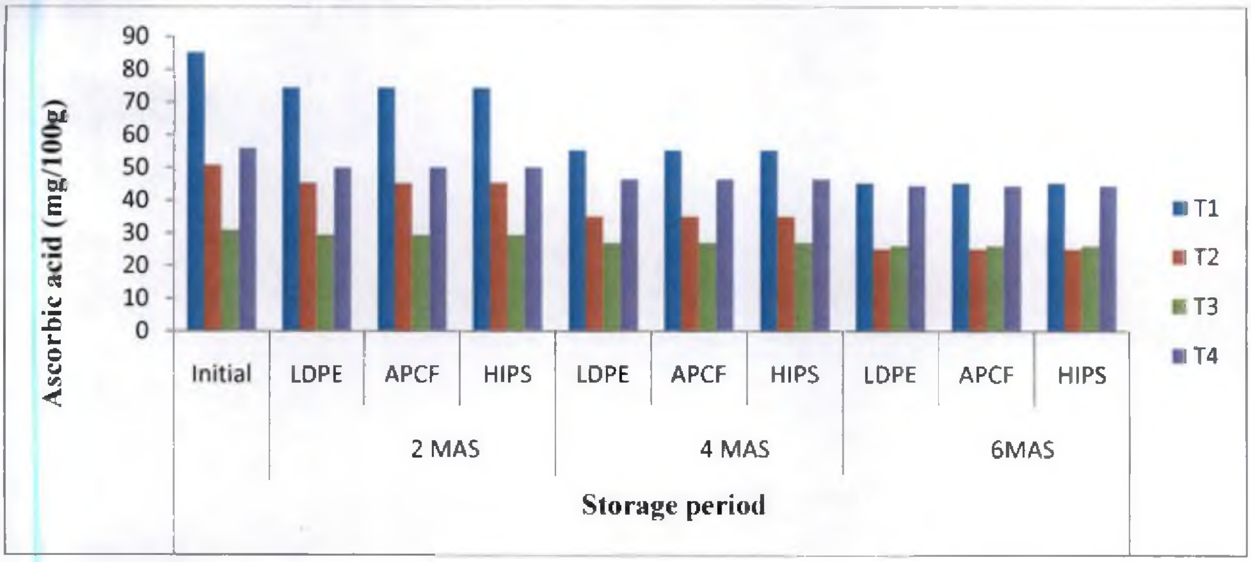


Fig. 11 Effect of packaging materials on ascorbic acid content (mg 100 g^{-1}) of enriched *aonla* fruit bars during storage



The total sugar content increased in all the fruit bars during storage. Increase in total sugar content of fruit bars during storage might be due to hydrolysis of polysaccharides and inversion of non reducing sugars. Roy and Singh (1979) observed increase in total sugars of bael fruit products during storage. Jain *et al.* (1983) also reported an increase in total sugar content of *aonla* candy during storage.

5.2.2.4 Ascorbic acid (mg/100g)

Ascorbic acid content of all fruit bars showed a significant decrease throughout the storage period. Maximum ascorbic acid content was observed in fruit bar from pure *aonla* pulp (45.37 mg/100g), after 6 months of storage. Decline in ascorbic acid content of fruit bars might be due to oxidation of ascorbic acid to dehydro ascorbic acid. Packaging materials did not show any significant variation with respect to retention of ascorbic acid during storage. Similar findings were reported by Shanthi *et al.* (2000) in mango bar enriched with soy flour. Chauhan *et al.* (1997) also observed reduction in ascorbic acid content of fruit bar from plain mango as well as the one in which mango pulp was blended with soy flour, during storage for 6 months at ambient temperature. Aruna *et al.* (1999) also found decrease in ascorbic acid content of papaya bar during storage over a period of 6 months.

5.2.2.5 Tannins (%)

Tannin content increased in all fruit bars during storage. Maximum tannin content was found in fruit bar prepared from pure *aonla* pulp. Increase in tannin content during storage might be due to reduction in moisture content of fruit bar and reduced activity of polyphenol oxidase. Packaging materials did not have any significant influence on retention of tannin content. Sethi (1986) reported that the tannin content of *aonla* pulp increased during storage. Shah and Masoodi (1994) observed that tannin content of apple pulp increased during storage. Inyang and Abah (1997) also reported that tannin content of *aonla* juice increased with increase in storage period.

Fig. 12 Effect of packaging materials on tannins (%) of enriched *aonla* fruit bars during storage

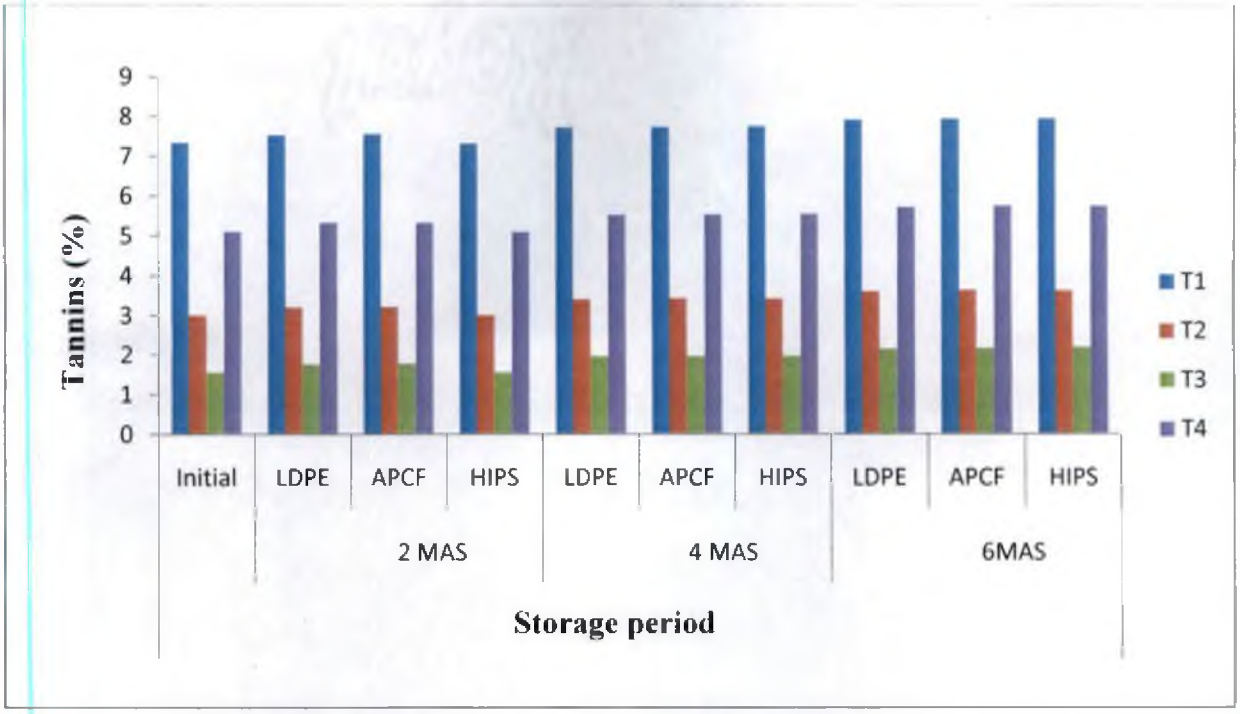
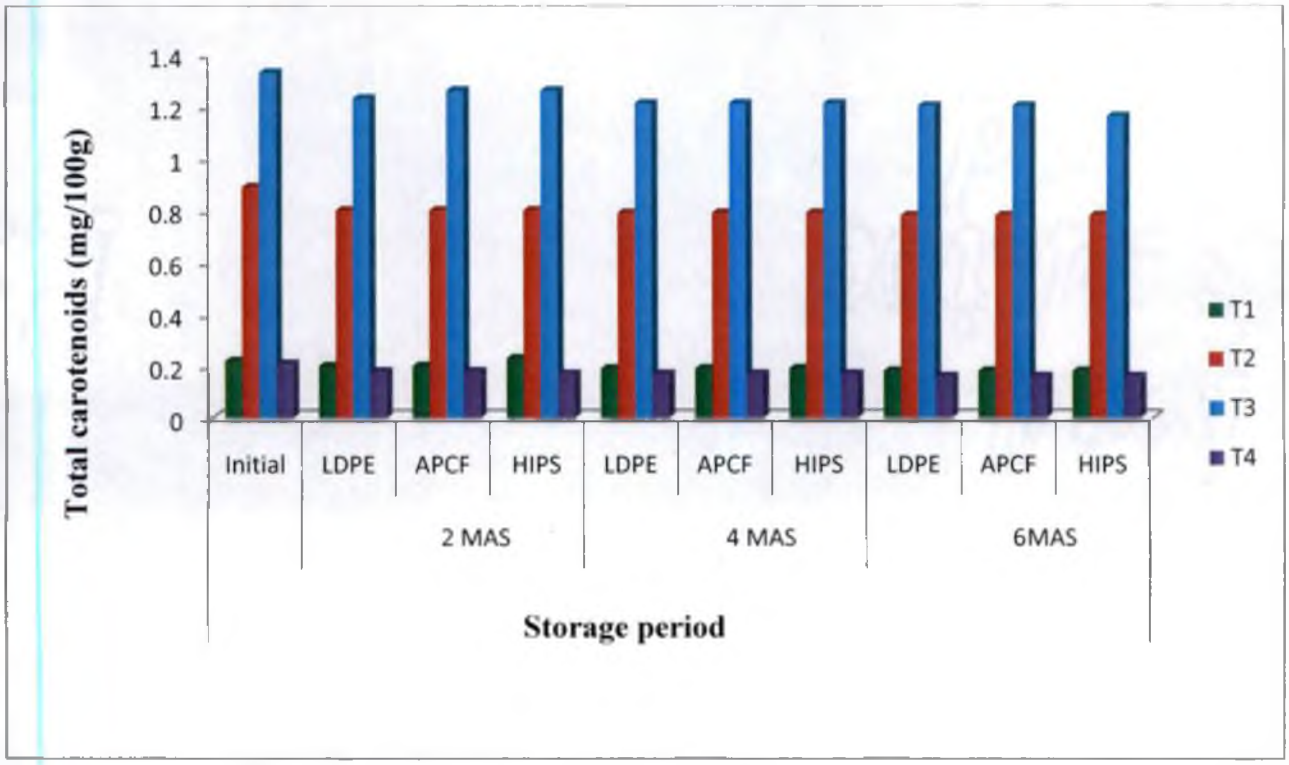


