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Prolonging storability of Indian gooseberry (*Emblica officinalis*) under semi-arid ecosystem of Gujarat

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ABSTRACT

An experiment was conducted during 2001–2002 to see the effect of different post-harvest treatments on storability of Indian gooseberry (*Emblica officinallis* Gaertn) during storage at ambient temperature. Increase in physiological loss in weight, spoilage percentage, total soluble solids, total sugar and reducing sugar and decrease in acidity, ascorbic acid with advancement of storage period were general phenomena in all the treatments. Fruits treated with calcium nitrate 1.5 % + perforated polyethylene bag and GA_3 100 ppm + perforated polyethylene bag recorded the least physiological loss in weight (2.12–16.00 and 2.15–16.34%) and spoilage loss (2.40–15.00% and 2.50-15.60 %) and exhibited 11 days of storage life. The same treatments also showed lowest respiratory activity (72.10–82.00 mg CO_2/kg/hr and 72.00–82.10 mg CO_2/kg/hr), on the last day of storage (day 13).

Key words: Indian gooseberry, *Emblica officinallis*, Ambient temperature, Calcium nitrate, GA_3, Physiological loss, Spoilage loss, Respiration rate

The Indian gooseberry or *aonla* (*Emblica officinalis* Gaertn) is highly nutritive and its cultivation has recently gained great significance in Gujarat owing to its adaptability to varied agroclimatic conditions, better comparative tolerance to various pests and diseases and high remunerative returns. Due to prevalence of high temperature (21–34° C) during the time of harvesting, *aonla* fruits start spoilage rapidly. Calcium is known to be an essential plant nutrient involved in number of physiological processes concerning membrane structure and enzyme activity and it has shown quality retention of fruits through maintaining firmness, reducing respiratory rate and ethylene evolution (Ramakrishna *et al.* 2001).

GA_3 restricts the ethylene accumulation in the fruit tissue and has been known to delay the ripening process and to regulate the nucleic acid and protein synthesis (Ahmed and Singh 2000). Fruits if stored in perforated polyethylene bags, enhanced their shelf life by restricting the transpiration and respiration (Damodaran *et al.* 2001 and Kumar *et al.* 2003). Since storage studies under ambient condition for 'NA 7' aonla are lacking, particularly under harsh semi-arid ecosystem of Gujarat, an experiment was conducted to evaluate the efficacy of different post-harvest treatments on storability and fruit quality attributes during storage at room temperature.

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MATERIALS AND METHODS

The hand picked mature and healthy fruits of uniform size, free from pest and diseases, injuries, bruises and blemishes were selected from the experimental orchard of Central Horticultural Experiment Station, Vejalpur (Godhra) during 2001 and 2002 and subjected to various post harvest treatments. The treatments were: T_1, GA_3 50 ppm; T_2, GA_3 100 ppm; T_3, calcium nitrate 1%; T_4, calcium nitrate 1.5%; T_5, perforated polyethylene bag; T_6, GA_3 50 ppm + perforated polyethylene bag; T_7, GA_3 100 ppm + perforated polyethylene bag; T_8, calcium nitrate 1% + perforated polyethylene bag; T_9, calcium nitrate 1.5% + perforated polyethylene bag; and T_{10}, control. The experiment was laid out in factorial completely randomized design with 4 replications. The fruits were separated into lots of 2.5 kg each treatment and were treated by dipping in different solutions for 5 minutes. Perforated polyethylene bag (200 gauge) having 1% vent was used. The fruits were stored at ambient temperature ranging between 21±2°C (minimum) and 33±2°C (maximum) with a relative humidity 65±3% at 8 AM. The physiological loss in weight, spoilage loss, total soluble solids and acidity were determined by standard methods. Economic life (in days) of fruits was determined by counting the number of days, on the date after which cumulative spoilage percentage of fruits in particular treatment exceeded 12%, from the date of harvest of the fruits (Hoda *et al.* 2000). Ascorbic acid and total sugar content were determined by the methods advocated by AOAC, Washington DC (1980). The respiration

Table 1 Physiological loss in weight, spoilage loss and economic life of aonla fruits during storage

