INDIAN JOURNAL OF ARID HORTICULTURE
2009, Vol. 4 (2) : 75-81

Effect of $CaCl_2$ and GA_3 on shelf life of aonla (*Emblica officinalis* Gaertn) fruits

R.C. Gupta and Bhagwan Deen*
Department of Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Faizabad (U.P.) 224229, India

Abstract

The Chakaiya variety of aonla was pre harvest sprayed with $CaCl_2$, GA_3 and their combinations. Full mature fruits were harvested and stored at ambient temperature (7.48-21.34°C). The findings suggest that fruits can be stored at ambient temperature for 5 days without any treatment whereas shelf life can be prolonged upto 20 days with 15.62 per cent decay loss by spraying 2% $CaCl_2$ + 100 ppm GA_3 25 days before harvesting of the fruits .The lowest PLW, higher T.S.S., maximum retention of ascorbic acid, higher reducing sugar, non-reducing sugar, total sugars and phenols were also estimated in 2% $CaCl_2$ + 100 ppm GA_3 treated fruits.

Key Words: *Emblica*, aonla, pre harvest spraying, nutrients, shelf life.

Introduction

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn) is one of the most important indigenous fruit of India. It is very hardy fruit which can be successfully grown in various agro-climatic and soil conditions on which usual fruit crops do not perform well. In addition to India naturally growing aonla trees have also been reported from Ceylon, Cuba, Hawaii, Florida, Iran, Iraq, Java, West-Indies, Trinidad, Pakistan, Malaya and China. It is one of the richest source of vitamin 'C' (500-700 mg/100 g pulp), minerals and phenolic compounds and well known for its neutraceutical and pharmacological properties (Chatterjee and Sil, 2007; Calixto *et al.*, 1998) and is a wonderful antioxidant (Kumar *et al.*, 2006). The famous Indian Ayurvedic medicines chyavanprash and Trifla are prepared from aonla fruits. It is processed into quality product such as preserve, pickle, beverage, powder, Jam, etc. Due to its nutritive, medicinal and antioxidant properties aonla fruits demand is increasing in processing, pharmaceutical and cosmetic industries subsequently the area under aonla cultivation is getting expansion in Indian states like Uttar Pradesh, West Bengal, Rajasthan, Gujraat, Haryana, Maharashtra, Chhatisgarh and even in Tamil Nadu. Quality fruits with longer shelf life are the requirement of processing industry. The foliar application of calcium chloride and GA_3 have very important role in increasing the shelf life of fruits. Earlier research shows that foliar spraying of micronutrients and plant growth regulators increased the quality and shelf life of the fruits, Singh and Vashistha (1999) and Srivastava (2003). Calcium compound have shown promise in the quality retention of fruits (Huber, 1983). The present investigation was conducted to find out the effectiveness of pre-harvest sprays of $CaCl_2$, GA_3 and their combinations on shelf life of aonla fruits at ambient storage.

Materials and Methods

The experiment was carried out on seventeen years old trees of aonla cv. Chakaiya planted under sodic soil conditions at Main Experiment Station of Horticulture Department, N.D. University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, during 2009-10. The experiment consists of nine treatments including calcium chloride, GA_3 & its different combinations as well as control. The spray solutions were prepared in water and few drops of alcohol were used to dissolve the GA_3 before mixing it in water and hair shampoo was used as sticker. The spraying was done on the randomly selected bearing trees by sprayer 25 days before harvesting the fruits. The water with sticker was sprayed on control. The fruit were harvesting at full maturity and stored in plastic baskets at ambient temperature (7.48-21.34°C) for storage studies. Two kg fruits from each replication of every treatment were harvested and mixed together thus 6 kg fruits were used in each treatment for storage studies. The observations were recorded at an interval of five days during storage. The experiment was laid out in complete randomized design with three replications. The physiological loss in weight was recorded on physical balance. The fruits started decaying was isolated from the lot and their weight was recorded. The per cent decay loss was calculated against the initial weight of the lot. Total soluble solids was estimated with ERMA hand refractometer of 0-32% range and calibrated at 20°C whereas to determine acidity a known volume of sample was titrated against 0.1 N NaOH solutions using phenolphthalein as an indicator. Vitamin 'C' was estimated by titration of a known volume of sample in 3% metaphosphoric acid against 2, 6 dichlorophenol indophenols dye (A.O.A.C., 1970). Total phenols were extracted into 80% ethyl alcohol and colour was developed by adding phenol reagent and sodium carbonate solution. The colour was measured at 750 nm using spectrophotometer. The total phenols were calculated by the standard curve drawn with graded concentration of Gallic acid (Swan and Hills, 1959). The reducing, non-reducing and total sugars were estimated using Fehling's solutions method given by Lane and Eynon (1923) as described by Ranganna (1978).