Fig. 13 Effect of packaging materials on total carotenoids (mg 100 g^{-1}) of enriched *aonla* fruit bars during storage



5.2.2.6 Total carotenoids (mg/100g)

Total carotenoid content of all fruit bars decreased during storage. The decrease in carotenoid content was not significant with respect to packaging materials and storage period. Loss of carotenoids during storage might be due to oxidative degradation. Mir and Nath (1993) observed greater loss of total carotenoids and β carotene in fortified mango bars during storage. Similar trend in loss of carotenoids during storage was also reported by Manimegalai *et al.* (2001) in jackfruit leather and by Gahiloid *et al.* (1982) in mango leather. Reduction in carotenoid content when samples were packed in polyethylene bags, after storage of 70 days was reported by Gahiloid *et al.* (1982) in mango bar and Manimegalai *et al.* (2001) in jackfruit bar, when packed in metallized polyester polyethylene (MPP) pouches after 3 months of storage.

5.2.2.7 Non-enzymatic browning (Absorbance)

Non-enzymatic browning increased in all fruit bars during storage. The increase was not significant with respect to type of packaging material used. Enriched fruit bar from *aonla* and papaya had maximum non-enzymatic browning. Non-enzymatic browning in fruit bars may be due to formation of furfural and hydroxyl furfural by aerobic and anaerobic degradation of ascorbic acid and also due to reaction between ascorbic acid, sugars and organic acid. Potter (1989) reported that there was increase in non-enzymatic browning of mango leather when stored for 70 days. Pandey and Singh (1999) also reported increase in non-enzymatic browning of blended guava RTS beverage, when stored at room temperature for 6 months.

5.3 ORGANOLEPTIC EVALUATION

Enriched fruit bar containing *aonla* and mango had the highest score in organoleptic evaluation and the lowest score was recorded in the fruit bar in which *aonla* pulp was enriched with jackfruit pulp. Organoleptic scores showed a progressive decline throughout storage. Packaging materials did not show any significant variation with regard to organoleptic acceptability of fruit bars. Rao and Roy (1980) observed that mango sheet was acceptable after 20, 30 and 40 days of storage, but its overall acceptability declined after 2 months of storage. Mir and Nath (1993) also reported that during 90 days of storage, overall acceptability of mango bar decreased due to development of undesirable colour. Decline in colour and

Fig. 14 Effect of packaging materials on non enzymatic browning (absorbance) of enriched *aonla* fruit bars during storage

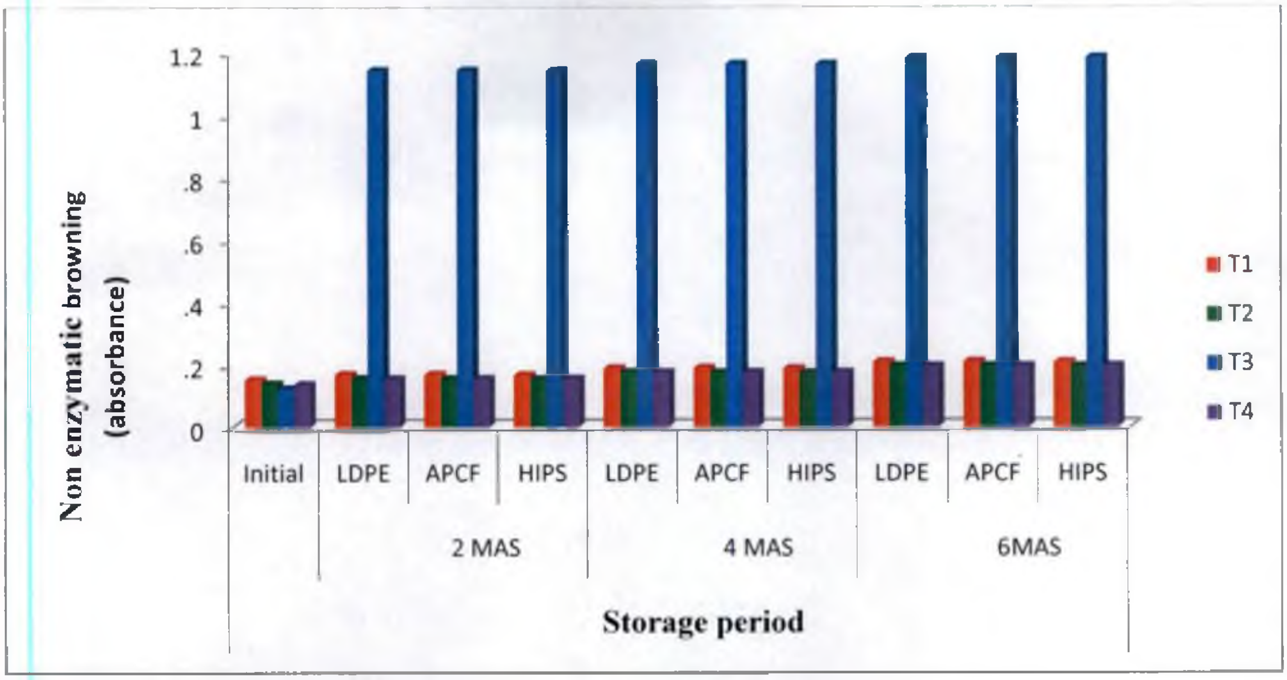


Fig. 15a Mean sensory scores for pure and enriched *aonla* fruit bars after 2 months of storage in LDPE bags

