Impact of pre-harvest calcium compounds on aonla (*Emblica officinalis*) shelf life

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ABSTRACT

This study investigated the effectiveness of pre-harvest calcium sprays, using calcium nitrate and calcium chloride, on extending the post-harvest shelf life and maintaining the quality of aonla (Indian gooseberry) fruits. The experiment was conducted at the Regional Research Station of CCS Haryana Agricultural University in Rewari, Haryana, from 2020 to 2023. Calcium compounds were applied at 1.0 and 1.5 per cent concentrations to fifteen-year-old NA-7 aonla plants at 10 and 20 days before harvest. After harvesting, healthy, uniformly sized fruits were stored at ambient temperature and changes in physiological loss in weight (PLW), decay loss, total soluble solids (TSS), titratable acidity and ascorbic acid content were monitored every other day. The results indicated that pre-harvest calcium applications significantly reduced PLW and decay loss. Specifically, calcium nitrate at 1.5 per cent applied 20 days before harvest proved to be the most effective treatment, minimizing PLW and decay loss over the 10-day storage period compared to the control. This treatment also consistently maintained higher titratable acidity and ascorbic acid content, suggesting a slower rate of fruit aging and nutrient degradation. While some previous studies reported an increase in TSS with calcium treatments, present findings showed no significant effect of calcium applications on the TSS of aonla fruits during storage. Overall, the study highlights the significant role of pre-harvest calcium nitrate sprays in enhancing the post-harvest quality and extending the shelf life of aonla fruits, primarily by reducing moisture loss and decay and better preserving nutritional attributes like ascorbic acid.

Keywords: Aonla; calcium nitrate; calcium chloride; pre-harvest spray; shelf life; PLW; decay loss, TSS; ascorbic acid; titratable acidity

INTRODUCTION

Indian gooseberry, also known as aonla (*Emblica officinalis* Gaertn), is a remarkable fruit from the Euphorbiaceae family. It's incredibly resilient, thriving even in neglected, dry areas and wastelands. This tough fruit crop has a deep root system and sheds its leaves, making it particularly well-suited for arid environments where efficient management of natural resources is key to successful cultivation. A mature aonla tree can even withstand temperatures as high as 46°C. It is a nutritional powerhouse, second only to Barbados cherry in its vitamin C content. Just 100 grams of its pulp can pack anywhere from 500 to 1,500 mg of ascorbic acid. What's more, aonla juice retains most of its vitamin C even after processing, as reported by Damame et al (2002). In India's northern plains, the harvest season for aonla typically runs from the second week of December through the third week of January. The fruit itself is pale green, ribbed and quite firm, with a round shape and a thin, translucent skin. However, aonla fruits are highly perishable and can only be stored for about 5-6 days at room temperature after being picked, as noted by Pathak et al (2009).

When fruits are kept at room temperature, they don't last very long after being picked. This spoilage happens because of natural changes within the fruit, things like shifts in its biology and chemistry, microbes causing rot, dehydration and even physical damage. Generally, during storage, fruits lose weight, start to decay and their nutritional value goes down. That's where calcium comes in. Applying calcium to fruits helps them stay good longer and slows down the aging

process. It also helps prevent physiological issues and reduces spoilage after harvest. Calcium works by stabilizing the fruit's cell membranes and forming calcium pectate, which makes cell walls and the middle lamella stronger. This results in the fruit resisting softening and staying firm. Calcium compounds are really important for extending shelf life because they control various processes in the plant and can stop certain aspects of abnormal aging in fruits like aonla (Gangwar et al 2012). So, in this study, efforts were made to use calcium compounds to make aonla fruits last longer.

MATERIAL and METHODS

The experiment was conducted from 2020 to 2023 at the Regional Research Station of CCS Haryana Agricultural University at Rewari, Haryana. This location is in an arid region known for its hot, dry summers and cold winters, situated at an altitude of 241.95 m amsl at coordinates 28°5'44.1204'' N latitude and 76°35'33.9036'' E longitude. Throughout the study, the plants were maintained using standard agricultural practices. For the study, selected forty healthy, fifteen-year-old NA-7 plants were selected at random. In August, these plants were given pre-harvest spray of calcium in the form of calcium nitrate and calcium chloride. The experiment followed a randomized block design with four replications.