Results and discussion

The physiological loss in weight among treatments significantly increased with the storage period. $CaCl_2$ (2%) + GA_3 (100 ppm) sprayed fruits showed lowest weight loss (16.28%), while fruits under control recorded the highest loss in weight (25.56%) at 20th day of storage (Table-1). This may be due to the role of calcium on limiting respiration which was attributed to altered membrane permeability (Bangerth, 1979). Bangerth *et al.* (1972) also reported that calcium could have reduced the endogenous substrate catabolism during respiration by limiting the diffusion of substrate from the vacuole to the cytoplasm and favoured the uptake of sorbitol, thus, disallowing its involvement in reactions related to internal breakdown. Similar results on reduction in weight loss by calcium chloride and GA_3 treatments were also reported in ber by Gupta *et al.* (1987) and in peaches by Bhullar *et al.* (1982).

The total soluble solids were significantly increased among all treatments with the storage period (Table-2). $CaCl_2$ (2%) + GA_3 (100 ppm) treated fruits had maximum T.S.S. content throughout the storage period in comparison to other treatments. Higher total soluble solids content in $CaCl_2$ (2%) + GA_3 (100 ppm) treated fruit was attributed to increase in dry matter accumulation particularly starch, which in turn broken down to simple sugars during maturation and ripening. (Upadhaya and Dixit, 1996) and Kumar *et al.* (2005) have also reported that $CaCl_2$ and GA_3 increased the T.S.S in aonla fruits which support the present finding.

The acidity was significantly influenced by $CaCl_2$ (2%) and GA_3 (100 ppm) there was an initial increase in acidity up to 5 days of storage and thereafter decreasing trend was observed till the end of storage (Table-3). An increase in acidity of initial stage might be due to biosynthesis of citric acid initially. Latter on decrease in acidity may be due to conversion of acids into sugars (Pool *et al.*, 1972). Similarly $CaCl_2$ and GA_3 have been found to increase and maintained higher acidity in guava Kher *et al.* (2004). The fruits pre harvest sprayed with $CaCl_2$ (2%) and GA_3 (100 ppm) retained the maximum ascorbic acid (725.9 mg/100g) than other treatments on the date of harvest (Table-4). Pre harvest spray of CaCl2 +GA_3 has increased the ascorbic acid that might be due to increased level of calcium in the fruits. The ascorbic content slowly decreasing in all the treatments without any significant change in the rate of decrease but retention was higher in $CaCl_2$ (2%) and GA_3 (100 ppm) treated fruits during storage in comparison to other treatments. The loss in ascorbic acid is due to rapid conversion of L-ascorbic acid into dehydro ascorbic acid in the presence of ascorbinase enzyme (Mapson, 1970) similar results on retention of ascorbic acid by $CaCl_2$ and GA_3 treatment were also reported in mango (Mukherjee and Srivastava, 1978).

