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# Use of calcium compound and modified atmospheric packaging of Indian gooseberry (*Emblica officinalis* Gaertn.) for shelf-life enhancement

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**Abstract**
Indian gooseberry or aonla is known for rich source of ascorbic acid, polyphenols, minerals, and nutraceuticals. Fruits are highly perishable due to spoilage and browning and our objective was to enhance shelf life by use of modified atmospheric packaging (MAP) and calcium hydroxide. Mature fruits of aonla cvs NA-7 and NA-10 were subjected to treatments like, control, 2% ventilated LDPE (200 gauge) film ($T_1$) and $T_1$+ dipped in 2% (w/v) $Ca(OH)_2$ solution ($T_2$) for 30 minutes and stored under ambient condition (18 $\pm$ 3 ºC; 55-65% RH). Storage attributes were studied at 0, 3, 6, 9, 12 and 15 days intervals. LDPE film 2% ventilated + 2% $Ca(OH)_2$ was found effective to prolong the shelf life for 15 days. After 9 days of storage $T_1$ has reduced loss in weight, browning and ascorbic acid with more spoilage. Control fruits deteriorated heavily owing to browning and spoilage and could be stored for 9 days. Cultivar NA-10 had a shelf life of 15 days as compared to NA-7. For extending storability, fruits should be packed in 2% ventilated LDPE film after treating with 2% calcium hydroxide solution.

**Keywords:** Modified atmospheric packaging, ascorbic acid, browning, total phenols

## Introduction
Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) belongs to family Euphorbiaceae, is an important indigenous and medicinal plant of India. Botanically, fruit is a berry with edible portion as epicarp and mesocarp. The market ability of aonla fruits are governed by greenness with glossy appearance and unblemished fruit surface. To keep the fruits fresh in good marketable quality, modified atmosphere packaging (MAP) is one of the simple and easily applicable storage methods among others. MAP involves reducing $O_2$ and/ or evolving more $CO_2$. This modification slows down metabolic processes, retard respiration and $C_2H_4$ production which extend the storage life and reduce post harvest losses. The significant role of MAP on shelf life extension of horticulture produce has been well documented [1-3]. Calcium has also been recognized as potent agent for deferral of senescence in horticultural crops [4]. Keeping these in view, the present work has been undertaken to see the response of LDPE film dovetailed with calcium compound as integrated approach on the storability of aonla with the objective to reduce loss in weight, browning and spoilage, maintenance of quality and to prolong the shelf life.

## Materials and methods
Mature aonla fruits of cvs. NA-7 and NA-10 were harvested and subjected to various treatments i.e. control (brown paper bag), 2% ventilated LDPE film bag of 200 gauge thickness (T1) and T1 + 2% $Ca(OH)_2$ ($T_2$) dip treatment for 30 minutes, then surface dried and packed. After packaging, the fruits were stored under ambient condition (18±3ºC and 55 to 65% RH). Various physico-chemical attributes like % CPLW, browning, and spoilage along with biochemical parameters such as TSS, acidity, ascorbic acid and total polyphenols were determined at 3 days interval up to 15 days of storage as per the methods [5]. Data were statistically analysed by adopting CRD [6].

## Results and discussion
Perusal of data (Table 1) pertaining to CPLW indicated a significant difference among the treatments and storage periods. Maximum CPLW was recorded in control fruits of both cvs. NA-7 and NA-10 on the 15th day of storage. Out of different treatments, 2% ventilated LDPE film bag + 2% $Ca(OH)_2$ exhibited minimum loss in weight (5.56%) in NA-10 and (8.46%) in NA-7 followed by packaging in 2% ventilated LDPE film bag on 15th day of storage.

This may be due to differences in skin thickness and lenticels per unit area. It is also observed that CPLW increased consistently on prolonging the storage period. Reduction in CPLW in ($T_2$) may be due to restricted rate of evapo-transpiration and buildup of more relative humidity inside the poly bags, which is mainly because of impermeable LDPE film against water and partial development of powdery thin film on fruit surface, which may clog the lenticels pores. Minimum loss in weight was recorded in fruits packed in HDPE bags [7]. Similar response of MAP has also been reported in mango [8], sapota [9] and in pomegranate [3].

Extent of browning was effectively controlled in fruits by packaging in 2% ventilated LDPE film bag after dipping fruits in 2% $Ca(OH)_2$, while maximum browning have been noted in untreated fruits during storage. It is interesting to note that browning increases with prolonging the storage period (Table 2). It is also observed that uses of chemical and packaging are more effective in both varieties NA-7 and NA-10. Similar response of cultivars i.e. less browning in NA-7 was also reported [10]. In addition, MAP may also reduce browning owing to $CO_2$ accumulation in poly bags. Earlier report [11] of MAP as 0.5% ventilated LDPE film bags reduced browning in litchi fruits. Polythene or plastic film as MAP reduced browning on fruits as noticed [12, 13]. MAP had ameliorative effects as it strengthens the peel tissue and prevents its breakdown [14].

