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Effect of storage conditions and benzoic acid concentrations on chemical composition and shelf life of aonla juice Cv. NA-10

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Abstract
The present study entitled, "Effect of Storage Conditions and Benzoic Acid Concentrations on Chemical Composition and Shelf life of Aonla Juice Cv. NA-10" was undertaken with 4 concentrations of benzoic acid (0, 200, 400, 600 ppm) and 2 storage conditions (ambient and cold storage).
Among different benzoic acid concentration tried, treatment T_4 (600 ppm benzoic acid) recorded maximum T.S.S, reducing sugars, total sugars, pH, ascorbic acid and minimum acidity content at the end of storage (6 month). Hence, for storage of aonla juice treatment T_4 was found to be good.
In case of storage condition, cold storage (S_2) was found to be good as it recorded increase in T.S.S, reducing sugars, total sugars, pH and decrease in acidity up to 6 months, as compared to ambient temperature and minimum decrease in ascorbic acid throughout storage period as compared to ambient temperature.
In case of shelf life, among different benzoic acid concentrations tried, treatment T_4 (600 ppm) and in case of storage conditions, cold storage (S_2) was found to be good. Hence, for better storage of aonla juice upto 6 months, interaction T_4S_2 (600 ppm benzoic acid and cold storage) was found to be good.

Keywords: Aonla, benzoic acid, ambient storage, cold storage, hand refractometer, Ph meter, aonla juice, plastic cans

Introduction
India ranks first in the word in area and production of aonla crop (Priya and Khatkar, 2013) [8]. In India, it is grown in area of 50, 000 ha with a total annual production 2, 00, 000 metric tonnes (Goyal *et al*., 2009) [7]. Among the fruits, aonla commonly known as Indian Gooseberry (*Emblica officinalis* Gaertn.) finds a special place in India as it has got tremendous medicinal value. Aonla is one of the richest sources of vitamin-C, pectin and tannin which is being used for preparation of various ayurvedic, unani system of medicine, cosmetic, pharmaceuticals and processing industry (Singh and Gaur, 2002) [6]. Now a days, world opinion has changed towards nutritional as well as medicinal value rather than huge horticultural crops. Improvement in the existing method of storage has an urgent need of the day. The fresh form of aonla fruit is generally not consumed due to their high astringency and thus fruit during their peak harvesting season go as waste due to limited usage. But, it has great potential in processed form. The work on processed form of aonla in this konkan region is scanty. There is great demand for pure aonla juice as it has medicinal value. Hence, to study the preservation of aonla juice, experiment entitled "Storage studies of aonla (*Emblica officinalis* Gaertn.) juice Cv. NA-10 was undertaken.

Materials and methods
The present investigation was carried out in the Fruit and Vegetable Processing Unit Laboratory, at Department of Horticulture, College of Agriculture, Dapoli, Dist-Ratnagiri (M.S.) during 2013-2014. For this experimentation, fully ripe and uniform sized fruits of aonla were procured from the Regional Fruit Research Station, Vengurle, Taluka- Vengurle, Dist.-Sindhudurg. About 100 Kg of aonla fruits were brought to the laboratory. Unripe, diseased,

washed with clean tap water to remove dirt and dust particles adhered to the pericarp of the fruit and then washing was done with 30 ppm KMS solution (30 mg/lit water) for 5 minutes. Finally fruits are wiped dry and then used for juice extraction. The extracted juice was stored at two different storage conditions viz. ambient temperature (S_1) and cold storage (S_2) for 6 months after adding different concentrations of benzoic acid viz. T_1- 0 ppm (control), T_2- 200 ppm, T_3- 400 ppm and T_4-600 ppm. Thus eight treatment combinations replicated thrice in factorial completely randomized design.