The plants were sprayed with 1.0 and 1.5 per cent concentrations of calcium nitrate and calcium chloride, as well as pure water for control group, at 10 and 20 days before harvest using a tractor-mounted spray pump. Fruits were harvested at maturity in the last week of November. Any undersized, oversized, diseased or damaged fruits were discarded, selecting only healthy, uniformly sized fruits for storage study. These fruits were packed into 2 kg perforated polyethylene bags and stored at ambient temperature. During the storage period, the fruits were analyzed every other day for changes in physiological loss in weight (PLW), decay loss, total soluble solids (TSS), titratable acidity and ascorbic acid content. The storage study itself was set up as a completely randomized design with four replications.

$$\text{PLW (\%)} = \frac{\text{Initial weight - Weight at sampling date}}{\text{Initial weight}} \times 100$$

Decay loss was calculated by weighing the decayed fruits (fungal infection/spoiled) and it was divided by initial weight and unit was expressed in percentage. Total soluble solids (TSS) of fruit juice were estimated by hand refractometer and expressed in degree brix (°B). Titratable acidity and ascorbic acid were estimated by using the method described by Anon (2000). The statistical analysis of the data was done using software OPSTAT (Sheoran 2004) and treatment means were compared at 5 per cent level of significance.

RESULTS and DISCUSSION

Effect of calcium treatments on PLW of aonla: Data in Table 1 indicate that T_4 (Calcium nitrate 1.5% applied 20 days before harvest) resulted in minimum PLW of 1.4, 1.8 and 2.2 per cent as compared to 2.9, 3.4 and 4.2 per cent in T_9 (Control) after 6, 8 and 10 days of storage respectively. T_3 (Calcium nitrate 1.5% sprayed 10 days before harvest) caused only 1.7 and 2.5 per cent PLW at 6 and 10 days after storage respectively and proved second best treatment. However, after 8 days of storage, T_3 treatment was at par with T_2 (Calcium nitrate 1.0% sprayed 20 days before harvest) and T_8 (Calcium chloride 1.5% sprayed 20 days before harvest) causing 2.1, 2.1 and 2.2 per cent PLW respectively.

Effect of calcium treatments on decay loss of aonla: T_4 resulted in only 1.06 and 2.03 per cent decay loss as compared to highest 5.15 and 6.41 per cent loss in control after 6 and 8 days of storage respectively (Table 2). T_3 was second best treatment causing only 1.57 and 2.54 per cent decay loss at 6 and 8 days after storage respectively. However, after 10 days of storage, T_4 was at par with T_3 and T_2 causing 2.85, 3.61 and 3.70 per cent decay loss respectively as compared to highest 7.09 per cent in T_9.

Effect of calcium treatments on TSS of aonla: The TSS ranged from 8.80 (T_2) to 9.52°B (T_4), 9.33 (T_6: Calcium chloride 1.0% sprayed 20 days before harvest) to 9.55°B (T_4), 9.35 (T_6) to 9.65°B (T_9), 8.69 (T_9) to 9.58°B (T_4), 8.79 (T_9) to 9.49°B (T_4) and 8.50 (T_9) to 9.43°B (T_4) at 0, 2, 4, 6, 8 and 10 days after storage respectively (Table 3). But there was no effect of the calcium treatments on TSS of the fruits.

Effect of calcium treatments on acidity of aonla: T_4, T_3 and T_2 resulted in 2.16, 2.15 and 2.14 per cent acidity respectively as compared to 2.02 in control after

Table 1. Effect of pre-harvest spray of calcium on PLW of aonla cv NA-7 during storage from 2020 to 2023 (four years)