The level of reducing sugar was higher on the date of harvest in fruits which were given pre-harvest treatments of $CaCl_2$ and GA_3 and their different combinations than control however maximum reducing sugar was recorded in $CaCl_2$ (2%) and GA_3 (100 ppm) treated fruits. This clearly indicates the treatment effect of reducing sugar content. Initially the reducing sugar was slightly increased up to 5 days (Table-5) but starts decreasing after 10 days of storage. The fruits treated with $CaCl_2$ (2%) and GA_3 (100 ppm) retained higher reducing sugar than other treatments. The initial rise in sugar content might be due to conversion of starch into sugars, while the subsequent decline was perhaps due to consumption of sugar for respiration. $CaCl_2$ and GA_3 are reported to protect reducing sugar in strawberry (Singh, *et al.* 2004).

Non-reducing sugar content of fruits did not differed significantly at harvest. However it was increased in all the treatments during storage upto 15 days thereafter started decreasing (Table-6). Pre-harvest spray of $CaCl_2$ (2%) and GA_3 (100 ppm) maintained highest level of non-reducing sugar followed by $CaCl_2$ (1%) and GA_3 (200 ppm) in comparison to control. The decreasing in non-reducing sugar in control was faster than in treated fruits. Calcium and GA_3 have also been reported to protect non-reducing sugar in litchi (Upreti and Kumar, 1996).

Similarly total sugar content was significantly highest in CaCl2 (2%) and GA_3 (100 ppm) treated fruits whereas fruits get other treatments also contains higher total sugar in comparison to control. Total sugars content initially increased but started decreasing after 15 days in all the treatments that was continued till the end of storage. (Table-7). It clearly showed the effect of treatments on level of total sugar content during storage of aonla fruits. Calcium and GA_3 are reported to protect total sugar in litchi (Rani and Brahmachari, 2002).

The total phenols were significantly higher in all treatments than control on the day fruit harvested and this difference continued up to 25th day of storage. Highest total phenol content was in fruit treated with $CaCl_2$ (2%) and GA_3 (100 ppm) in comparison to other treatments and was lowest in control. Total phenol increased till end of storage (Table-8). Increasing in total phenol might be due to loss of moisture and increase in dry matter accumulation. A total phenol is reported to increase during storage of aonla fruits by other scientists like Singh *et al.* (1993) and Singh and Kumar (2000).

The decay loss among treatments significantly increased with the storage period but $CaCl_2$ (2%) and GA_3 (100 ppm) treated fruits recorded the lowest decay loss while control recorded the highest decay loss (Table-9). There was no decay loss upto 5 days in all treatments. However, in ($CaCl_2$ 2% and GA_3 100 ppm) treated fruits decay loss was 15.62% after 20 days yet it was lowest among all treatments. The $CaCl_2$ and GA_3 appear to be enhancing shelf life by controlling decay loss due to increased Ca and GA_3 level in fruits. The decay loss by $CaCl_2$ application has also been controlled in grape (Ferguson *et al.*, 1983).

References

A.O.A.C. 1970. Official method of analysis; Association of official analytical chemists, Washington D.C. 11th edition.

Bangerth, F. 1979.Calcium related physiological disorders of plants. *Ann.Rev. Phytopath.*17:97-122.

Bangerth, F.; Dilley, D.R. and Dewey, D.H. 1972. Effect of post harvest calcium treatments on internal breakdown and respiration of apple fruits. *J.Amer.Soc.Hort.Sci.* 87:679-682.

Bhullar,J.S.; Dhillon,B.S. and Randhawa, J.S.1982. Effect of preharvest spray of calcium nitrate on the cold storage life of Flordasun peach fruits. *Indian J. Hort.* 39:9-13.

Calixto, J.B.; Santos A.R.S.; Filho V.C. and Tunes R.A. 1998. A review of the plants of the genus Phyllanthus: Their chemistry, pharmacology, and therapeutic potential. *J. Med. Biol. Res.* 31: 225-258.