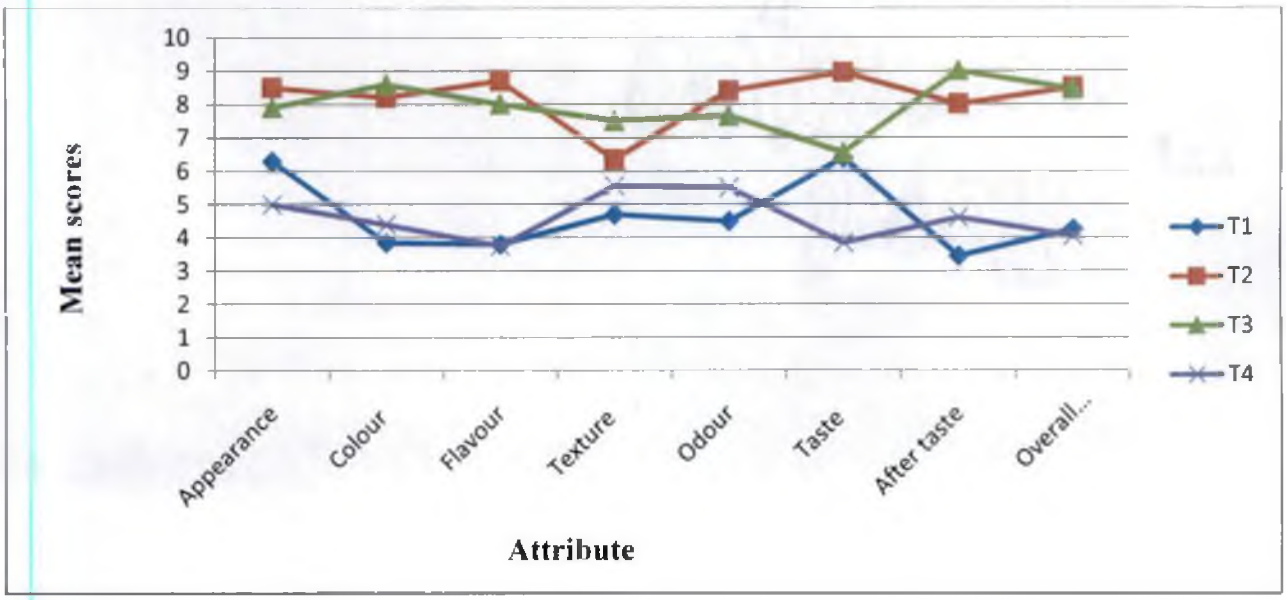


Fig. 15b Mean sensory scores for pure and enriched *aonla* fruit bars after 4 months of storage in LDPE bags

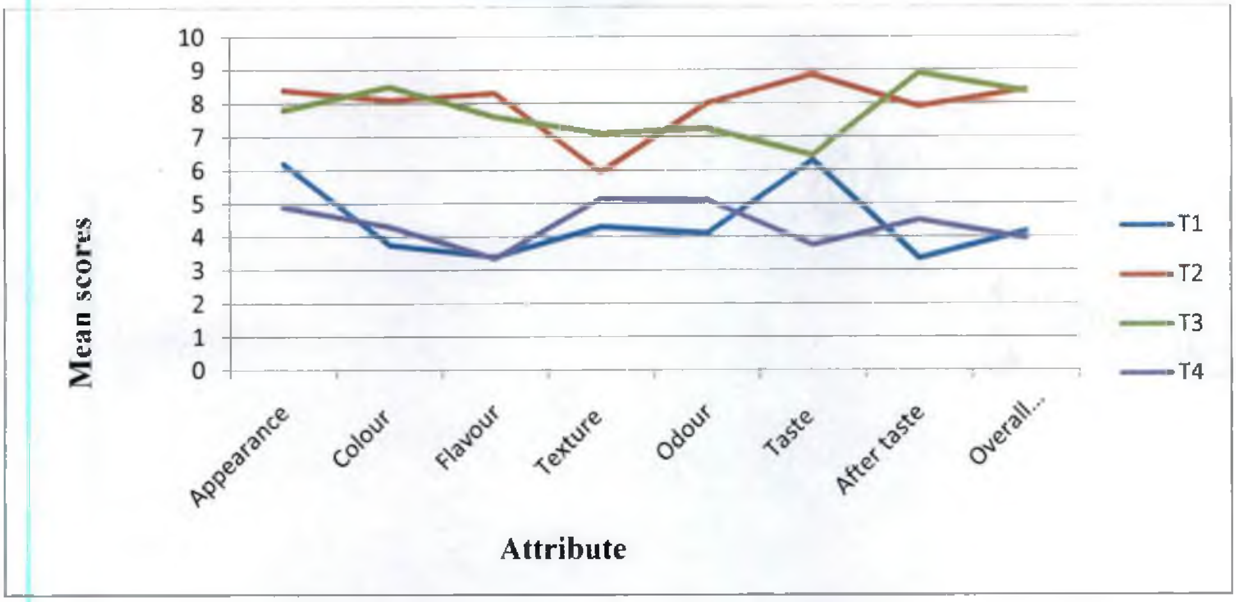


Fig. 15c Mean sensory scores for pure and enriched *aonla* fruit bars after 6 months of storage in LDPE bags

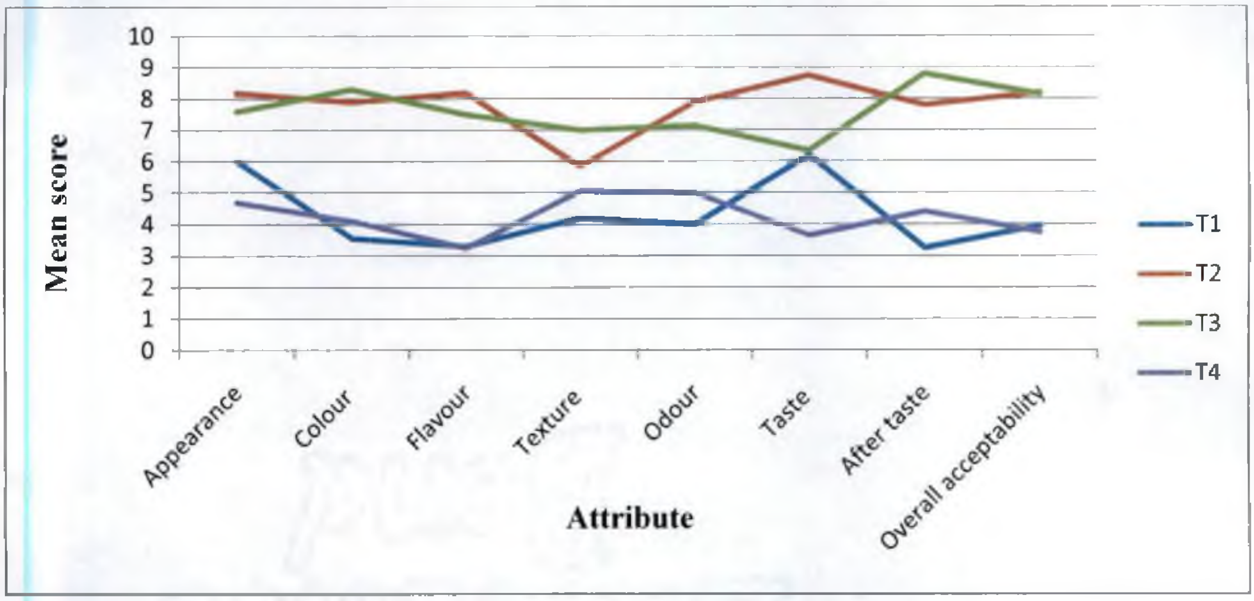


Fig. 15d Mean sensory scores for pure and enriched *aonla* fruit bars after 2 months of storage in APCF

