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Effect of processing methods on keeping quality of aonla (*Emblica officinalis* Gaertn.) preserve

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Abstract

Effect of different treatments and storage (90 days) on various physicochemical, sensory and microbial properties of aonla preserve was investigated. TSS, pH, reducing sugars, total sugars and browning of the 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 in all the samples. The "no-cooking method" at sugar syrup of 70°B was found most effective in retention of ascorbic acid and tannins in the preserves and showed low microbial-load. Preserves with initial sugar concentration of above 60°B can be stored safely at room temperature for 90 days.

Introduction

Aonla (*Emblica officinalis* Gaertn.), is also known as Indian gooseberry. It belongs to the family Euphorbiaceae. It is reported to be the native of India, Ceylon, Malaysia and China. India ranks first in the World in area and production of aonla crop. Aonla is credited with medicinal value such as antisorbutic, divretic, laxative and antibiotic. The fruit also possesses pronounced expectorant, antiviral, cardiotonic and hypoglycaemic activity (Mehta and Tomar, 1979). Fresh aonla is so sour that most people find it intolerable, and hence is preferred in the form of preserves, dried aonla, trifala, jam, juice, pickle and chavyanprash, toffees and fruit bar (Singh and Kumar, 2000). An Aonla preserve, called aonla murabba is a processed product consumed in India, and is an important product in the indigenous system of medicine. Aonla murabba has beneficial effects in reducing the blood cholesterol and improving the eye sight. Pretreatment like soaking, blanching, brining of the fruit results in loss of tannin and vitamin-C contents in aonla preserves (Anand, 1970).Various methods are adopted for processing of aonla. It was, therefore felt logical to conduct a comparative study to investigate the effect of processing methods on keeping quality of aonla preserve.

Materials and Methods

Fully matured, large sized aonla fruits were procured from the local market, Hisar. Preserves were prepared by three methods i.e., "traditional method", "brine method" and "no-cooking method". All the chemicals used in the study were of A.R. (Analytical Reagent) grade obtained from Sigma Chemicals, U.K.

Traditional method

In this method aonlas (1 kg) were washed thoroughly. Pricking of the fruit was done with a fork at regular intervals and immersed in tap water for three days. Plenty of water was boiled in a pan; aonlas were added and boiled for ten minutes over a high flame. Aonlas were drained and kept aside. Sugar syrup was prepared by using 1 kg of sugar in water (1.5 liter) and syrup was brought to boil. Then the aonlas were added to the sugar syrup and were cooked over a slow flame for about 40 minutes or until the aonlas were soft. The mixture was allowed to cool completely, and kept covered in a cool dry place for three days. On the fourth day, the whole mixture was boiled again so that aonlas reduces their astringency. The mixture was again allowed to cool completely, bottled in sterilized glass jars and stored.

Brine method

In this method aonlas (1 kg) were washed

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thoroughly. Pricking of the fruit was done with a fork at regular intervals. The pricked fruits were kept in 2% common salt solution, strength of which was raised gradually to 8% in three days. The fruits were washed and again placed in a freshly prepared 8% salt solution for a week (Lal *et al*., 1998). The fruits were then blanched for 10 minutes in water to soften them and to lock the activity of enzyme. The care was taken that fruits should not get crack in blanching. 1 kg of sugar was boiled in 1.5 liters of water, on the weight of sugar and 2.5 g of citric acid was added to this sugar syrup. Citric acid prevents the crystallization of sugar during storage. The syrup was filtered and cooled. The soften fruits were added to the syrup and kept overnight. The next day the whole mass was cooked (40 minutes) till it became thickened. The mass was cooled and kept for 2 days. On third day the whole process for thickening the syrup was done again so that no more dilution of the syrup took place, due to fruits in syrup. After boiling the whole mass, it was cooled and transferred to clean, sterilized, and dry glass jars and stored. Preserves were prepared with two concentrations of sugar syrups i.e. 60°B and 70°B for making two different types of preserves.