Treatment	PLW (%) (days after storage)				
	2	4	6	8	10
T_1: Calcium nitrate 1.0% sprayed 10 days before harvest	1.2	1.4	1.9	2.3	2.7
T_2: Calcium nitrate 1.0% sprayed 20 days before harvest	1.2	1.3	1.8	2.1	2.6
T_3: Calcium nitrate 1.5% sprayed 10 days before harvest	1.0	1.3	1.7	2.1	2.5
T_4: Calcium nitrate 1.5% sprayed 20 days before harvest	1.0	1.2	1.4	1.8	2.2
T_5: Calcium chloride 1.0% sprayed 10 days before harvest	1.5	1.8	2.1	2.6	3.2
T_6: Calcium chloride 1.0% sprayed 20 days before harvest	1.5	1.7	1.9	2.3	3.0
T_7: Calcium chloride 1.5% sprayed 10 days before harvest	1.3	1.6	2.1	2.5	2.9
T_8: Calcium chloride 1.5% sprayed 20 days before harvest	1.3	1.6	1.9	2.2	2.8
T_9: Control	1.7	2.2	2.9	3.4	4.2
$CD_{0.05}$	0.1	0.1	0.05	0.1	0.1
SE(m)	0.02	0.03	0.02	0.04	0.02

Table 2. Effect of pre-harvest spray of calcium on decay loss of aonla cv NA-7 during storage from 2020 to 2023 (four years)

Treatment	Decay loss (%) (days after storage)				
	2	4	6	8	10
T_1: Calcium nitrate 1.0% sprayed 10 days before harvest	0	0	2.54	3.14	4.12
T_2: Calcium nitrate 1.0% sprayed 20 days before harvest	0	0	2.03	2.81	3.70
T_3: Calcium nitrate 1.5% sprayed 10 days before harvest	0	0	1.57	2.54	3.61
T_4: Calcium nitrate 1.5% sprayed 20 days before harvest	0	0	1.06	2.03	2.85
T_5: Calcium chloride 1.0% sprayed 10 days before harvest	0	0	3.55	4.15	4.49
T_6: Calcium chloride 1.0% sprayed 20 days before harvest	0	0	3.06	3.65	4.55
T_7: Calcium chloride 1.5% sprayed 10 days before harvest	0	0	2.51	3.22	4.30
T_8: Calcium chloride 1.5% sprayed 20 days before harvest	0	0	2.08	3.05	4.11
T_9: Control	0	2.15	5.15	6.41	7.09
$CD_{0.05}$	-	-	0.07	0.12	1.10
SE(m)			0.03	0.04	0.38

2 days of storage (Table 4). T_4 resulted in highest acidity of 2.14, 2.08, 2.02 and 1.97 per cent as compared to lowest 1.96, 1.84, 1.78 and 1.73 per cent in control after 4, 6, 8 and 10 days of storage respectively. However, after 10 days of storage, T_3 (1.94%) was at par with T_4 (1.97%).

Effect of calcium treatments on ascorbic acid content of aonla: Data in Table 5 depict that, among the treatments, T_6 resulted in maximum ascorbic acid content (545.6 mg/100 g pulp) as compared to lowest in T_9 (482.8 mg/100 g pulp) after 2 days of storage. However, after 4 days of storage, T_4 (499.9 mg/100 g pulp) and T_3 (497.2 mg/100 g pulp) resulted in maximum content and were at par, as compared to minimum in T_9 (477.1 mg/100 g pulp). After 6 days of storage, T_4 (491.2 mg/100 g pulp) showed maximum ascorbic acid content as compared to minimum in T_5 (Calcium chloride 1.0% sprayed 10 days before harvest) (463.3 mg/100 g pulp) and T_9 (464.9 mg/100 g pulp), the latter two treatments being at par. T_4 gave maximum ascorbic acid content of 484.0 and 475.7 mg per 100 g pulp in comparison to 451.9 and 429.2 mg per 100 g pulp after 8 and 10 days of storage respectively.

Kumar et al (2021) recorded lowest PLW and decay loss in the aonla fruits sprayed with calcium nitrate 1.5 per cent before 20 days of harvest. Highest TSS, lowest titratable acidity and maximum ascorbic

Table 3. Effect of pre-harvest spray of calcium on TSS of aonla cv NA-7 during storage from 2020 to 2023 (four years)