Chatterjee, M. and Sil, P.C. 2007. Protective role of Phyllanthus niruri against nimusulide induced hepatic damage. *Ind. J. Clin. Biochem.* 22: 109-116.

Ferguson, L.; Davies, F.S.; Ismail, M.A. and Wheaton, T.A. 1983. Growth regulator and nutritional effect on grape fruit colour and storage quality. Proceedings, Tenth Annual Meeting. Plant Growth Regulator Society of America.

Gupta, O.P.; Siddiqui, S. and Chauhan, K.S. 1987. Evaluation of various calcium compounds for increasing the shelf life of ber fruits. *Indian J. Agric. Res.*, 21(2):65-70.

Huber, D.J. 1983. Role of cell wall hydrolases in fruit softening. *Hort. Rev.* 21:65-70.

Kumar, S.; Kumar, A.; Baig, M.J.; Chaudhary, B.K. 2005. Effect of pre-harvest treatment calcium compounds treatment on the storage life of aonla cv. NA-7. *Indian J. Hort.*, 62(4):324-326.

Kumar, S.G.; Nayaka, H.; Dharmesh, S.M. and Salimath, P.V. 2006. Free and bound phenolic antioxidants in amla (*Emblica officinalis*) and turmeric (*Curcuma longa*). *J. Food. Comp. Anal.* 19: 446-452.

Kher, Ravi; Bhat, Shanoo and Tiku, A.K. 2004. Effect of pre-harvest application of plant growth regulators (GA, NAA & CCC) on post-harvest quality of Guava (*Psidium guajava* L.) cv. Sardar. International Seminar on Recent Trends in Hi-Tech Hort. & PHT, Kanpur, Feb. 4-6, 252,

Lane, J.H. and Eynon, J. 1923. 'Determination of reducing sugars by Fehling's solution with methylene blue as an indicator', *J. Soc. Chem. Ind.*, 42: 32T

Mukherijee, P.K and Srivastava, R.B. 1979. Increasing storage life of mango by lowering the critical temperature. *Prog. Hort.*, 1:63.

Mapson, L.W. 1970. Vitamins in fruits, stability of L-ascorbic acid in biochemistry of fruits and their products. (Ed Hulme, A.C.) Academic Press, London, 376-377.

Pool, R.M.; Weaver, R.J. and Kuewer, W.M. 1972.Effect of growth regulators on changes in fruits of Thomson Seedless during cold storage *J.Amer.Soc.Hort.Sci.*, 97:67-70.

Ranganna, S. 1978. Manual of Analysis of Fruit & Vegetable Products. Tata Pub. Co. Ltd., New Delhi.

Rani, R. and Bramhachari, V.S. 2002. Effect of growth substances and girdling on fruit set, fruit drop and quality of litchi (*Litchi chinensis* Sonn.) cv. China. Horticulture Journal, 15(3):1-8.

Singh, P.S. and Vashistha, B.B. 1999. Effect of foliar spray of nutrients on fruit drop, yield and quality of ber cv. Seb.Haryana *J. Hort.Sci.*, 26:20-24.

Singh, J.N.; Singh, A.; Dixit, S.K. and Srivastava, A.K. 2004. Effect of chemicals and packaging on shelf life and quality of strawberry fruits cv. Sweet Charlie. International Seminar on Recent Trends in Hi-Tech Hort. & PHT, Kanpur, Feb. 4-6, 269.

Singh, I.S., Pathak, R.K.; Dwivedi, R. and Singh, H.K. 1993. Aonla production and post harvest technology. Tech Bull. N.D.U.A.T., Faizabad.

Singh, R. and Kumar, S. 2000. Effect of post harvest growth regulator treatment on the shelf life of aonla fruits during storage. *Haryana J. Hort. Sci*, 29 (3/4):178-179.