No-cooking method

One kg aonla fruits were selected and immersed in tap water for a period of three days. Fruits were well washed, pricked and blanched in boiling water for 5 minutes in a stainless steel pan. Now fruits were placed in a container in layers over layer sandwiching dry sugar (1.5 kg). During this period the fruits would give off sufficient water in which the sugar would go into solution. Ordinarily, the resulting syrup will be of 36 to 38°B. Studies shows that equal parts of sugar and fruit used for making preserves found to be insufficient to provide the required amount of syrup to cover the preserves prepared. Hence, 1.5 kg sugar was used to overcome this difficulty (Jain *et al*., 1983). After two days the fruits were taken out and after adding 2.5 g of citric acid the remaining content was heated to raise the concentration of syrup to 50°B. Citric acid was added in order to prevent the crystallization of sugar occurring in concentrated sugar syrup during storage. The fruits were again transferred into the syrup. Later on the syrup was gradually concentrated at an interval on three days till the syrup concentration reached 60°B. The preserves prepared were kept in glass container and stored at room temperature. The preserves were prepared with two concentrations of sugar syrup i.e. 60°B and 70°B for making two different types of preserves.

Analysis

Preserves were analyzed at 15 days interval for chemical and sensory analysis and at 20 days interval for microbial analysis. Moisture content, pH, titratable acidity, sugars, ascorbic acid content, non-enzymatic browning was determined according to Ranganna (1997) method. Total soluble solids were determined by hand refractometer. The tannin content was determined using spectrophotometer. Microbial analysis of aonla preserves were examined for their bacterial count and yeast/mould counts. Potato dextrose agar and nutrient agar were used as media for growth of fungal and bacterial colonies, respectively. Consumer preference is strongly desired for successful promotion of any food product in market (Mudgil *et al*., 2011). Sensory evaluation of aonla preserves was carried out using 9 point hedonic scale. The data obtained in present investigation was subjected to statistical analysis of variance (ANOVA) techniques using two factorial completely randomized designs (CRD). All the tests were made in triplicate.

Results and Discussion

Chemical analysis of fresh aonla fruit

The average value of the moisture content of aonla fruit was 80.74%. The total soluble solids 10.93°B of fresh fruit was similar to the findings of Singh and Pathak (1987). The titratable acidity of the fruit was 2.82%. Similar results were also noticed by Ghorai and Sethi (1996). The pH of the fruit in the present study was 2.2. In the present study, reducing sugars of 0.39% and total sugars of 1.56% were noticed. The similar results were obtained by (Jain, 1983). The ascorbic acid content of the fruit was 300mg/100g. The tannin content was 46 mg/g. The results were similar to the findings of (Sethi, 1986). Browning of aonla was measured as optical density at 440nm and it was 0.072.

Chemical analysis of aonla preserves during storage

Moisture content (%)

A significant decrease in moisture content (Table 1) was observed during the storage period of 90 days. The minimum mean treatment values of 50.979% moisture content was noticed in the samples of preserves made by ‘no-cooking’ method at sugar syrup of 70°B. The preserves prepared using ‘brine method’ at sugar syrup of 60°B showed highest average moisture content of 65.036%. A decrease of moisture content was also reported in the aonla preserves (Daisy and Gehlot, 2006). The gradual decrease of moisture content can be contributed to the transfer of sugar from the syrup to the aonla

Table 1. Effects of different treatments and storage on moisture content (%) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	72.500	66.400	62.355	*	*	*	*	
Brine method								
Sugar syrup 60°B	75.250	69.300	68.500	65.800	61.750	58.250	56.400	**65.036^{a}**
Sugar syrup 70°B	72.450	64.400	61.500	59.700	57.300	54.500	52.500	**60.336^{b}**
No-cooking method								
Sugar syrup 60°B	65.300	63.600	58.350	53.650	51.650	48.600	47.650	**55.543^{c}**
Sugar syrup 70°B	61.250	57.400	52.350	49.300	47.100	46.100	43.350	**50.979^{d}**
Mean	**68.563^{a}**	**63.675^{b}**	**60.175^{c}**	**57.113^{d}**	**54.450^{e}**	**51.862^{f}**	**49.975^{g}**	

C.D. at 5% of Treatment was 0.1545, Storage was 0.2044 and Treatment × Storage was 0.4090. Means with the same superscripts are not significantly different. * Not recorded due to fermentation.