Treatment	TSS (°B) (days after storage)					
	0	2	4	6	8	10
T_1: Calcium nitrate 1.0% sprayed 10 days before harvest	9.37	9.42	9.43	9.45	9.30	9.23
T_2: Calcium nitrate 1.0% sprayed 20 days before harvest	8.80	9.45	9.48	9.51	9.42	9.27
T_3: Calcium nitrate 1.5% sprayed 10 days before harvest	9.41	9.48	9.53	9.53	9.42	9.34
T_4: Calcium nitrate 1.5% sprayed 20 days before harvest	9.52	9.55	9.56	9.58	9.49	9.43
T_5: Calcium chloride 1.0% sprayed 10 days before harvest	9.14	9.41	9.46	9.51	9.26	9.11
T_6: Calcium chloride 1.0% sprayed 20 days before harvest	9.17	9.33	9.35	9.42	9.26	9.15
T_7: Calcium chloride 1.5% sprayed 10 days before harvest	9.24	9.42	9.44	9.45	9.34	9.15
T_8: Calcium chloride 1.5% sprayed 20 days before harvest	9.34	9.45	9.46	9.47	9.34	9.13
T_9: Control	9.27	9.54	9.65	8.69	8.79	8.50
$CD_{0.05}$	NS	NS	NS	NS	NS	NS
SE(m)	0.37	0.30	0.29	0.29	0.30	0.29

Table 4. Effect of pre-harvest spray of calcium on acidity of aonla cv NA-7 during storage from 2020 to 2023 (four years)

Treatment	Acidity (%) (days after storage)					
	0	2	4	6	8	10
T_1: Calcium nitrate 1.0% sprayed 10 days before harvest	2.24	2.12	2.06	2.01	1.91	1.87
T_2: Calcium nitrate 1.0% sprayed 20 days before harvest	2.23	2.14	2.07	2.02	1.94	1.92
T_3: Calcium nitrate 1.5% sprayed 10 days before harvest	2.23	2.15	2.11	2.05	1.98	1.94
T_4: Calcium nitrate 1.5% sprayed 20 days before harvest	2.23	2.16	2.14	2.08	2.02	1.97
T_5: Calcium chloride 1.0% sprayed 10 days before harvest	2.23	2.10	2.02	1.92	1.85	1.81
T_6: Calcium chloride 1.0% sprayed 20 days before harvest	2.24	2.13	2.04	1.94	1.87	1.83
T_7: Calcium chloride 1.5% sprayed 10 days before harvest	2.23	2.12	2.06	1.96	1.90	1.85
T_8: Calcium chloride 1.5% sprayed 20 days before harvest	2.24	2.13	2.08	2.01	1.93	1.88
T_9: Control	2.15	2.02	1.96	1.84	1.78	1.73
$CD_{0.05}$	0.02	0.02	0.01	0.02	0.02	0.04
SE(m)	0.01	0.01	0.01	0.01	0.01	0.01

acid content were recorded in fruits of calcium nitrate sprayed (1.5%) plants at 20 days of storage. Lodhi and Tiwari (2017) observed that 1.0 per cent calcium nitrate treated fruits of aonla reduced the physiological loss in weight, decay loss, exhibited better quality on account of its favourable effect on total soluble solids, total sugar and in retaining more acidity, thereby, rendering them acceptable up to period of 15 days. Kumar et al (2005), in their study, reported that calcium compounds namely calcium chloride and calcium nitrate increased the TSS in aonla in storage. But in the present study, no effect of calcium treatments was observed on TSS of aonla fruits in storage. They also reported increase in ascorbic acid content in aonla with 1.00 per cent calcium nitrate solution. Yadav and Singh (2002) found that treatment with 1 per cent calcium + 0.1 per cent Bayleton resulted in increased total soluble solids and reduced levels of losses in acidity, ascorbic acid and reducing sugars. Gangwar et al (2012) reported that 1.0 per cent calcium nitrate treated fruits exhibited better quality on account of its favourable effect on total soluble solids, total sugar and in retaining more ascorbic acid and acidity, thereby, rendering them acceptable up to period of 15 days. Tripathi and Shukla (2011) reported that the foliar application of calcium nitrate at 1.5 per cent increased the TSS and ascorbic acid content and reduced titratable acidity of aonla fruits as compared to control.