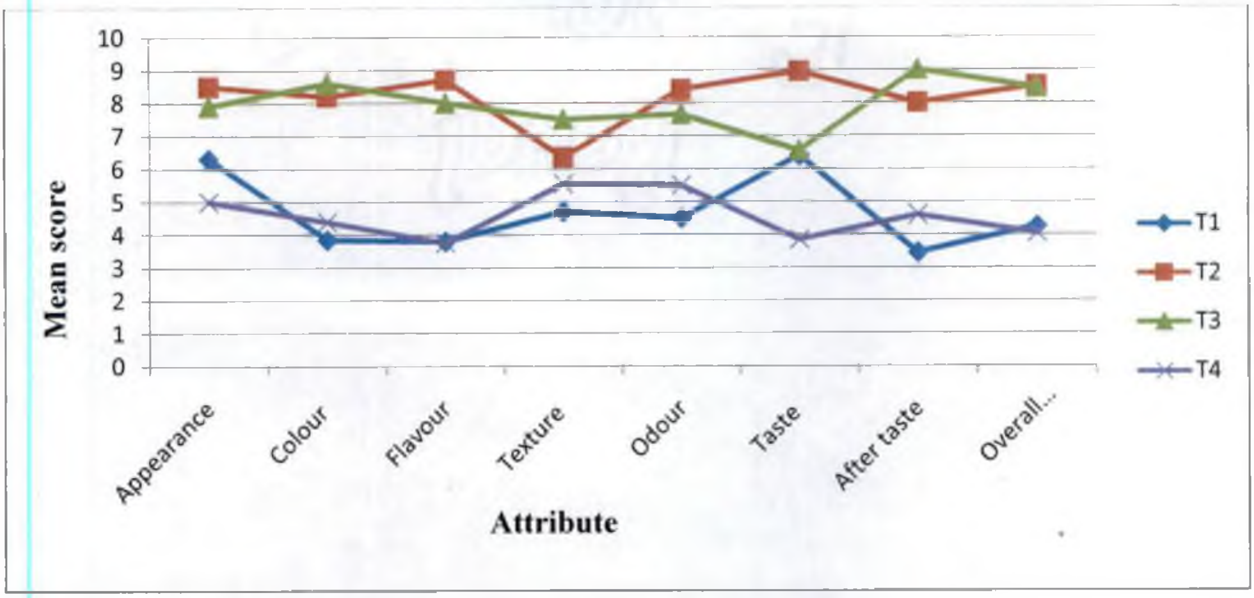


Fig. 15f Mean sensory scores for pure and enriched *aonla* fruit bars after 4 months of storage in APCF

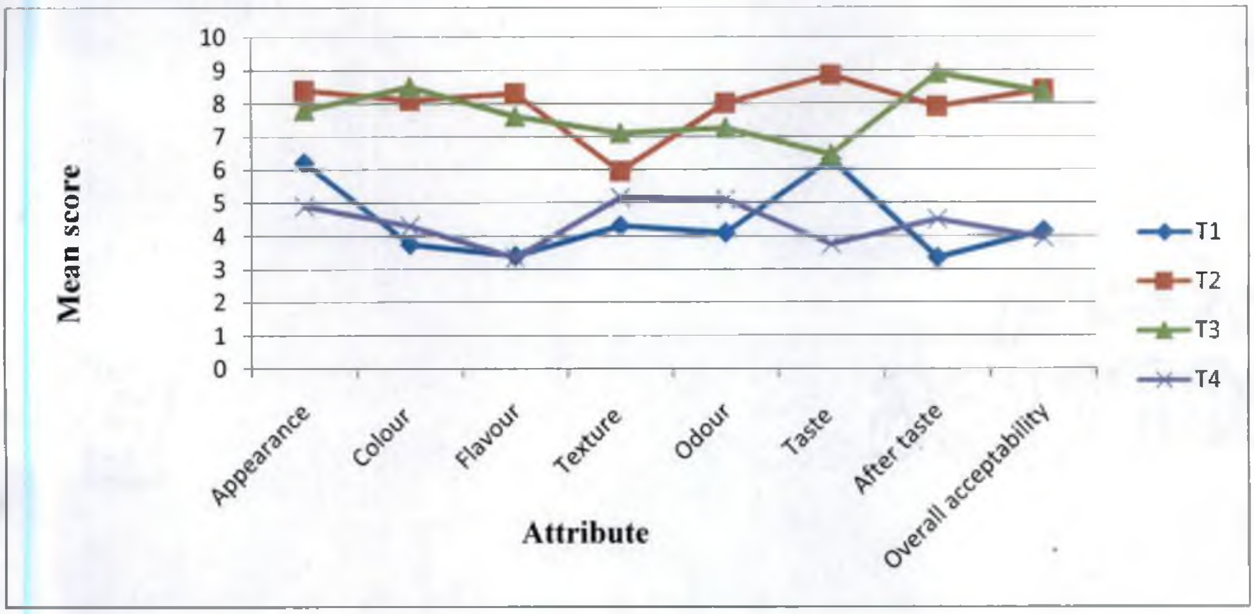


Fig. 15g Mean sensory scores for pure and enriched *aonla* fruit bars after 6 months of storage in APCF

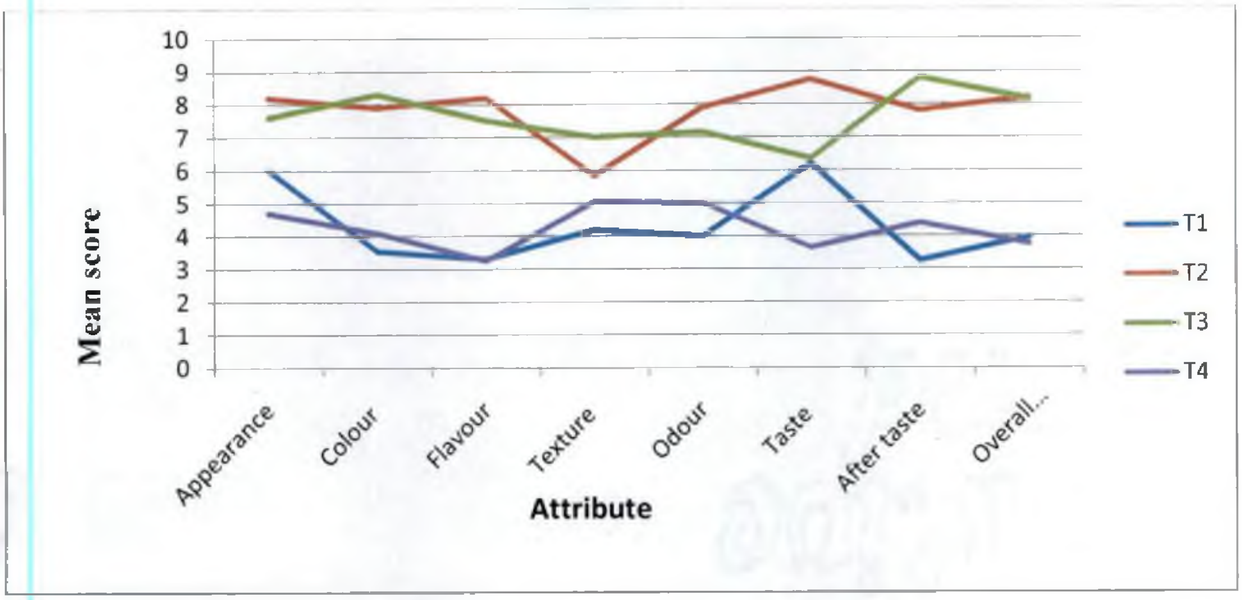


Fig. 15h Mean sensory scores for pure and enriched *aonla* fruit bars after 2 months of storage in HIPS boxes

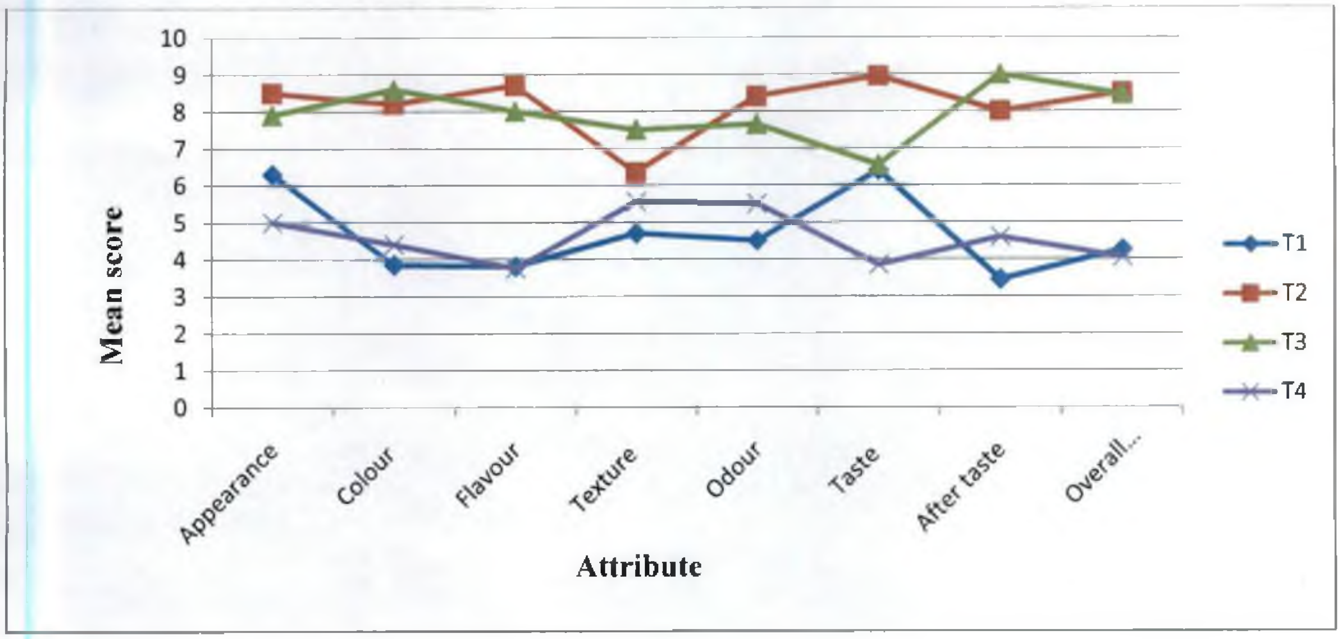


Fig. 15i Mean sensory scores for pure and enriched *aonla* fruit bars after 4 months of storage in HIPS boxes