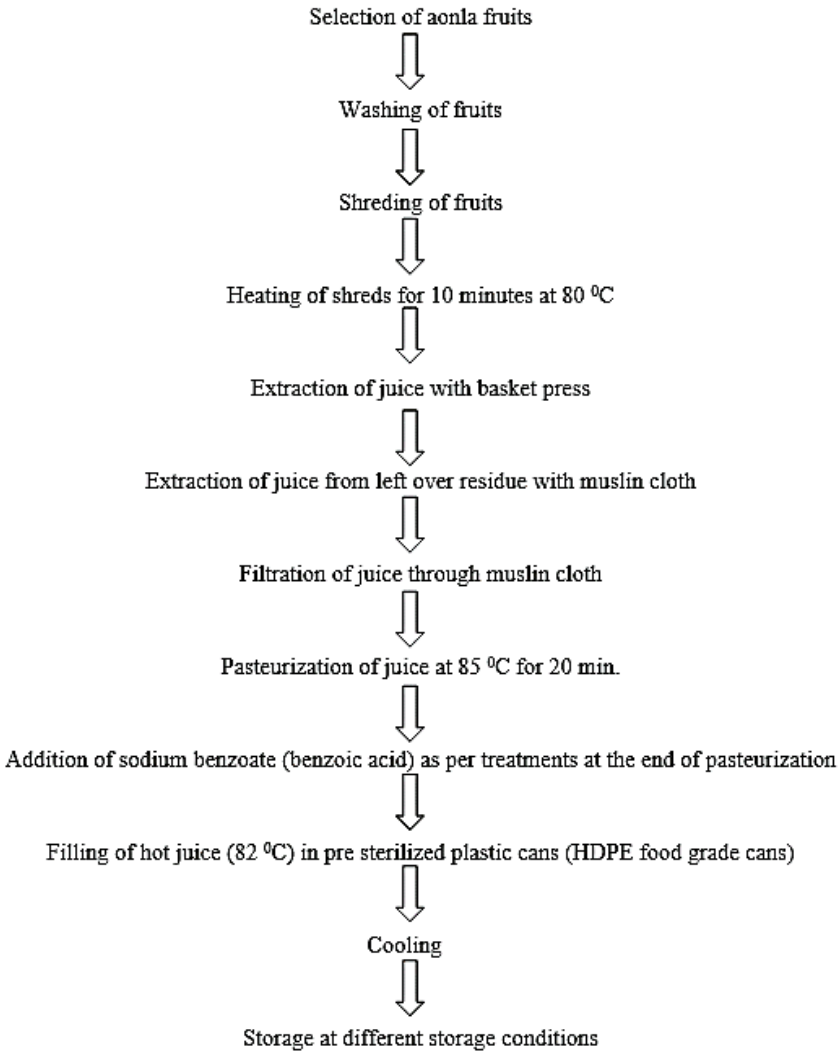

Fig 1: Flow chart for extraction of juice from aonla fruits

The T.S.S. content of aonla juice was determined by using Hand Refractometer and was recorded as °Brix (AOAC., 1975) [1]. The reducing sugar, total sugar and titratable acidity content of aonla juice were determined as per the procedures described by Ranganna (1979) [9]. The pH was determined with the help of pH meter (Model Systronics µ pH system 361). Ascorbic acid was determined by 2, 6, dichlorophenol indophenol dye method of Johnson as described by Ranganna (1986) [10]. Shelf life of stored aonla juice was decided on the basis of sensory evaluation score (average score) of the aonla juice. The aonla juice which recorded sensory score below 5.5 in 9-point Hedonic scale was rated as unacceptable and shelf life of this juice was considered to be over. However, the juice which recorded overall acceptability score (average score) above 5.5 were found to be good.

Results and discussion

Results of the chemical composition of aonla juice are presented in Table 1 to 7. The storage conditions, benzoic acid concentrations and their interactions showed significant results at 4 and 6 months storage with respect to all chemical parameters studied.

