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Effect of packaging on quality of enriched fruit bars from aonla (*Emblica officinalis* G.) during storage

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Abstract

The main objective of the study was to evaluate the packaging materials to maintain quality of enriched fruit bars during storage. The experiment was laid out in CRD with 10 treatments. Blending of *aonla* pulp with pulp of provitaminA rich fruits viz. mango, papaya and jackfruit in different ratios was carried out and its effect on the quality of resultant fruit bars in different packaging materials was evaluated during storage for a period of 6 months. A declining trend in moisture, acidity, non-reducing sugars and ascorbic acid and total carotenoids was observed whereas Total Soluble Solids, total sugars, reducing sugars and non-enzymatic browning showed an upward trend. Enrichment of aonla pulp with fruit pulp of provitamin A rich fruits like mango, papaya and jackfruit showed a rise in total carotenoids and reduced astringency and acidity, thereby resulting in fruit bars with altered palatability and enhanced nutrition. Packaging materials did not reveal any significant variation in sugar retention of fruit bars during storage. 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. Enriched fruit bars contained three vital antioxidants viz. Vitamin C, carotenoids and polyphenols.

Highlights

- This paper covers an exhaustive research work on *aonla* pulp with pulp of different fruits and its effect on the quality in different packaging materials.

Keywords: Aonla, fruit bar, nutritional properties, storage, packaging materials

Aonla (*Emblica officinalis* G.) or Indian gooseberry is indigenous to India. It is well known for its nutritional qualities and pharmacological properties which belongs to the family Euphorbiaceae. It is a store house 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 medicines. Though valued for its therapeutic role, *aonla* is still regarded as a minor and under exploited fruit crop. It is the richest and cheapest source of ascorbic acid, next only to Barbados cherry. 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. *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).

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. 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). 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). 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* with suitable packaging materials. 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.

Materials and methods

Experimental site: The present investigation "Effect of packaging on quality of enriched fruit bars from *aonla* (*Emblica officinalis* G.) during storage" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara in the year 2013-14.

The experiment was carried out with *aonla* fruits of the local variety and fruits of papaya (Red Lady), jackfruit (Then Varikka) and mango (Bangalora) were procured from the fruit market, Thrissur.

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^{o} Brix and the acidity of the pulp was adjusted to 0.6 %. 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^{o}C. The pulp was dried to a thickness of 5 mm. After drying to optimum moisture content, the dried pulp was cut into bars.

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

T_1- *Aonla* pulp (100%)

T_2- *Aonla* (25%) + Mango (75%)

T_3- *Aonla* (25%) + Papaya (75%)

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

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.

LDPE: Low Density Polyethylene

APCF: Areca Plate over wrapped with Cling Film

HIPS: High Impact Polystyrene Box

Physico-chemical characteristics of fruit bar viz., Total soluble solids (TSS) were estimated by hand refractometer (0-32°B). The readings obtained were calibrated against a standard temperature at 20°C as per the International Temperature Correction Table and expressed as °Brix. The moisture content was determined by drying a known weight of the sample at 50-60^{o}C to a constant weight and expressed as % (Ranganna, 1997). Acidity and ascorbic acid were determined by standard method (AOAC, 1990) and results were expressed as percentage citric acid and mg/100ml of juice respectively. Total sugars, reducing and non-reducing sugars were estimated by the Lane and Eynon volumetric methods (AOAC, 1990). Tannin content was determined by colorimetric method (Ranganna 1997) using a standard curve of tannic acid. Total carotenoids were measured by spectrophotometer (Ranganna, 2000).

Non-enzymatic browning: To a known volume of sample, 30 ml of 60% 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 % alcohol as blank. The results were reported as absorbance (Optical density) value (Ranganna, 1997).

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.

Results and Discussion

Enriched fruit bars were evaluated at ambient temperature for changes in their quality during storage. 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.

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 1). 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. Reduction in moisture content of all fruit bars may be due to loss of moisture through evaporation. 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) and Manimegalai *et al*. (2001) reported in jackfruit bar packed in polypropylene bag.

Titratable acidity (%): All the fruit bars showed a significant decline in titratable acidity up to 2 months of storage, irrespective of packaging materials (Table 2). 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 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. 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) and Priya and Khatkar (2013). 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.

Total Soluble Solids (°Brix): TSS content of all types of fruit bars showed an upward trend. 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 (53.70 – 52.67 °B), than the one from *aonla* pulp alone (45.63 – 45.67 °B). TSS content of enriched fruit bar from *aonla* and papaya was on par (52.63 – 53.79 °B) with that of enriched fruit bar from *aonla* and mango. 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 trend was reported by Tripathi *et al*. (1988) in *aonla* candy and preserve. 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 °C and 60 % RH for a period of one month.

Reducing sugars (%): An upward trend was noticed in reducing sugar content of all the fruit bar during storage (Table 4). 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.

Table 1: Effect of packaging materials on moisture content (%) 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 2: Effect of packaging materials on titratable acidity (%) 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

Table 3: Effect of packaging materials on Total Soluble Solids (^{0}B) 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 4: Effect of packaging materials on reducing sugars (%) 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

Table 5: Effect of packaging materials on non reducing sugars (%) during storage

Treatments	Non-reducing 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

Table 6: Effect of packaging materials on total sugars (%) 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 7: Effect of packaging materials on ascorbic acid content (mg/100 g) during storage

Treatments	Ascorbic acid content (mg/100 g)									
			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

Table 8: Effect of packaging materials on tannins (%) 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

Table 9: Effect of packaging materials on total carotenoids (mg/100 g) during storage

Treatments	Total carotenoids (mg/100 g)									
			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 10: 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.

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, Manimeghalai *et al*. (2001) in jackfruit leather.

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 5). 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 %). 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 Manimeghalai *et al*. (2001) in jackfruit leather. In pure *aonla* bar, significant reduction in non-reducing sugar was observed during 6 months of storage.

Total sugars (%): An increase in total sugar content was observed in all the fruit bars during the entire storage period (Table 6). 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 – 5.54 %). 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.

Ascorbic acid (mg/100g): 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 7). Maximum ascorbic acid content was observed in fruit bar from pure *aonla* pulp (45.37 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. Decline in ascorbic acid content of fruit bars might be due to oxidation of ascorbic acid to dehydro ascorbic acid. Similar findings were reported by Shanthi, (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 and Aruna *et al*. (1999) found decrease in ascorbic acid content of papaya bar during storage over a period of 6 months.

Tannins (%): Tannin content increased 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 8). 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. Increase in tannin content during storage might be due to reduction in moisture content of fruit bar and reduced activity of polyphenol oxidase. 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.

Total carotenoids (mg/100g): 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 jackfruit (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. 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 Manimeghalai *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 Manimeghalai *et al*. (2001) in jackfruit bar, when packed in metallized polyester polyethylene (MPP) pouches after 3 months of storage.

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 10). 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). 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.

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.

Conclusion

The main objectives of the study wasto evaluate the packaging materials to maintain quality of enriched fruit bars during storage. 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 in different packaging materials was evaluated during storage. Moisture content was recorded immediately after preparation and also at bimonthly intervals. 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. Ascorbic acid, total carotenoids and titratable acidity content of all fruit bars decreased significantly during storage which is an indication in the reduction of astringency. Fruit bar from *aonla* pulp enriched with mango pulp had maximum TSS and an increase in TSS was observed during storage. 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. Fall in ascorbic acid content was to the tune of about 50 %, after 6 months of storage. Variation in total carotenoids retention with respect to type of packaging material used was negligible. 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.

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