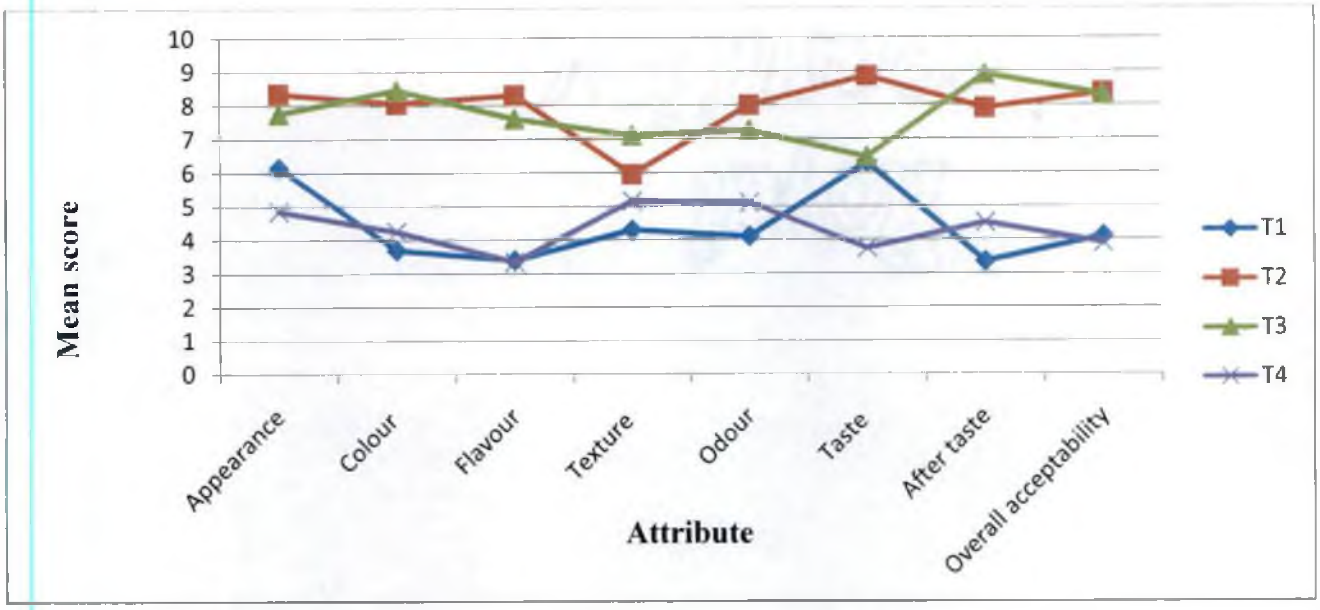
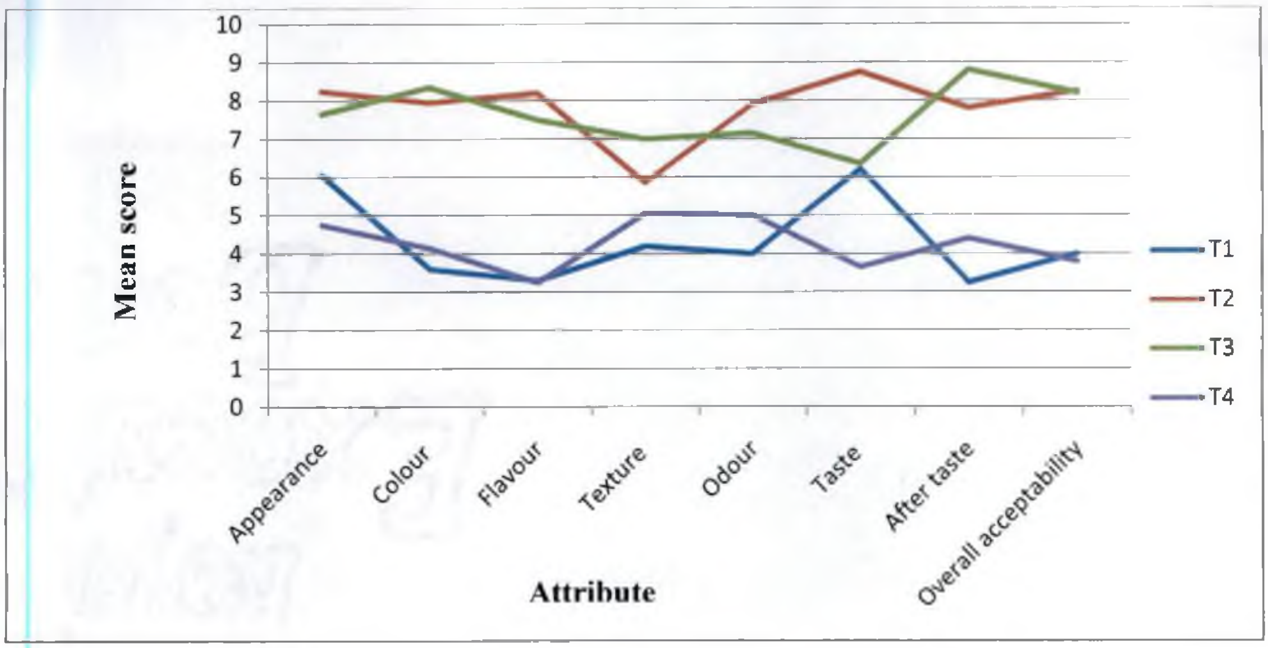


Fig. 15j Mean sensory scores for pure and enriched *aonla* fruit bars after 6 months of storage in HIPS boxes