Srivastav, C.P. 2003.Studies on foliar feeding of plant growth substances and nutrients on yield and quality of aonla (*Emblica officinalis* Gaertn) M.Sc. (Ag) Thesis submitted to N.D.University of Agriculture and Technology, Faizabad, U.P.

Swan, T. and Hills, V.E. 1959. The phenolic constituents of Prunus domestica. Quantitative analysis of phenolic constituents. *J. Sci. Agri.*, 10:63-78.

Upadhyay, M.N. and Dixit, C.K. 1996. Storability of aonla cv. Gujarati Amla-1 increased by post harvest treatment. Nov. *J. App. Hort.*, 2(1/2):44-55.

Upriti, A. and Kumar, G. 1996. Effect of mineral nutrient sprays on yield and quality of litchi fruits. *Indian J. Hort.*, 53 (2):121-124.

Table 1. Pre-harvest treatments effect on PLW (%) during ambient storage of aonla fruits.

Treatments	Days of storage				
	5	10	15	20	25
T_1- Control (water)	3.33	9.05	17.61	25.56	31.48
T_2-100 ppm GA_3	3.04	7.58	13.76	20.46	25.71
T_3-1% $CaCl_2$	2.42	6.75	12.51	18.45	23.62
T_4-1% $CaCl_2$+100 ppm GA_3	2.17	7.15	12.66	19.37	21.67
T_5-1.5% $CaCl_2$+100 ppm GA_3	1.92	6.22	11.10	18.49	22.16
T_6-2% $CaCl_2$+100 ppm GA_3	1.61	5.03	9.79	16.28	20.41
T_7-50 ppm GA_3+1% $CaCl_2$	2.66	8.23	13.29	18.40	22.30
T_8-150 ppm GA_3+1% $CaCl_2$	2.15	7.33	13.04	18.08	21.46
T_9-200 ppm GA_3+1% $CaCl_2$	2.12	6.69	10.06	17.53	21.53
CD at 5%	NS	3.44	6.95	7.88	10.11

Table 2. Pre-harvest treatments effect on total soluble solids (%) during ambient storage of aonla fruits.

Treatments	**Days of storage**					
	0	**5**	**10**	**15**	**20**	**25**
T_1- Control (water)	8.73	8.97	9.37	9.73	10.07	10.37
T_2-100 ppm GA_3	8.77	9.03	9.67	10.43	11.23	11.33
T_3-1% $CaCl_2$	8.80	9.67	10.27	10.83	11.47	11.63
T_4-1% $CaCl_2$+100 ppm GA_3	8.83	9.70	10.47	10.70	11.63	11.73
T_5-1.5% $CaCl_2$+100 ppm GA_3	9.51	10.10	10.57	11.23	11.73	12.00
T_6-2% $CaCl_2$+100 ppm GA_3	10.20	10.67	11.43	11.90	12.57	12.63
T_7-50 ppm GA_3+1% $CaCl_2$	8.97	10.07	10.73	11.30	11.77	11.90
T_8-150 ppm GA_3+1% $CaCl_2$	9.23	10.50	10.70	11.77	12.03	12.37
T_9-200 ppm GA_3+1% $CaCl_2$	9.70	10.57	11.13	11.83	12.23	12.53
CD at 5%	0.25	0.26	0.21	0.21	0.27	0.31

Table 3. Pre-harvest treatments effect on acidity (%) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	1.88	2.17	1.75	1.53	1.37	1.24
T_2-100 ppm GA_3	2.09	2.30	1.83	1.57	1.51	1.37
T_3-1% $CaCl_2$	2.22	2.61	1.88	1.62	1.53	1.45
T_4-1% $CaCl_2$+100 ppm GA_3	2.39	2.68	1.92	1.73	1.62	1.53
T_5-1.5% $CaCl_2$+100 ppm GA_3	2.56	2.72	2.13	1.74	1.65	1.57
T_6-2% $CaCl_2$+100 ppm GA_3	2.85	2.94	2.30	1.88	1.75	1.66
T_7-50 ppm GA_3+1% $CaCl_2$	2.26	2.60	1.83	1.70	1.61	1.51
T_8-150 ppm GA_3+1% $CaCl_2$	2.43	2.68	1.88	1.72	1.62	1.53
T_9-200 ppm GA_3+1% $CaCl_2$	2.72	2.85	1.92	1.75	1.67	1.57
CD at 5%	0.15	0.18	0.35	0.15	0.17	0.17