Table 2. Effects of different treatments and storage on titratable acidity (%) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	0.815	0.755	0.795	*	*	*	*	
Brine method								
Sugar syrup 60°B	0.850	0.695	0.675	0.610	0.570	0.530	0.505	**0.643^{c}**
Sugar syrup 70°B	0.815	0.685	0.635	0.575	0.500	0.485	0.440	**0.591^{d}**
No-cooking method								
Sugar syrup 60°B	0.875	0.715	0.695	0.685	0.670	0.635	0.630	**0.701^{a}**
Sugar syrup 70°B	0.825	0.700	0.685	0.630	0.605	0.570	0.515	**0.647^{b}**
Mean	**0.841^{a}**	**0.699^{b}**	**0.672^{c}**	**0.625^{d}**	**0.586^{e}**	**0.555^{f}**	**0.522^{g}**	

C.D. at 5% of Treatment was 0.0091, Storage was 0.012 and Treatment × Storage was 0.0240. Means with the same superscripts are not significantly different. * Not recorded due to fermentation.

Table 3. Effects of different treatments and storage on total soluble solids (°Brix) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	42.500	45.900	48.100	*	*	*	*	
Brine method								
Sugar syrup 60°B	55.200	56.350	58.700	62.700	68.300	71.300	71.550	**63.443^{d}**
Sugar syrup 70°B	65.450	68.150	70.900	72.350	73.500	75.300	77.300	**71.850^{b}**
No-cooking method								
Sugar syrup 60°B	55.200	58.450	60.450	72.600	72.850	73.300	74.300	**66.736^{c}**
Sugar syrup 70°B	67.550	69.300	71.300	73.500	74.620	76.650	78.850	**73.107^{a}**
Mean	**60.850^{g}**	**63.062^{f}**	**65.338^{e}**	**70.228^{d}**	**72.313^{c}**	**74.138^{b}**	**75.500^{a}**	

C.D. at 5% of Treatment was 0.3534, Storage was 0.4675 and Treatment × Storage was 0.9358. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

Table 4. Effects of different treatments and storage on pH of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	2.430	2.456	2.410	*	*	*	*	
Brine method								
Sugar syrup 60°B	2.385	2.470	2.530	2.555	2.885	3.240	3.260	**2.761^{b}**
Sugar syrup 70°B	2.465	2.810	2.650	2.655	3.130	3.405	3.500	**2.949^{a}**
No-cooking method								
Sugar syrup 60°B	2.315	2.405	2.485	2.525	2.775	2.925	3.105	**2.648^{d}**
Sugar syrup 70°B	2.410	2.705	2.595	2.635	2.865	3.230	3.310	**2.821^{c}**
Mean	**2.394^{f}**	**2.598^{d}**	**2.565^{e}**	**2.593^{d}**	**2.914^{c}**	**3.200^{b}**	**3.301^{a}**	

C.D. at 5% of Treatment was 0.0128, Storage was 0.0169 and Treatment × Storage was 0.0338. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

and migration of the moisture from the fruit into the syrup.

Titratable acidity (%)

The titratable acidity (Table 2) of aonla preserves decreased significantly during storage period of 90 days. The mean titratable acidity was 0.841% on first day of storage which decreased significantly to 0.522% during 90 days of storage. Minimum titratable acidity of 0.591% was observed in the preserve samples of "brine method" at sugar syrup of 70°B, probably due to more leaching losses of acid in sugar. However, maximum titratable acidity of 0.701% was recorded in the samples of "no-cooking method" at sugar syrup of 60°B. The observations were similar to the results reported earlier (Rani and Bhatia, 1985) in which a decrease in acidity with storage period of pear candy was noticed.