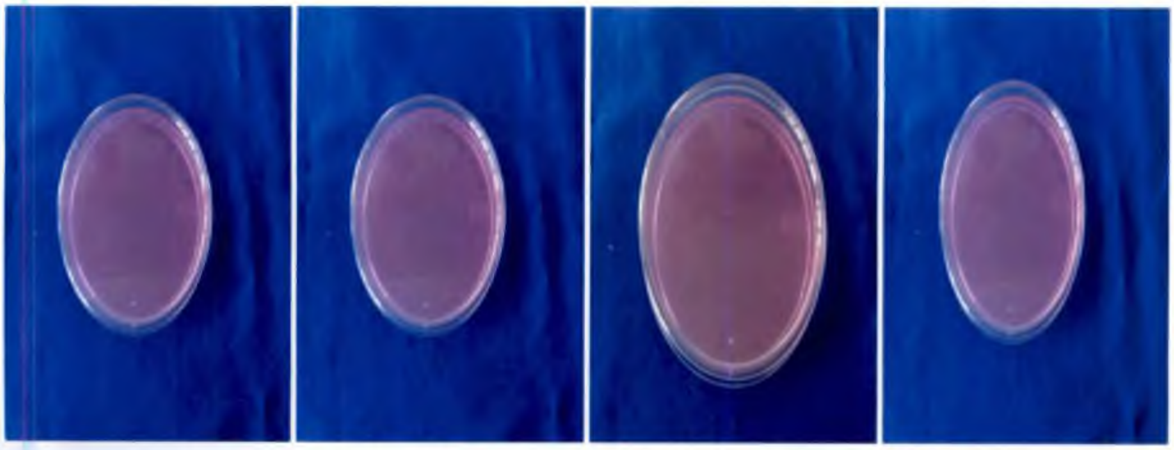


Pure *aonla* | Enriched fruit bars after 2 months of storage

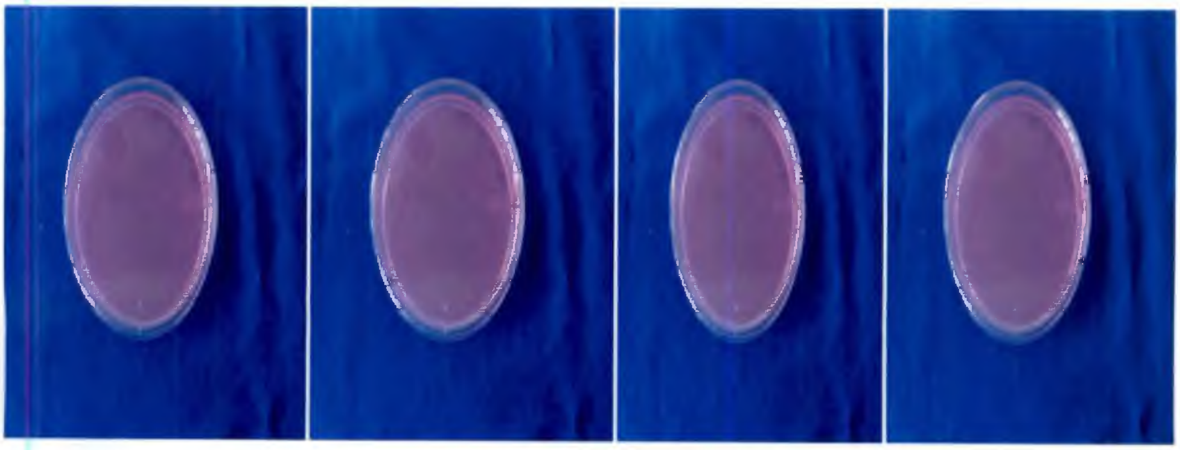
Pure *aonla* | Enriched fruit bars after 4 months of storage

Pure *aonla* | Enriched fruit bars after 6 months of storage

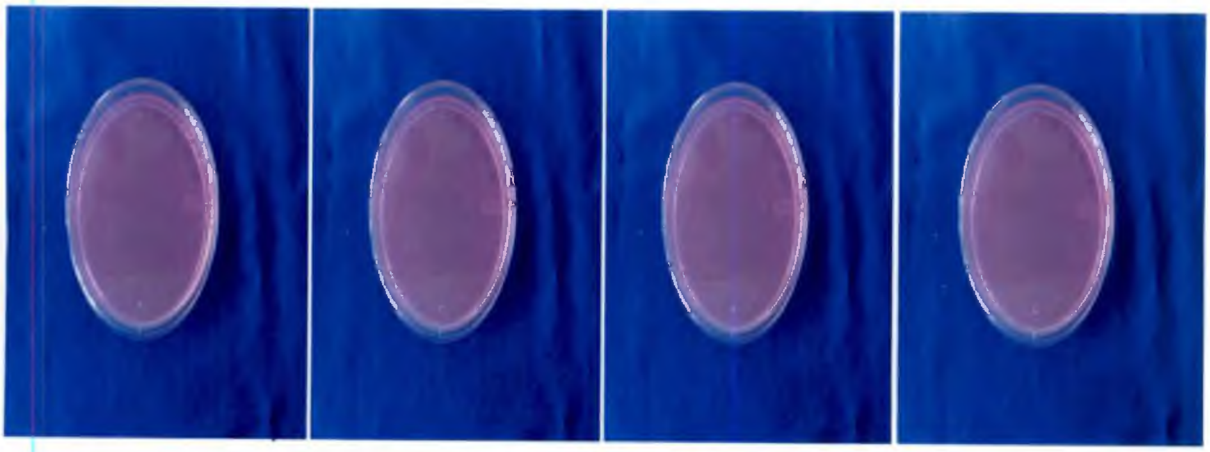
Plate 9. Growth of bacteria in pure and enriched *aonla* fruit bars after 2, 4 and 6 months of storage in different packaging materials



Pure *aonla* | Enriched fruit bars after 2 months of storage



Pure *aonla* | Enriched fruit bars after 4 months of storage



Pure *aonla* | Enriched fruit bars after 6 months of storage

Plate 10. Growth of fungi in pure and enriched *aonla* fruit bars after 2, 4 and 6 months of storage in different packaging materials

texture values of jackfruit leather was reported by Man and Taufik (1995), during storage for two months. Similar findings were also reported by Aruna *et al.* (1995) in papaya fruit bar. Shanthi (2000) reported that all the quality attributes of mango fruit bar were significantly high in metallized polyester polyethylene than in polypropylene. Jackfruit bar packed in metallized polyester polyethylene had better quality than the one in polypropylene (Manimegalai *et. al.*, 2001).

5.4 MICROBIAL LOAD (cfu/g)

Microbial load of all fruit bars was within acceptable limits. High impact polystyrene boxes were more effective in preventing microbial proliferation. Bacterial population was negligible initially and thereafter, there was slight increase in bacterial population after 6 months of storage. Fungal population was not detected even after 6 months of storage period in fruit bars packaged in areca plate overwrapped with cling film and High Impact Polystyrene. However, fruit bar packed in LDPE showed fungal growth after 6 months of storage. All the fruit bars could be safely stored at ambient temperature up to 6 months without deterioration in quality. Garg *et al.* (1993) reported a higher bacterial and fungal count of 8.0 x 10^{-1} and 6.6 x 10^{-1} cfu/g, respectively in a sample of mango leather obtained from market. Similar findings were reported by Sobana (1998), where the bacterial and fungal population increased in papaya fruit bar after 3 months of storage. Manimegalai *et. al.* (2001) reported that the minimum microbial population was recorded in jackfruit bar when it was packed in polypropylene bags.

Enrichment of *aonla* pulp with fruit pulp of mango and papaya resulted in enhanced nutrition, altered palatability and thereby, greater consumer acceptability of the fruit bar prepared through this technique. However, enrichment of *aonla* with jackfruit in the preparation of fruit bar did not go down well with the consumers.

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Fig. 16 Bacterial population (cfu/g) in the enriched fruit bars during storage