In case of different benzoic acid concentrations, the T.S.S, reducing sugar, total sugar and pH and ascorbic acid content of aonla juice was found to be increased and acidity was decreased with increase in benzoic acid concentrations, at the end of storage (6 months). This indicates that control and low concentrations (200 ppm) failed to stop fermentation of juice during storage. However, higher concentrations of benzoic acid (400 and 600 ppm) were effective still 6 months for controlling microbial fermentation. Similar findings have been reported by Ayub (2010) [2] in strawberry juice and Bagkar (2017) [3] in jamun juice.

Among different benzoic acid concentrations under study, treatment T_4 (600 ppm benzoic acid) recorded highest T.S.S, reducing sugar, total sugar pH and ascorbic acid and lowest titratable acidity content at the end of storage (6 months), which was at par with T_3 (400 ppm benzoic acid) in case of total sugars and titratable acidity at the end of storage. Hence, for storage of aonla juice treatment T_4 (600 ppm benzoic acid) was found to be good followed by T_3 (400 ppm benzoic acid).

In case of storage conditions it was noticed that, at ambient temperature (S_1) the T.S.S, reducing sugars, total sugars and pH content of aonla juice was increased up to 2 months

storage and then it was decreased at 4 and 6 months storage. However, acidity decreased up to 2 months storage and then it was increased at 4 and 6 months storage. The decrease in T.S.S, reducing sugars, total sugars and pH in ambient storage may be due to higher rate of microbial fermentation as high temperature favourable for microbial growth was available at ambient temperature. This might have converted sugar into alcohol. The ascorbic acid content of aonla juice decreased throughout the storage period in both the storage conditions. However, maximum decrease was observed at ambient temperature storage (S_1).

While at cold storage, the T.S.S, reducing sugar, total sugar and pH content of aonla juice was increased and acidity decreased up to 6 months storage. This may be due to hydrolysis of complex carbohydrates into simple sugars. Even low temperature (12±1 ^{0}C) available at cold storage might have restricted the growth and activity of microbes and hence no fermentation. Similar findings were also reported by Bhandari (2004) [5], Bagkar (2017) [3] in jamun juice at ambient storage and Bahadur *et al.* (2008) [4] in aonla juice at cold storage condition.

Among the two storage conditions, the cold storage (S_2) condition recorded highest T.S.S, reducing sugars, total sugars, pH and ascorbic acid and lowest acidity content during storage. Hence, the cold storage condition was found to be good for storage of aonla juice.

Among different interactions tried, the interaction T_4S_2 recorded highest T.S.S, reducing sugars, total sugars, pH, ascorbic acid and lowest acidity at the end of storage (6 months) and it was at par with T_3S_2 in case of T.S.S., total sugars and titratable acidity. Hence, interaction T_4S_2 was found to be good for storage of aonla juice. The aonla juice prepared with different benzoic acid concentrations and stored at cold storage (S2) recorded maximum (6 month) shelf life and juice stored at ambient temperature (S1) recorded minimum (2 months) shelf life.

Table 1: Effect of storage conditions and benzoic acid concentrations on shelf life of aonla juice

Interaction	Shelf life (months)
T_1S_1	2
T_1S_2	6
T_2S_1	2
T_2S_2	6
T_3S_1	2
T_3S_2	6
T_4S_1	2
T_4S_2	6

Table 2: Effect of benzoic acid concentrations and storage conditions on total soluble solids (°Brix) content of aonla juice

Benzoic acid concentrations (T)	Storage Period (Months)											
	Initial (0 months)			2 months			4 months			6 months		
	Storage conditions (S)			Storage conditions (S)			Storage conditions (S)			Storage conditions (S)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	10.40	10.40	10.40	10.60	10.80	10.70	8.50	9.80	9.15	7.80	9.50	8.65
T_2	10.40	10.40	10.40	10.70	10.80	10.75	8.90	10.90	9.90	8.30	11.00	9.65
T_3	10.40	10.40	10.40	10.60	10.50	10.55	10.50	11.00	10.75	10.70	11.20	10.95
T_4	10.40	10.40	10.40	10.70	10.50	10.60	10.70	11.30	11.00	10.90	11.70	11.30
Mean	10.40	10.40	10.40	10.65	10.65	10.65	9.65	10.75	10.20	9.43	10.85	10.14
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
Benzoic acid concentrations (T)	0.096		NS	0.015		0.062	0.087		0.364	0.087		0.367
Storage conditions (S)	0.204		NS	0.031		NS	0.184		0.773	0.185		0.779
Interactions (T×S)	0.136		NS	0.020		0.088	0.122		0.516	0.123		0.520