Total soluble solids (°Brix)

The soluble solids (Table 3) increased gradually during the storage period. The average total soluble solid content was increased from 60.850°B to 75.500°B during storage period of 90 days. The mean total soluble solid content was observed maximum 73.107°B in the samples of "no-cooking method" at sugar syrup of 70°B whereas, minimum soluble solids 63.443°B were recorded in the samples of "brine method" at sugar syrup of 60°B. The same findings were observed in aonla candy and karonda candy (Kumar and Singh, 2001; Manivasagan et al., 2006).

pH

The pH (Table 4) of preserves increased significantly during storage. The mean pH was increased from 2.394 to 3.301 during 90 days of storage. The minimum pH of 2.648 was recorded in samples of "no-cooking method" at sugar syrup of 60°B. Maximum pH of 2.949 was recorded in the samples of "brine method" at sugar syrup of 70°B. Similar findings for increase in pH during storage were also observed by (Daisy and Gehlot, 2006) in aonla preserves.

Reducing sugar (%)

The gradual increase in reducing sugar (Table 5) was noticed during storage period of 90 days. The mean reducing sugar values for treatments shows that maximum reducing sugar of 45.45% was noticed in the samples of "no-cooking method" at sugar syrup of 70°B and minimum 38.418% was observed in samples of "brine method" at sugar syrup of 60°B. The results were in conformity with the findings reported earlier in which they noticed a marked increase in reducing sugar content of aonla preserves (Damame *et al*., 2002; Sharma, 2000).

Table 5. Effects of different treatments and storage on reducing sugar (%) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	30.500	26.700	21.500	*	*	*	*	
Brine method								
Sugar syrup 60°B	29.650	33.500	34.550	35.975	41.050	46.000	48.200	**38.418^{d}**
Sugar syrup 70°B	35.150	36.000	39.020	40.415	46.200	48.050	53.800	**42.662^{b}**
No-cooking method								
Sugar syrup 60°B	28.200	30.250	38.000	41.650	45.850	50.850	53.200	**41.143^{c}**
Sugar syrup 70°B	33.300	35.750	39.400	45.000	51.350	54.300	59.050	**45.450^{a}**
Mean	**31.575^{g}**	**33.875^{f}**	**37.743^{e}**	**40.760^{d}**	**46.113^{c}**	**49.800^{b}**	**53.562^{a}**	

C.D. at 5% of Treatment was 0.7797, Storage was 1.0315 and Treatment × Storage was 2.0646. Means with the same superscripts are not significantly different. * Not recorded due to fermentation.

Table 6. Effects of different treatments and storage on total sugar (%) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	45.600	49.900	47.700	*	*	*	*	
Brine method								
Sugar syrup 60°B	52.150	52.650	53.850	55.475	56.200	60.350	60.800	**55.925^{c}**
Sugar syrup 70°B	64.850	64.600	67.800	68.365	70.500	70.800	71.100	**68.287^{b}**
No-cooking method								
Sugar syrup 60°B	50.150	51.100	52.400	56.950	59.150	60.500	60.950	**55.885^{c}**
Sugar syrup 70°B	63.650	63.950	67.550	71.450	71.800	72.500	72.800	**69.100^{a}**
Mean	**57.700^{g}**	**58.075^{f}**	**60.400^{e}**	**63.060^{d}**	**64.412^{c}**	**66.037^{b}**	**66.412^{a}**	

C.D. at 5% of Treatment was 0.7773, Storage was 1.1600 and Treatment × Storage was 2.0230. Means with the same superscripts are not significantly different. * Not recorded due to

Table 7. Effects of different treatments and storage on ascorbic acid content (mg/100g) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	99.000	40.500	32.450	*	*	*	*	
Brine method								
Sugar syrup 60°B	85.850	42.150	37.850	36.850	36.250	36.100	36.100	**44.450^{d}**
Sugar syrup 70°B	90.300	44.250	40.000	37.500	37.300	37.650	36.600	**46.229^{c}**
No-cooking method								
Sugar syrup 60°B	255.300	180.400	156.300	155.150	152.800	147.650	148.350	**170.807^{b}**
Sugar syrup 70°B	258.150	194.200	170.850	168.300	168.100	164.900	165.250	**184.250^{a}**
Mean	**172.400^{a}**	**115.175^{b}**	**101.250^{c}**	**99.450^{d}**	**98.612^{e}**	**96.575^{f}**	**96.575^{f}**	