Table 5. Effect of pre-harvest spray of calcium on ascorbic acid content of aonla cv NA-7 during storage from 2020 to 2023 (four years)

Treatment	Ascorbic acid (mg/100 g pulp) (days after storage)					
	0	2	4	6	8	10
T_1: Calcium nitrate 1.0% sprayed 10 days before harvest	515.8	494.3	480.1	468.3	462.0	454.7
T_2: Calcium nitrate 1.0% sprayed 20 days before harvest	515.7	497.3	481.5	473.3	467.6	460.7
T_3: Calcium nitrate 1.5% sprayed 10 days before harvest	517.5	501.4	497.2	485.7	475.7	469.7
T_4: Calcium nitrate 1.5% sprayed 20 days before harvest	519.5	508.1	499.9	491.2	484.0	475.7
T_5: Calcium chloride 1.0% sprayed 10 days before harvest	513.5	493.6	481.9	463.3	458.7	447.9
T_6: Calcium chloride 1.0% sprayed 20 days before harvest	514.5	545.6	484.6	465.7	459.8	450.7
T_7: Calcium chloride 1.5% sprayed 10 days before harvest	515.8	500.6	489.3	470.2	464.0	454.9
T_8: Calcium chloride 1.5% sprayed 20 days before harvest	515.8	504.0	494.7	480.3	470.6	460.9
T_9: Control	513.3	482.8	477.1	464.9	451.9	429.2
$CD_{0.05}$	2.6	2.9	2.8	2.2	2.7	1.6
SE(m)	0.9	9.6	1.0	0.7	0.9	0.6

CONCLUSION

This study definitively shows that applying calcium compounds before harvest significantly enhances the post-harvest quality and extends the shelf life of aonla fruits, which are otherwise highly perishable. The findings highlight that the treatment spraying calcium nitrate at a 1.5 per cent concentration 20 days before harvest was particularly effective. This method notably reduced both physiological weight loss and decay, ensuring the fruits remained firmer and more visually appealing for a longer period. Furthermore, this treatment played a crucial role in preserving the nutritional value of the aonla, as evidenced by the sustained levels of titratable acidity and ascorbic acid throughout storage. While a significant impact on total soluble solids was not observed, the overall improvements in physical quality and nutrient retention strongly advocate for the adoption of such pre-harvest calcium strategies. This approach offers a practical and impactful solution for farmers to minimize post-harvest losses and improve the marketability of aonla, especially in regions facing similar challenges to the one studied.

REFERENCES

Anonymous 2000. Official methods of analysis. 17th Edn, The Association of Official Analytical Chemists, Gaithersburg, Maryland, USA.

Damame SV, Gaikwad RS, Patil SR and Masalkar SD 2002. Vitamin C content of various aonla products during storage. Orissa Journal of Horticulture **30(1):** 19-22.

Gangwar S, Shukla HS, Katiyar D and Pandey V 2012. Effect of calcium nitrate on physico-chemical changes and shelf life of aonla (*Emblica officinalis* Gaertn) fruits. HortFlora Research Spectrum **1(3):** 253-258.

Kumar M, Kumar M and Bishnoi A 2021. Effect of pre-harvest spray of calcium chloride and calcium nitrate on shelf life of aonla fruits (*Phyllanthus embilica*) cv NA7. Indian Journal of Arid Horticulture **3(1-2):** 37-40.

Kumar S, Kumar A, Baig MJ and Chaubey BK 2005. Effect of calcium on physico-chemical changes in aonla (*Emblica officinalis* Gaertn) Indian Journal of Horticulture **62(4):** 324-326.

Lodhi DK and Tiwari R 2017. Effect of calcium nitrate on physico-chemical changes and shelf life of aonla (*Emblica officinalis* Gaertn) fruits. Annals of Plant and Soil Research **19(1):** 32-36.

Pathak PK, Dwivedi P and Kumar S 2009. Effect of post-harvest treatments on shelf life of aonla (*Emblica officinalis*) fruits damaged during harvesting. Journal of Food Science and Technology **46(3):** 283-285.

Sheoran OP 2004. Statistical package for agricultural research workers. CCS Haryana Agricultural University, Hisar, Haryana, India.

Tripathi VK and Shukla HS 2011. Influence of calcium chloride and calcium nitrate on physico-chemical composition of aonla Banarasi. Acta Horticulturae **890:** 371-374

Yadav VK and Singh HK 2002. Effect of pre-harvest application of calcium nitrate, Topsin-M and bayleton on post-harvest life of aonla (*Embilica officinalis* Gaertn) fruit. Journal of Applied Horticulture **4(2):** 83-86.