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 Ppm,
S_1- ambient temperature, S_2- cold storage

Table 3: Effect of benzoic acid concentrations and storage conditions on reducing sugar (%) content of aonla juice

Benzoic acid concentrations (T)	Storage Period (Months)											
	Initial (0 months)			2 months			4 months				6 months	
	Storage conditions (S)			Storage conditions (S)			Storage conditions (S)				Storage conditions (S)	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	1.62	1.62	1.62	1.86	1.80	1.83	1.24	1.57	1.41	0.43	1.20	0.82
T_2	1.62	1.66	1.62	1.70	1.68	1.69	1.68	1.75	1.72	1.11	1.90	1.51
T_3	1.62	1.62	1.62	1.68	1.65	1.67	1.77	1.82	1.80	1.91	2.21	2.06
T_4	1.62	1.62	1.62	1.65	1.64	1.65	1.67	1.70	1.69	1.95	2.37	2.16
Mean	1.62	1.62	1.62	1.72	1.69	1.71	1.59	1.71	1.66	1.35	1.92	1.64
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%		SEm±	CD at 1%
Benzoic acid concentrations (T)	0.018		NS	0.017		0.071	0.013		0.053		0.020	0.086
Storage conditions (S)	0.038		NS	0.036		NS	0.027		0.112		0.043	0.182
Interactions (T×S)	0.026		NS	0.024		NS	0.018		0.075		0.029	0.121

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 Ppm,
S_1- ambient temperature, S_2- cold storage

Table 4: Effect of benzoic acid concentrations and storage conditions on total sugar (%) content of aonla juice

Benzoic acid concentrations (T)	Storage Period (Months)											
	Initial (0 months)			2 months			4 months			6 months		
	Storage conditions (S)			Storage conditions (S)			Storage conditions (S)			Storage conditions (S)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	1.95	1.95	1.95	2.10	2.05	2.08	1.35	1.67	1.51	0.58	1.28	0.93
T_2	1.95	1.95	1.95	2.04	2.02	2.03	2.02	2.13	2.08	1.19	2.22	1.71

T_3	1.95	1.95	1.95	2.04	2.00	2.02	2.07	2.18	2.13	2.14	2.39	2.27
T_4	1.95	1.95	1.95	2.03	1.97	2.00	2.04	2.12	2.08	2.18	2.46	2.32
Mean	1.95	1.95	1.95	2.05	2.01	2.03	1.87	2.03	1.95	1.52	2.09	1.81
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
Benzoic acid concentrations (T)	0.049		NS	0.019		NS	0.019		0.081	0.015		0.063
Storage conditions (S)	0.104		NS	0.039		NS	0.041		0.171	0.031		0.134
Interactions (T×S)	0.070		NS	0.026		NS	0.027		0.144	0.021		0.089

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 Ppm,
S_1- ambient temperature, S_2- cold storage

Table 5: Effect of benzoic acid concentrations and storage conditions on titratable acidity (%) content of aonla juice