C.D. at 5% of Treatment was 0.5002, Storage was 0.6616 and Treatment × Storage was 1.3242. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

Table 8. Effects of different treatments and storage on ascorbic acid content (mg/100ml) in sugar syrup of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	65.150	62.550	54.750	*	*	*	*	
Brine method								
Sugar syrup 60°B	52.250	48.650	47.500	44.300	41.300	40.850	39.400	**44.893^{a}**
Sugar syrup 70°B	46.500	42.600	39.450	35.400	34.600	32.600	32.400	**37.650^{b}**
No-cooking method								
Sugar syrup 60°B	38.300	37.400	34.500	31.300	29.350	28.620	27.450	**32.414^{c}**
Sugar syrup 70°B	30.150	28.850	27.700	25.450	21.450	24.650	18.750	**25.286^{d}**
Mean	**41.800^{a}**	**39.375^{b}**	**37.288^{c}**	**34.113^{d}**	**31.675^{e}**	**31.675^{e}**	**29.500^{f}**	

C.D. at 5% of Treatment was 0.1373, Storage was 0.1816 and Treatment × Storage was 0.3634. Means with the same superscripts are not significantly different. * Not recorded due to fermentation.

Total sugar (%)

A significant increase in the total sugars (Table 6) with increase in storage period was observed. The mean total sugar value shows that maximum total sugars of 69.100% were found in samples of preserves of "no-cooking method" at sugar syrup of 70°B. Same results were noticed by Daisy and Gehlot (2006) in aonla preserves.

Ascorbic acid content (mg/100g)

A decreasing trend of ascorbic acid (Table 7) content in all the treatments and storage period was observed during storage of 90 days. Similar findings were also made in aonla products (Kumar and Singh, 2001). The samples of "no-cooking method" retained maximum ascorbic acid content as compared to samples of "brine method" of preserves. The maximum retention of ascorbic acid 184.250mg/100g was noticed in samples of "no-cooking method" at sugar syrup of 70°B and minimum 44.450mg/100g was observed in "brine method" at sugar syrup of 60°B. The loss of ascorbic could be consequence of oxidation of ascorbic acid in the formation of dehydroascorbic acid in syrup.

Ascorbic acid content (mg/100ml) in sugar syrup

The ascorbic acid content in syrup (Table 8) was observed fairly high but a decreasing trend of ascorbic acid in syrup was also noticed. The mean vitamin-C content in syrup was decreased from 41.800mg/100ml to 29.500mg/100ml during storage of 90 days. The maximum 44.893mg/100ml content of vitamin-C in syrup was observed in the samples of "brine method" at sugar syrup of 60°B and minimum 25.286mg/100ml was observed in "no-cooking method" at sugar syrup of 70°B. The vitamin-C in the syrup might be due to the leach out of the vitamin-C from the fruit into the syrup.

Tannin content (mg/g)

A decreasing trend of tannin content (Table 9) in all the treatments and storage period was observed during storage period of 90 days. The same results were observed by Kumar and Singh (2001) in aonla products. The maximum retention of tannin content 28.493mg/g was noticed in samples of "no-cooking method" at sugar syrup of 70°B and minimum 17.086mg/g was observed in samples of "brine method" at sugar syrup of 60°B.

Tannin content (mg/ml) in sugar syrup

The gradual decrease of tannin content in the sugar syrup (Table 10) could be seen during 90 days of storage periods. The maximum mean tannin content of 7.857mg/ml in syrup was noticed in the samples of "brine method" at sugar syrup of 60°B and minimum of 5.271mg/ml was observed in the samples of "no-cooking method" at sugar syrup of 70°B. Similar results were reported by Sethi and

Table 9. Effects of different treatments and storage on tannin content (mg/g) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	26.000	23.150	20.500	*	*	*	*	
Brine method								
Sugar syrup 60°B	26.150	24.100	21.250	16.200	11.750	10.700	9.450	**17.086^{d}**
Sugar syrup 70°B	27.300	24.700	22.300	20.450	14.600	12.300	10.100	**18.821^{c}**
No-cooking method								
Sugar syrup 60°B	34.100	30.550	28.100	21.650	18.450	18.150	17.700	**24.095^{b}**
Sugar syrup 70°B	38.450	33.600	30.400	28.200	24.200	22.350	22.250	**28.493^{a}**
Mean	**31.500^{a}**	**28.237^{b}**	**25.512^{c}**	**21.625^{d}**	**17.252^{e}**	**15.875^{f}**	**14.875^{g}**	