Table 4. Pre-harvest treatments effect on ascorbic acid (mg/100 g) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	663.67	636.73	577.37	508.40	448.07	421.37
T_2-100 ppm GA_3	697.63	675.80	631.17	579.60	492.47	465.50
T_3-1% $CaCl_2$	706.36	685.03	661.67	590.50	530.37	479.03
T_4-1% $CaCl_2$+100 ppm GA_3	710.70	695.33	668.73	603.67	544.33	486.93
T_5-1.5% $CaCl_2$+100 ppm GA_3	717.93	699.60	676.20	618.23	559.23	499.60
T_6-2% $CaCl_2$+100 ppm GA_3	725.90	707.63	682.60	631.60	572.13	538.00
T_7-50 ppm GA_3+1% $CaCl_2$	709.27	688.10	660.20	601.23	542.50	480.63
T_8-150 ppm GA_3+1% $CaCl_2$	715.73	698.43	670.87	617.10	554.33	495.80
T_9-200 ppm GA_3+1% $CaCl_2$	720.10	705.41	678.33	624.33	566.57	514.70
CD at 5%	3.69	3.94	6.84	5.89	8.13	32.98

Table 5. Pre-harvest treatments effect on reducing sugar (%) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	2.10	2.21	1.97	1.91	1.73	1.57
T_2-100 ppm GA_3	2.45	2.57	2.30	1.99	1.90	1.70
T_3-1% $CaCl_2$	2.64	2.73	2.37	2.06	1.91	1.80
T_4-1% $CaCl_2$+100 ppm GA_3	2.87	3.11	2.57	2.31	2.03	1.82
T_5-1.5% $CaCl_2$+100 ppm GA_3	2.91	3.19	2.70	2.32	2.15	1.87
T_6-2% $CaCl_2$+100 ppm GA_3	2.97	3.28	2.87	2.43	2.41	2.17
T_7-50 ppm GA_3+1% $CaCl_2$	2.61	2.91	2.57	2.11	2.00	1.80
T_8-150 ppm GA_3+1% $CaCl_2$	2.67	3.11	2.62	2.23	2.25	1.91
T_9-200 ppm GA_3+1% $CaCl_2$	2.94	3.24	2.73	2.37	2.33	2.10
CD at 5%	0.42	0.20	0.22	0.22	0.11	0.28

Table 6. Pre-harvest treatments effect on non reducing sugar (%) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	2.03	2.34	2.64	2.72	2.56	2.37
T_2-100 ppm GA_3	2.32	2.53	2.93	3.11	2.92	2.87
T_3-1% $CaCl_2$	2.34	2.55	3.12	3.27	2.89	2.83
T_4-1% $CaCl_2$+100 ppm GA_3	2.38	2.57	3.10	3.44	3.02	2.99
T_5-1.5% $CaCl_2$+100 ppm GA_3	2.43	2.60	3.15	3.55	3.22	3.15
T_6-2% $CaCl_2$+100 ppm GA_3	2.48	2.62	3.27	3.78	3.31	3.22
T_7-50 ppm GA_3+1% $CaCl_2$	2.37	2.57	2.99	3.35	3.15	3.10
T_8-150 ppm GA_3+1% $CaCl_2$	2.41	2.59	3.18	3.62	3.21	3.12
T_9-200 ppm GA_3+1% $CaCl_2$	2.45	2.61	3.21	3.76	3.28	3.23
CD at 5%	0.32	0.19	0.27	0.36	1.16	0.46