Benzoic acid concentrations (T)	**Storage Period (Months)**											
	Initial (0 months)			**2 months**			**4 months**			**6 months**		
	Storage conditions (S)			**Storage conditions (S)**			**Storage conditions (S)**			**Storage conditions (S)**		
	S_1	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**
T_1	2.35	2.35	2.35	2.32	2.30	2.31	2.64	2.42	2.53	3.28	2.53	2.91
T_2	2.35	2.35	2.35	2.29	2.26	2.28	2.61	2.18	2.40	2.86	2.16	2.51
T_3	2.35	2.35	2.35	2.28	2.22	2.25	2.22	2.15	2.19	2.20	2.08	2.14
T_4	2.35	2.35	2.35	2.26	2.18	2.22	2.18	2.14	2.16	2.15	2.00	2.08
Mean	2.35	2.35	2.35	2.29	2.24	2.27	2.41	2.22	2.32	2.62	2.19	2.41
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
Benzoic acid concentrations (T)	0.047		NS	0.013		0.053	0.013		0.054	0.013		0.056
Storage conditions (S)	0.100		NS	0.027		0.112	0.027		0.155	0.028		0.118
Interactions (T×S)	0.067		NS	0.018		NS	0.018		0.077	0.019		0.079

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 Ppm,
S_1- ambient temperature, S_2- cold storage

Table 6: Effect of benzoic acid concentrations and storage conditions on pH content of aonla juice

Benzoic acid concentrations (T)	**Storage Period (Months)**											
	Initial (0 months)			**2 months**			**4 months**			**6 months**		
	Storage conditions (S)			**Storage conditions (S)**			**Storage conditions (S)**			**Storage conditions (S)**		
	S_1	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**
T_1	2.73	2.73	2.73	2.79	2.85	2.82	2.59	2.83	2.71	2.32	2.65	2.49
T_2	2.70	2.70	2.70	2.82	2.88	2.85	2.66	2.91	2.79	2.41	2.93	2.67
T_3	2.72	2.72	2.72	2.84	2.88	2.86	2.88	2.94	2.91	2.93	3.05	2.99
T_4	2.74	2.74	2.74	2.87	2.93	2.90	2.90	2.97	2.94	2.94	3.25	3.10
Mean	2.72	2.72	2.72	2.83	2.89	2.86	2.76	2.91	2.84	2.65	2.97	2.81
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
Benzoic acid concentrations (T)	0.022		NS	0.019		NS	0.016		0.067	0.016		0.069
Storage conditions (S)	0.046		NS	0.400		NS	0.034		0.141	0.035		0.146
Interactions (T×S)	0.030		NS	0.027		NS	0.022		0.094	0.023		0.098

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 Ppm,
S_1-ambient temperature, S_2-cold storage

Table 7: Effect of benzoic acid concentrations and storage conditions on ascorbic acid (mg/100g) content of aonla juice under different storage conditions.

Benzoic acid concentrations (T)	**Storage Period (Months)**											
	Initial (0 months)			**2 months**			**4 months**			**6 months**		
	Storage conditions (S)			**Storage conditions (S)**			**Storage conditions (S)**			**Storage conditions (S)**		
	S_1	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**	**S_1**	**S_2**	**Mean**
T_1	465.00	465.00	465.00	217.00	268.60	242.80	99.80	165.20	132.50	53.60	97.40	75.50
T_2	465.00	465.00	465.00	217.00	273.80	245.40	123.20	194.60	158.90	55.40	138.80	97.10
T_3	465.00	465.00	465.00	232.60	279.00	255.80	145.40	213.20	179.30	81.00	148.20	114.60
T_4	465.00	465.00	465.00	237.80	289.20	263.50	147.20	226.20	186.70	88.20	155.40	121.80
Mean	465.00	465.00	465.00	226.10	277.65	251.88	128.90	199.80	164.35	69.55	134.95	102.25
	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
Benzoic acid concentrations (T)	2.656		NS	0.163		0.687	0.103		0.435	0.151		0.636
Storage conditions (S)	5.634		NS	0.346		1.458	0.219		0.923	0.321		1.350
Interactions (T×S)	3.756		NS	0.231		0.972	0.146		0.615	0.214		0.900

T_1- control, T_2- benzoic acid 200 ppm, T_3- benzoic acid 400 ppm, T_4- benzoic acid 600 ppm,
S_1-ambient temperature, S_2-cold storage

Conclusion

From the present findings it is concluded that, for storage of aonla juice, 600 ppm benzoic acid and cold storage condition was found good followed by 400 ppm benzoic acid and cold storage condition.

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