C.D. at 5% of Treatment was 0.3283, Storage was 0.4343 and Treatment × Storage was 0.8693. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

Table 10. Effects of different treatments and storage on tannin content (mg/ml) in the sugar syrup of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	10.500	8.800	7.5000	*	*	*	*	
Brine m]ethod								
Sugar syrup 60°B	8.850	8.650	8.300	7.550	7.350	7.350	6.950	**7.857^{a}**
Sugar syrup 70°B	9.000	8.550	8.050	7.500	7.345	6.400	6.450	**7.613^{b}**
No-cooking method								
Sugar syrup 60°B	6.650	6.200	6.100	5.700	5.500	5.500	5.400	**5.864^{c}**
Sugar syrup 70°B	6.400	6.100	5.500	5.000	4.600	4.400	4.900	**5.271^{d}**
Mean	**7.725^{a}**	**7.375^{b}**	**6.987^{c}**	**6.363^{d}**	**6.437^{de}**	**5.912^{e}**	**5.925^{f}**	

C.D. at 5% of Treatment was 0.2377, Storage was 0.3145 and Treatment × Storage was 0.6294. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

Table 11. Effects of different treatments and storage on non-enzymatic browning (O.D.at 440nm) of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Traditional method								
(Sugar syrup 50°B)	0.097	0.120	0.150	*	*	*	*	
Brine method								
Sugar syrup 60°B	0.083	0.097	0.115	0.173	0.175	0.195	0.250	**0.155^{b}**
Sugar syrup 70°B	0.092	0.125	0.205	0.245	0.248	0.246	0.265	**0.203^{a}**
No-cooking method								
Sugar syrup 60°B	0.033	0.037	0.070	0.103	0.155	0.156	0.164	**0.102^{d}**
Sugar syrup 70°B	0.043	0.065	0.084	0.163	0.170	0.175	0.200	**0.129^{c}**
Mean	**0.063^{c}**	**0.081^{d}**	**0.094^{c}**	**0.172^{b}**	**0.186^{a}**	**0.193^{a}**	**0.195^{a}**	

C.D. at 5% of Treatment was 0.0077, Storage was 0.0102 and Treatment × Storage was 0.0205. Means with the same superscripts are not significantly different. * Not recorded due to fermentation

Table 12. Effects of different treatments and storage on overall acceptability of aonla preserves

Treatments	Storage period (Days) 0	15	30	45	60	75	90	Mean
Brine method								
Sugar syrup 60°B	8.550	8.200	7.950	7.850	7.500	7.150	6.950	**7.736^{b}**
Sugar syrup 70°B	8.350	8.000	7.850	7.510	7.200	6.900	6.510	**7.474^{c}**
No-cooking method								
Sugar syrup 60°B	7.100	7.250	7.600	7.800	8.100	8.200	8.250	**7.757^{b}**
Sugar syrup 70°B	7.350	7.450	7.850	8.050	8.300	8.300	8.650	**7.993^{a}**
Mean	**7.837^{a}**	**7.725^{b}**	**7.812^{a}**	**7.802^{a}**	**7.775^{b}**	**7.637^{c}**	**7.590^{c}**	

C.D. at 5% of Treatment was 0.0878, Storage was 0.1161 and Treatment × Storage was 0.2324. Means with the same superscripts are not significantly different

Anand (1983). They observed a considerable amount of tannin content in syrup of aonla preserves.