Table 7. Pre-harvest treatments effect on total sugar (%) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	4.13	4.55	4.61	4.63	4.29	3.94
T_2-100 ppm GA_3	4.77	5.18	5.23	5.17	4.82	4.57
T_3-1% $CaCl_2$	4.98	5.35	5.49	5.38	4.89	4.63
T_4-1% $CaCl_2$+ 100 ppm GA_3	5.17	5.19	5.67	5.75	5.05	4.79
T_5-1.5% $CaCl_2$+100 ppm GA_3	5.34	5.75	5.85	5.87	5.37	5.02
T_6-2% $CaCl_2$+ 100 ppm GA_3	5.45	5.89	6.14	6.17	5.72	5.39
T_7-50 ppm GA_3+ 1% $CaCl_2$	4.98	5.48	5.56	5.34	5.05	4.90
T_8-150 ppm GA_3+1% $CaCl_2$	5.08	5.68	5.83	5.85	5.46	5.03
T_9-200 ppm GA_3+1% $CaCl_2$	5.39	5.83	5.94	6.13	5.61	5.33
CD at 5%	0.46	0.59	0.49	0.59	0.26	0.74

Table 8. Pre-harvest treatments effect on total phenol (mg/100g) during ambient storage of aonla fruits.

Treatments	Days of storage					
	0	5	10	15	20	25
T_1- Control (water)	146.33	152.00	159.67	165.67	173.33	182.33
T_2-100 ppm GA_3	153.00	161.33	168.67	175.33	181.67	185.00
T_3-1% $CaCl_2$	154.67	164.00	171.00	176.33	183.33	190.67
T_4-1% $CaCl_2$+ 100 ppm GA_3	160.33	167.67	174.00	179.67	187.33	195.00
T_5-1.5% $CaCl_2$+100 ppm GA_3	164.00	170.37	176.00	182.00	190.67	197.33
T_6-2% $CaCl_2$+ 100 ppm GA_3	170.67	178.00	186.67	195.67	203.00	210.67
T_7-50 ppm GA_3+ 1% $CaCl_2$	159.00	165.00	172.33	176.33	185.33	192.33
T_8-150 ppm GA_3+1% $CaCl_2$	162.33	168.33	175.00	180.33	187.33	193.33
T_9-200 ppm GA_3+1% $CaCl_2$	167.67	176.33	182.00	190.67	197.67	206.33
CD at 5%	1.51	1.55	1.84	1.36	1.68	2.78

Table 9 Pre-harvest treatments effect on decay loss (%) during ambient storage of aonla fruits.

Treatments	Days of storage				
	5	10	15	20	25
T_1- Control (water)	00	6.29 (2.61)	15.03	27.05	41.31
T_2-100 ppm GA_3	00	5.02 (2.35)	12.75	20.50	32.25
T_3-1% $CaCl_2$	00	3.04 (1.88)	11.41	19.88	28.58
T_4-1% $CaCl_2$+100 ppm GA_3	00	00 (0.71)	8.04	17.59	26.38
T_5-1.5% $CaCl_2$+100 ppm GA_3	00	00 (0.71)	6.85	16.66	25.47
T_6-2% $CaCl_2$+100 ppm GA_3	00	00 (0.71)	4.21	15.62	22.89
T_7-50 ppm GA_3+ 1% $CaCl_2$	00	3.57 (2.02)	11.58	18.92	27.77
T_8-150 ppm GA_3+1% $CaCl_2$	00	00 (0.71)	7.14	17.91	25.20
T_9-200 ppm GA_3+1% $CaCl_2$	00	00 (0.71)	6.07	15.67	24.54
CD at 5%	-	0.03	1.73	1.93	1.73

Note- Transformed data ($Y = \sqrt{x + \frac{1}{2}}$) are shown in parenthesis.