Treatment	Physiological loss in weight (%) Days after harvest						Spoilage loss (%) Days after harvest					Economic life of fruits (days)
	3	5	7	9	11	13	5	7	9	11	13	
GA_3 50 ppm	3.11	6.49	8.42	11.89	14.84	17.19	2.00	6.63	9.90	14.90	22.00	9 days
GA_3 100 ppm	3.14	6.45	8.30	11.73	14.67	17.10	2.00	6.50	9.50	14.70	21.50	9 days
Calcium nitrate 1.0%	3.16	6.43	8.80	11.90	14.79	17.40	2.00	6.60	9.60	14.94	21.50	9 days
Calcium nitrate 1.5%	3.20	6.40	8.40	11.34	14.71	17.30	2.30	6.40	9.30	14.40	20.50	9 days
Perforated polyethylene bag	3.10	6.31	9.40	12.34	15.00	18.00	2.30	6.40	9.40	14.80	22.50	9 days
GA_3 50 ppm + perforated polyethylene bag	2.81	5.84	8.25	10.50	13.73	16.73	2.00	6.40	8.00	13.00	18.00	9 days
GA_3 100 ppm + perforated polyethylene bag	2.15	5.70	8.14	10.23	13.61	16.34	0.00	2.50	6.50	11.00	15.60	11 days
Calcium nitrate 1.0% + perforated polyethylene bag	2.80	5.90	8.23	10.40	13.71	16.51	2.00	4.13	7.80	13.50	16.60	9 days
Calcium Nitrate 1.5 %+ perforated polyethylene bag	2.12	5.67	8.13	10.14	13.50	16.00	0.00	2.40	6.00	11.50	15.00	11 days
Control	4.21	7.41	11.20	15.10	18.30	23.45	6.20	9.50	13.50	18.00	26.00	7 days
C D (P = 0.05)	Treatments (T) = 0.15, Days (D) = 0.18, D × T = 0.24,						Treatments (T) = 0.08, Days (D) = 0.13, D × T = 0.23					

Table 2 Changes in total soluble solids (TSS) and titratable acidity during storage of aonla fruits

Treatment	TSS (%) Days after harvest							Titratable acidity (%) Days after harvest							
	1	3	5	7	9	11	13	1	3	5	7	9	11	13
GA_3 50 ppm	11.32	11.75	12.35	12.63	13.25	13.60	14.15	1.90	1.85	1.76	1.69	1.66	1.58	1.52
GA_3 100 ppm	11.31	11.75	12.30	12.60	13.20	13.60	14.10	1.90	1.86	1.76	1.69	1.65	1.59	1.50
Calcium nitrate 1.0%	11.38	11.71	12.20	12.68	13.20	13.63	14.20	1.92	1.89	1.74	1.67	1.65	1.57	1.52
Calcium nitrate 1.5%	11.31	11.65	12.15	12.65	13.15	13.61	14.11	1.90	1.89	1.75	1.68	1.67	1.59	1.50
Perforated polyethylene bag	11.30	11.65	12.10	12.60	13.13	13.60	14.10	1.92	1.88	1.75	1.69	1.63	1.58	1.52
GA_3 50 ppm + perforated polyethylene bag	11.30	11.63	11.92	12.40	12.79	13.50	13.81	1.90	1.86	1.78	1.70	1.65	1.60	1.59
GA_3 100 ppm + perforated polyethylene bag	11.35	11.51	11.91	12.10	12.71	13.11	13.39	1.96	1.90	1.81	1.76	1.71	1.64	1.61
Calcium nitrate 1.0% + perforated polyethylene bag	11.31	11.60	12.00	12.34	12.91	13.40	13.50	1.91	1.85	1.79	1.72	1.65	1.60	1.58
Calcium nitrate 1.5% + perforated polyethylene bag	11.34	11.50	11.90	12.10	12.60	13.10	13.36	1.93	1.90	1.80	1.75	1.70	1.65	1.60
Control	11.31	11.90	12.50	12.90	13.60	13.90	14.90	1.90	1.80	1.72	1.64	1.60	1.52	1.44
C D (P = 0.05)	Treatments (T) = 0.08, Days (D) = 0.13, D × T = 0.22							Treatments (T) = 0.01, Days (D) = 0.02, D × T = 0.03							

rate was measured as suggested by Loomis and Shull (1973).