Table 13. Effects of different treatments and storage on bacterial count (cfu/g) and yeast /mold count (cfu/g) of aonla preserves

Treatments	Storage period (Days) 0	20	40	60	80	Mean
Bacterial count (cfu/g)						
Traditional method						
(Sugar syrup 50°B)	-	3.2×10^{4}	4.5×10^{5}	*	*	
Brine method						
Sugar syrup 60°B	-	-	2.1×10^{3}	2.7×10^{3}	3.3×10^{3}	**2.7×10^{3a}**
Sugar syrup 70°B	-	-	2.1×10^{3}	2.4×10^{3}	2.7×10^{3}	**2.4×10^{3b}**
No-cooking method						
Sugar syrup 60°B	-	-	1.4×10^{3}	1.4×10^{3}	2.2×10^{3}	**1.6×10^{3c}**
Sugar syrup 70°B	-	-	1.1×10^{3}	1.3×10^{3}	2.3×10^{3}	**1.5×10^{3d}**
Mean			**1.6×10^{3c}**	**1.9×10^{3b}**	**2.4×10^{3a}**	
Yeast/mold content						
Traditional method						
(Sugar syrup 50°B)	-	2.3×10^{2}	2.8×10^{2}	*	*	
Brine method						
Sugar syrup 60°B	-	-	2.3×10^{1}	2.8×10^{1}	2.9×10^{1}	**2.6×10^{1a}**
Sugar syrup 70°B	-	-	2.4×10^{1}	2.5×10^{1}	2.6×10^{1}	**2.5×10^{1a}**
No-cooking method						
Sugar syrup 60°B	-	-	1.1×10^{1}	1.5×10^{1}	1.8×10^{1}	**1.4×10^{1b}**
Sugar syrup 70°B	-	-	1.1×10^{1}	1.6×10^{1}	1.6×10^{1}	**1.4×10^{1b}**
Mean			**1.7×10^{1b}**	**2.1×10^{1a}**	**2.2×10^{1a}**	

C.D. at 5% of Treatment was 0.2117, Storage was 0.1834 and Treatment × Storage was 0.3669. Means with the same superscripts are not significantly different. * Not recorded due to fermentation. (-) Not found

Non-enzymatic browning (O.D. at 440nm)

The non-enzymatic browning (Table 11) increased with the increase in storage period. Maximum browning was found 0.203 in the samples of "brine method" at sugar syrup of 70°B and minimum browning 0.102 was examined in the samples of "no-cooking method" at sugar syrup of 60°B. Increase in browning with storage was also reported in aonla preserves (Sethi and Anand, 1982).

Overall acceptability

A decrease in the scores for the overall acceptability (Table 12) was observed during the storage period of 90 days. The maximum scores (7.993) for overall acceptability was noticed in the samples of "no-cooking method" at sugar syrup 70°B. The minimum scores (7.474) for overall acceptability was observed in the samples "brine method" at sugar syrup of 70°B.

Microbial analysis of aonla preserves during storage

Bacterial count

Increase in bacterial count (Table 13) was observed with increase in storage period. Maximum counts 2.7×10^{3} cfu/g was seen in the of samples "brine method" at sugar syrup of 60°B. In the samples of "traditional method" no growth was noticed on the day 1 of storage but after that a tremendous increase was noticed in the microbial growth that lead to fermentation of preserves. The results were in conformity with the earlier findings in which increased bacterial count in aonla preserves was noticed during storage (Sethi and Anand, 1982).

Yeast and mould count

An increase in fungal count (Table 13) was observed during storage of 80 days. The minimum fungal count of 1.4×10^1 cfu/g was noticed in the samples of "no-cooking method" at sugar syrup 60°B and 70°B. The maximum fungal count of 2.6×10^1 cfu/g was observed in the samples of "brine method" at sugar syrup of 60°B.

Conclusions

The present investigation suggests that preserves made using "traditional method" cannot be stored for more than a month at initial concentration of sugar syrup below 60°B. It can also be concluded that preserves prepared by "no-cooking method" at sugar syrup of 70°B were most effective in retaining the nutrients, and showed low bacterial and yeast/ mould count as compared to the other methods. It is recommended that preserves made by "no-cooking method" should be stored for at least 60 days before consumption for development of full flavor and taste of the preserves. The intake of sugar syrup along with preserves is also advocated as considerable amount of vitamin-C and tannins were found present in the sugar syrup of preserves.

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