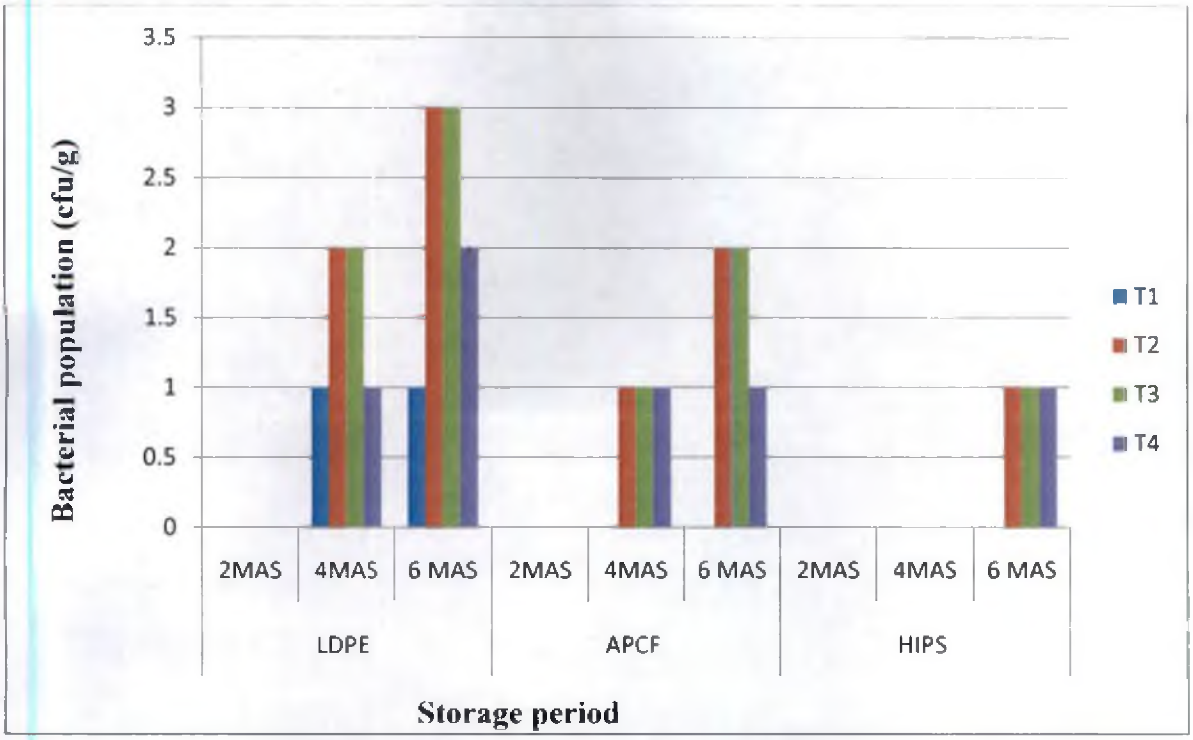
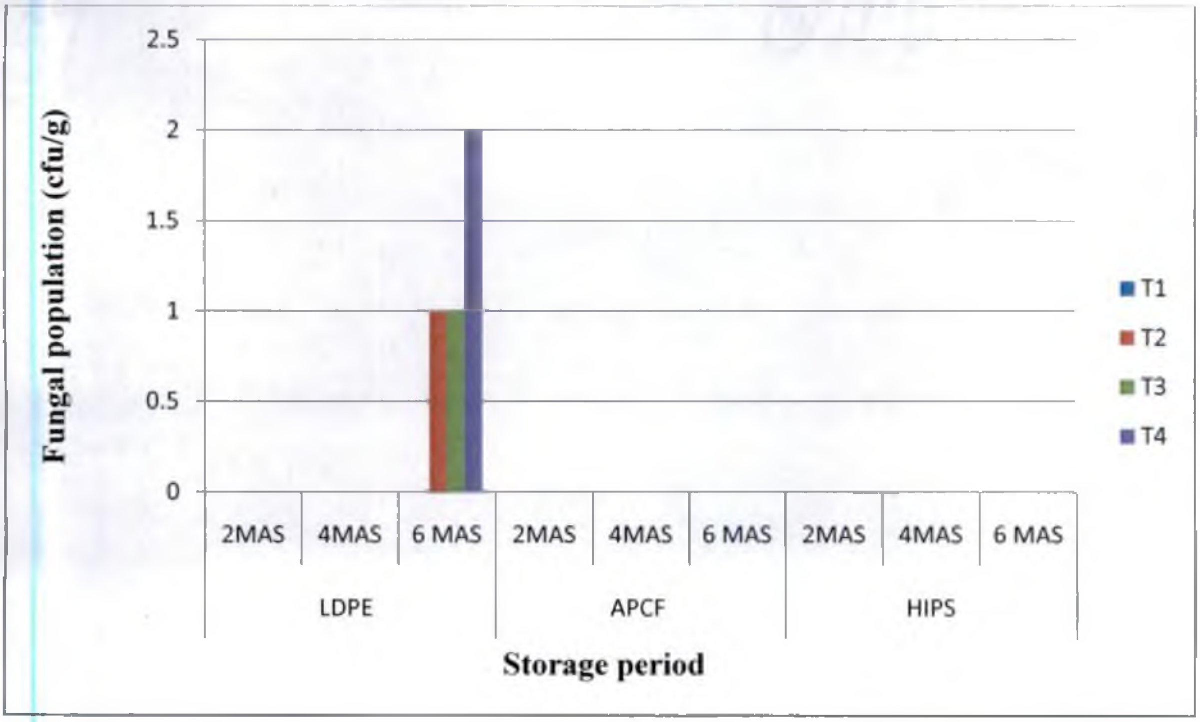


Fig. 17 Fungal population (cfu/g) in the enriched fruit bars during storage



Summary

SUMMARY

The main objectives of the study were standardization of enrichment of *aonla* pulp to develop fruit bars and evaluation of packaging materials to maintain quality during storage. The study was conducted to observe the changes in physico-chemical, biochemical and sensory attributes, due to enrichment, packaging and storage of fruit bars.

Blending of *aonla* pulp with pulp of provitamin A rich fruits viz. mango, papaya and jackfruit in different ratios was carried out and its effect on the quality of resultant fruit bars was evaluated. Moisture content was recorded immediately after preparation and also at bimonthly intervals. The initial moisture content was highest in *aonla* pulp enriched with mango pulp in 1:3 proportion while it was the lowest in fruit bar from pure *aonla* pulp. Moisture content decreased during storage. Changes in biochemical attributes like titratable acidity, Total Soluble Solids, reducing, non-reducing and total sugars, ascorbic acid, tannins and total carotenoids were also recorded initially and also at bimonthly intervals during storage for a period of 6 months.

Enrichment resulted in reduction of titratable acidity. Decline in titratable acidity was noticed in all fruit bars during storage. Fruit bar from *aonla* pulp enriched with mango pulp in 1:3 ratio had maximum TSS and an increase in TSS was observed during storage. Enrichment also resulted in an increase in reducing, non-reducing and total sugars of the resultant fruit bars. However, during storage, reducing and total sugars showed an increasing trend, whereas non-reducing sugars decreased. Packaging materials did not reveal any significant variation in sugar retention of fruit bars during storage.

Enrichment of *aonla* pulp with fruit pulp of mango, papaya and jackfruit reduced the ascorbic acid content of the resultant fruit bars compared to that from pure *aonla* pulp. Ascorbic acid content of all fruit bars decreased significantly during storage. Fall in ascorbic acid content was to the tune of about 50 %, after 6 months of storage.

Fruit bars prepared from *aonla* pulp enriched with pulp of fruits containing provitamin A, showed a rise in total carotenoids, the increase being higher with greater proportion of the pulp of these fruits. Fruit bar from *aonla* pulp enriched with papaya in 1:3 ratio had maximum total carotenoids. Total carotenoids also declined during storage. Variation in total carotenoids retention with respect to type of packaging material used was negligible.

Aonla pulp when blended with fruit pulp of mango, papaya and jackfruit reduced the tannin content of the resultant enriched fruit bars as compared to that from pure *aonla* pulp, which is an indication in the reduction of astringency. A rise in tannin content was observed in all fruit bars during storage. Retention of tannin with respect to packaging materials was insignificant.

Non-enzymatic browning showed an upward trend throughout storage, irrespective of the type of enrichment and the packaging material used. High Impact Polystyrene boxes were found to be more effective in reduction of non-enzymatic browning as compared to LDPE and areca plate overwrapped with cling film.

Enrichment of *aonla* pulp with fruit pulp of mango and papaya significantly improved acceptability with increasing proportion of these fruits. However, a reverse trend was observed when *aonla* was blended with jackfruit. *Aonla* and jackfruit blended in 3:1 had higher acceptability score, eventhough the score was insignificant when compared to the enrichment with mango and papaya. Organoleptic score showed a gradual decline throughout storage, irrespective of the type of packaging material.

Microbes did not proliferate upto two months of storage. A gradual, but slight increase in bacterial population was observed during storage. Fungi was detected only in fruit bars packaged in LDPE bags after two months of storage. However, microbial load in all fruit bars was within acceptable limits.

Enrichment of *aonla* pulp with mango and papaya resulted in enhanced acceptability of the fruit bar. However, fruit bar from enriched pulp of *aonla* and jackfruit was not acceptable. Quality of fruit bar was maintained through packaging, with little conspicuous variation in chemical constituents during storage.