RESULTS AND DISCUSSION

The physiological loss in weight gradually increased in all the treatments with the advancement of storage period (Table 1). Calcium nitrate 1.5% + perforated polyethylene bag was the most effective treatment in retaining the physiological loss in weight in all the days of observations and showed only 16% physiological loss in weight on day 13 of storage followed by GA_3 100 ppm + perforated polyethylene bag. The highest physiological loss in weight was recorded in the control. The increased weight loss in untreated fruits might be due to increased storage break down associated with higher transpiration and respiration rate compared to calcium and GA_3 treated fruits. The polyethylene bag acts as barrier for smooth passage or diffusion of moisture to the atmosphere (Ahmed and Singh 2000). Ramkrishna *et al.* (2001), Yadav *et al.* (2003) and Singh *et al.* (2004) also recorded similar trends during storage of fruits. The minimum spoilage loss was recorded in calcium nitrate 1.5% + perforated polyethylene bag (15%) which was closely followed by GA_3 100 ppm + perforated polyethylene bag while the maximum was in the control on day 13 of storage. Pathogens of 3 genera, viz *Aspergillus niger* v Tieghem, *Rhizopus* sp and *Penicillium oxalicum* Currie & Thom were detected from the rotted fruits. Minimum infection caused by fungal pathogens was observed in calcium nitrate 1.5% or GA_3 100ppm treated fruits and kept in perforated polyethylene bag, while the maximum was in

Table 3 Changes in ascorbic acid and respiration rate during storage of aonla fruits

Treatment	Ascorbic acid (mg/ 100g) Days after harvest							Respiration rate (mg CO_2/kg/h) Days after harvest						
	1	3	5	7	9	11	13	1	3	5	7	9	11	13
GA_3 50 ppm	636	575	525	461	416	385	355	72.30	73.50	74.20	75.20	80.20	83.26	85.60
GA_3 100 ppm	635	581.50	532	470	425	390	360	72	73.40	74.13	75.10	80	83	85.10
Calcium nitrate 1.0%	635	580.10	530	465	415	396	372	72	73.20	74	75.12	80.20	83.20	85.30
Calcium nitrate 1.5%	630	585	535	470	421	395	375	72	73.20	74	75.10	80.10	83.10	85
Perforated polyethylene bag	630	570	530	460	410	390	370	72.50	73.10	74.10	75.30	80.13	83.20	85.60
GA_3 50 ppm + perforated polyethylene bag	635	595	542	480	445	412	392	72.50	73.20	73.21	75.10	79.10	81.10	83.50
GA_3 100 ppm + perforated polyethylene bag	635	605	555	512	486	425	409	72	72.10	73.20	74.60	78.10	80.01	82.10
Calcium nitrate 1% + perforated polyethylene bag	630	590	540	485	440	410	400	72	73	73.80	75	79	81	83
Calcium nitrate 1.5% + perforated polyethylene bag	632	610	550	510	480	422	405	72.10	72.50	73.10	74.50	78.10	80	82
Control	630	540	475	425	395	382	350	72.00	74.00	76	80.50	78.00	86.50	89.10
C D *(P = 0.05)*	Treatments (T) = 8.30, Days (D) = 9.13, D × T = 15.10							Treatments (T) = 1.70, Days (D) = 2.30, D × T = 0.73						

Table 4 Changes in total sugar and reducing sugar during storage of aonla fruits

Treatment	Total sugar (%) Days after harvest							Reducing sugar (%) Days after harvest						
	1	3	5	7	9	11	13	1	3	5	7	9	11	13
GA_3 50 ppm	8.00	8.36	8.59	8.71	8.88	9.27	9.57	5.30	5.40	5.74	5.85	5.98	6.13	6.28
GA_3 100 ppm	8.02	8.36	8.58	8.70	8.85	9.26	9.55	5.31	5.39	5.73	5.83	5.96	6.11	6.24
Calcium nitrate 1.0%	8.06	8.35	8.56	8.70	8.88	9.28	9.56	5.30	5.39	5.73	5.82	5.96	6.13	6.23
Calcium nitrate 1.5%	8.00	8.33	8.55	8.68	8.85	9.26	9.54	5.30	5.38	5.72	5.81	5.95	6.12	6.12
Perforated polyethylene bag	8.05	8.31	8.56	8.69	8.86	9.23	9.64	5.30	5.39	5.71	5.80	5.94	6.10	6.20
GA_3 50 ppm + perforated polyethylene bag	8.04	8.30	8.51	8.63	8.80	9.05	9.23	5.30	5.37	5.67	5.77	5.91	5.97	6.16
GA_3 100 ppm + perforated polyethylene bag	8.00	8.21	8.42	8.52	8.75	8.93	9.12	5.32	5.36	5.60	5.73	5.84	5.94	6.11
Calcium nitrate 1% + perforated polyethylene bag	8.00	8.30	8.52	8.62	8.81	9.01	9.20	5.31	5.37	5.66	5.76	5.89	5.98	6.15
Calcium nitrate 1.5% + perforated polyethylene bag	8.10	8.20	8.41	8.50	8.71	8.91	9.11	5.31	5.34	5.61	5.72	5.83	5.93	6.10
Control	8.00	8.35	8.60	8.81	9.12	9.53	10.13	5.30	5.49	5.81	5.96	6.12	6.38	6.49
C D *(P = 0.05)*	Treatments (T) = 0.86, Days (D) = 0.12, D × T = 0.23							Treatments (T) = 0.06, Days (D) = 0.07, D × T = 0.12						

untreated control on the last day of storage. GA_3 probably has an antagonistic effect on the biogenesis of endogenous ethylene, the compound, which at threshold level, triggers the ripening process and consequently biochemical changes are retarded (Damodaran *et al.* 2001). Ramkrishna *et al.* (2001) opined that calcium reduced respiration rate and ethylene evolution thus reduced the spoilage loss. This is in close agreement with findings of Ahmed and Singh (2000) and Hiwale and Singh (2003).

On the basis of spoilage within 12%, the maximum economic life (11 days) was exhibited by GA_3 100 ppm + perforated polyethylene bag and calcium nitrate 1.5% + perforated polyethylene bag, however the untreated control recorded 7 days only. Total soluble solids content increased in all the treatments during storage (Table 2). It was found to be maximum (14.90%) in the control and minimum in the fruits treated with calcium nitrate 1.5% and kept in perforated polyethylene bag on the last day of storage period. Increase in total soluble solids during storage might be associated with the transformation of pectic substances, starch, hemi cellulose or other polysaccharides in soluble sugar and also with the dehydration of fruits (Hoda *et al.* 2000). During storage, the titratable acidity gradually decreased in all the treatments. The minimum acidity (1.44%) was recorded in the control on the last day of storage, while the maximum was observed in GA_3 100 ppm + perforated polyethylene bag. The treated fruits could maintain a higher level of acidity up to last day of storage. It might be due to reduced respiration rate in the later stage of storage as affected by GA_3 and calcium treatments. Similar findings have been reported by Hoda *et al.* (2000) and Gautam *et al.* (2003) during storage.

The ascorbic acid content of fruits decreased progressively during storage in all the treatments (Table 3). Maximum ascorbic acid content (409 mg/100 g) was retained by the fruits treated with GA_3 100 ppm + perforated polyethylene bag followed by calcium nitrate 1.5% + perforated polyethylene bag while it was least in the control. During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be causing decrease in ascorbic acid of the fruits (Damodaran *et al.* 2001). Activities of oxidizing enzymes might be reduced in the treated fruits that resulted the higher level of ascorbic acid content up to last day of storage. This finding is in agreement with those of Ahmed and Singh (2000) and Singh *et al.* (2004) during storage. There was continuous decrease in respiratory activity till the last day of storage. The lowest respiratory activity (82 mg CO_2/kg/hr) was noted in calcium nitrate 1.5% + perforated polyethylene bag followed by GA_3 100 ppm + perforated polyethylene bag, while it was found to be highest in the control. The results are in consonance with the findings of Damodaran *et al.* (2001), Jain *et al.* (2001) and Singh *et al.* (2004). Total sugar and reducing sugar were found to be maximum in the control and minimum in the fruits treated with calcium nitrate 1.5% and kept in perforated polyethylene bag on the last day of storage. These findings are in close agreement with the findings of Kumar *et al.* (2003) and Mahajan *et al.* (2004). An increase in sugars during storage was probably due to conversion of starch and polysaccharides into soluble sugars and dehydration of fruits (Hoda *et al.* 2000). On the basis of spoilage loss and fruit quality attributes, it may be concluded that fruits treated with calcium nitrate 1.5% and GA_3 100 ppm and kept in perforated polyethylene bag could be stored up to day 11 during storage at ambient temperature under semi-arid ecosystem of Gujarat.

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