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Appendices

APPENDIX - I

Score card for organoleptic evaluation of enriched *aonla* fruit bar

Name of the judge:

Date:

Characteristics	**Score**			
	T_1	**T_2**	**T_3**	**T_4**
Appearance				
Colour				
Flavour				
Texture				
Odour				
Taste				
After taste				
Overall acceptability				

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature:

APPENDIX II

NUTRIENT COMPOSITION OF MEDIA

1. STANDARD PLATE COUNT AGAR (FOR BACTERIA)

Peptone	: 5 g
Glucose	: 10g
Yeast extract	: 2.5g
Agar	: 18 g
Beef extract	: 2.0g
Distilled water	: 1 litre
p^H	: 7.0

2. MARTIN ROSE BENGAL AGAR (FOR FUNGUS)

Glucose	: 10 g
Peptone	: 5.0 g
KH_2PO_4	: 1.0g
$MgSO_4.7H_2O$	: 0.5g
Rose Bengal	: 0.035g
Agar	: 18 g
Distilled water	: 1 litre
p^H	: 6-6.5

APPENDIX - III

A. Mean rank scores for pure and enriched *aonla* fruit bars after 2 months of storage in LDPE bags

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.62	1.53	1.64	1.89	2.30	1.51	1.72	1.67
T_2	3.56	3.51	3.78	2.91	3.60	3.65	3.67	3.60
T_3	2.56	2.85	2.56	2.78	2.20	2.61	2.30	2.22
T_4	1.67	1.90	1.90	2.31	1.70	2.34	2.00	2.21
Kendall's cofficient	0.321	0.174	0.166	0.051.	0.324	0.110	0.516	0.884

B. Mean rank scores for pure and enriched *aonla* fruit bars after 4 months of storage in LDPE bags

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.45	1.45	1.35	1.10	2.21	1.42	1.64	1.56
T_2	3.42	3.25	3.30	2.72	3.40	3.25	3.22	3.27
T_3	2.20	2.71	2.10	2.52	2.00	2.56	2.28	2.17
T_4	1.28	1.51	1.40	2.27	1.67	2.16	2.04	2.16
Kendall's cofficient	0.082	0.593	0.342	0.347	0.641	0.684	0.794	0.827

C. Mean rank scores for pure and enriched *aonla* fruit bars after 6 months of storage in LDPE bags

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	1.89	1.40	1.20	1.00	2.09	1.40	1.64	1.45
T_2	3.40	3.10	3.00	2.75	3.30	3.30	3.21	3.10
T_3	2.60	2.25	2.00	2.30	2.00	2.50	2.25	2.15
T_4	1.20	1.50	1.20	2.15	1.65	2.00	2.00	2.00
Kendall's cofficient	0.072	0.582	0.304	0.354	0.601	0.634	0.794	0.820

APPENDIX - IV

A. Mean rank scores for pure and enriched *aonla* fruit bars after 2 months of storage in APCF

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.52	1.50	1.64	1.80	2.24	1.45	1.67	1.60
T_2	3.50	3.45	3.70	2.86	3.56	3.60	3.62	3.56
T_3	2.50	2.80	2.50	2.74	2.17	2.56	2.23	2.20
T_4	1.61	1.89	1.89	2.23	1.67	2.30	2.00	2.18
Kendall's cofficient	0.182	0.573	0.302	0.324	0.621	0.634	0.754	0.817

B. Mean rank scores for pure and enriched *aonla* fruit bars after 4 months of storage in APCF

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.40	1.40	1.30	1.02	2.12	1.37	1.60	1.55
T_2	3.34	3.20	3.21	2.62	3.30	3.20	3.20	3.22
T_3	2.20	2.61	2.10	2.45	2.00	2.40	2.21	2.12
T_4	1.26	1.50	1.40	2.22	1.60	2.10	2.00	2.16
Kendall's cofficient	0.162	0.543	0.332	0.327	0.621	0.664	0.734	0.807

C. Mean rank scores for pure and enriched *aonla* fruit bars after 6 months of storage in APCF

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	1.70	1.30	1.00	1.00	2.00	1.20	1.54	1.35
T_2	3.30	3.10	3.00	2.65	3.20	3.20	3.11	3.00
T_3	2.50	2.15	2.00	2.20	2.00	2.40	2.15	2.15
T_4	1.10	1.40	1.10	2.10	1.55	2.00	2.00	2.00
Kendall's cofficient	0.142	0.523	0.312	0.317	0.601	0.634	0.714	0.787

APPENDIX –V

A. Mean rank scores for pure and enriched *aonla* fruit bars after 2 months storage in HIPS boxes

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.65	1.55	1.65	1.90	2.35	1.55	1.80	1.70
T_2	3.60	3.55	3.80	2.95	3.65	3.70	3.75	3.70
T_3	2.60	2.95	2.60	2.80	2.25	2.65	2.40	2.30
T_4	1.70	1.95	1.95	2.35	1.75	2.40	2.15	2.30
Kendall's cofficient	0.321	0.174	0.166	0.051	0.324	0.110	0.716	0.884

B. Mean rank scores for pure and enriched *aonla* fruit bars after 4 months of storage in HIPS boxes

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.50	1.50	1.40	1.15	2.30	1.50	1.70	1.60
T_2	3.50	3.30	3.35	2.80	3.45	3.30	3.30	3.30
T_3	2.25	2.75	2.15	2.60	2.05	2.60	2.30	2.20
T_4	1.30	1.55	1.45	2.30	1.70	2.20	2.10	2.20
Kendall's cofficient	0.311	0.144	0.156	0.051	0.324	0.110	0.706	0.864

C. Mean rank scores for pure and enriched *aonla* fruit bars after 6 months of storage in HIPS boxes

Samples	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T_1	2.00	1.45	1.25	1.00	2.10	1.45	1.70	1.45
T_2	3.40	3.10	3.00	2.75	3.30	3.30	3.25	3.10
T_3	2.60	2.25	2.00	2.30	2.00	2.50	2.25	2.15
T_4	1.20	1.50	1.20	2.15	1.65	2.00	2.00	2.00
Kendall's cofficient	0.321	0.174	0.166	0.051	0.324	0.110	0.686	0.844

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ENRICHMENT, PACKAGING AND STORAGE OF FRUIT BARS FROM *AONLA* (*Emblica officinalis* G.)

By

DEEPIKA
(2012-12-113)

ABSTRACT

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2014

ABSTRACT

The study on "Enrichment, packaging and storage of fruit bars from *aonla* (*Emblica officinalis* G.)" was conducted during 2013-2014 in the Department of Processing Technology, College of Horticulture, Vellanikkara. The main objective of the study was to standardize enrichment of aonla pulp to develop fruit bars and to evaluate various packaging materials to maintain quality during storage. There were two experiments, viz. "Effect of enrichment on quality of *aonla* fruit bars" and "Effect of packaging on quality of enriched fruit bars during storage". The experiment on "Effect of enrichment on quality of *aonla* fruit bars" was laid out in CRD with 10 treatments viz. *Aonla* pulp (100%), *Aonla* (75%)+ Mango(25%), *Aonla* (50%)+ Mango(50%), *Aonla* (25%)+ Mango(75%), *Aonla* (75%)+ Papaya (25%), *Aonla* (50%)+ Papaya (50%), *Aonla* (25%)+ Papaya (75%), *Aonla* (75%)+ Jackfruit (25%), Aonla (50%)+ Jackfruit (50%), *Aonla* (25%)+ Jackfruit (75%). *Aonla* enriched with fruit pulp of mango and papaya in 1:3 proportion and with jackfruit in 3:1 proportion, was found superior in organoleptic evaluation. Enriched fruit bars from these three combinations along with fruit bar from pure *aonla* were selected for storage studies. These four types of fruit bars viz. *aonla* (100 %), *aonla* (25 %) + mango (75 %), *aonla* (25 %) + papaya (75 %) and *aonla* (75 %) + jackfruit (25 %) were subjected to pre-packaging in Vegetable Parchment Paper (VPP), followed by enclosing in different types of packaging materials like LDPE (Low Density Polyethylene), APCF (Areca Plate overwrapped with Cling Film) and HIPS (High Impact Polystyrene) boxes. Thus there were 12 treatments with 3 replications in the second experiment.

A declining trend in moisture, acidity, non reducing sugars, ascorbic acid and total carotenoids was observed whereas Total Soluble Solids, total sugars, reducing sugars and non-enzymatic browning showed an upward trend. Slight increase in microbial load was observed at the end of the storage period. Organoleptic scores showed a gradual decline during storage but the scores were within the range of acceptability throughout the storage period. Enrichment of *aonla* pulp with fruit pulp of provitamin A rich fruits like mango, papaya and jackfruit reduced astringency and acidity, thereby resulting in fruit bars with altered palatability and enhanced nutrition. Enriched fruit bars contained three vital antioxidants viz. Vitamin C, carotenoids and

polyphenols. Packaging of fruit bars and subsequent storage at ambient temperatu resulted in a shelf life of 6 months without deterioration in quality.