It is also revealed that MAP + 2% $Ca(OH)_2$ treatment significantly reduced spoilage in both cultivars of aonla (Table 3 ). Minimum spoilage (4.70%) was recorded in NA-7 after 15 days of storage. This treatment caused maximum reduction (52.02%) of spoilage over untreated fruits. Calcium compound has also been reported to reduce the spoilage in fruit crops [15, 8, 14]. In addition, packaging have additive effects to reduce spoilage caused by the growth of *Pencillium digitatum*, *Pencillium wehnner* and other fungi were suppressed due to higher concentration of $CO_2$ [16].

Total soluble solids in the fruits differed significantly due to cultivars, treatments and storage period. It is indicated from the (Table 4.) that TSS was maximum in NA-7 after 12 days of storage and remained constant up to 15 days of storage. Fruits treated with 2% ventilated LDPE film bag + 2% $Ca(OH)_2$ showed minimum TSS contents than other treated fruits in both the cultivars and it maintained throughout storage period. Addition to these, higher level of acidity exists in NA-10 as compared to NA-7 cv. of aonla (Table 5.). The response of various treatments also indicated that MAP combined with 2% $Ca(OH)_2$ exhibited low level of acidity in both cultivars throughout storage period than other treatments. The amount of ascorbic acid also varied significantly due to cultivars, treatments and storage periods (Table 6.). Among various treatments, $T_2$ have again shown maximum (436.7 mg/100g) ascorbic acid content in NA-10 as compared to $T_1$, while minimum (291.3 mg/100g) was recorded in control fruits of NA-7 during storage of 15 days. The ascorbic acid content decreased significantly as the storage period prolonged. It is further noted that $T_2$ treatments retained more ascorbic acid than others throughout the storage periods.

Total polyphenol content also differed due to treatments and storage period (Table.7). Among various treatments, minimum total polyphenols was found in 2% ventilated poly film + 2% $Ca(OH)_2$ treatment as compared to other treatment and maximum was recorded in control fruits of NA-7 followed by NA-10. It is also noted that total polyphenols content increased consistently with the advancement of storage and the maximum was noticed in the control fruits. This may be due to fast rate of evapotranspiration and activity of polyphenoloxidase of fruits. These findings are in accordance with the findings [17, 11]. The accumulation of tannin may be associated with the ability of condensed tannins or polymers of pro-anthocyanidins to form complexes with proteins and other components [18]. Higher concentration of $CO_2$ increased the non- tannin polyphenol fraction by preventing the decline in tannin fraction during ripening of cherimoya fruit [19].

**Table 1:** Effect of MAP and $Ca(OH)_2$ on % CPLW of aonla cvs. during storage.

| Treatments | Storage period (days) | | | | | CD at 5% |
|---|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 15 | |
| **NA-7** | | | | | | |
| Control | 5.37 | 10.15 | 14.78 | 19.68 | 23.78 | T = 0.525 |
| 2% Vent.LDPE($T_1$) | 2.68 | 4.60 | 6.53 | 7.97 | 9.82 | S = 0.742 |
| ($T_1$)+2% $Ca(OH)_2$($T_2$) | 1.94 | 3.71 | 5.39 | 6.71 | 8.46 | TXS=1.286 |
| **NA-10** | | | | | | |
| Control | 3.23 | 7.49 | 8.75 | 12.39 | 16.02 | T = 0.562 |
| 2% Vent.LDPE($T_1$) | 3.13 | 5.48 | 6.10 | 7.79 | 9.86 | S = 0.795 |
| ($T_1$)+2% $Ca(OH)_2$($T_2$) | 1.35 | 2.51 | 2.84 | 4.08 | 5.56 | TXS=1.37 |

**Table 2:** Effect of MAP and $Ca(OH)_2$ on browning (%) of aonla cvs during storage.

| Treatments | Storage period (days) | | | | |
|---|---|---|---|---|---|
| | 6 | 9 | 12 | 15 | Mean |
| NA-7 | | | | | |
| Control | 1.4 (6.8) | 8.5 (16.9) | 58.6 (49.9) | 41.2 (39.9) | 27.4 (31.6) |
| 2% Vent.LDPE($T_1$) | 0.0 (0.0) | 8.5 (16.9) | 28.0 (31.9) | 67.0 (54.9) | 25.9 (30.6) |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 0.0 (0.0) | 0.0 (0.0) | 2.1 (10.1) | 9.0 (17.5) | 2.78 (9.8) |
| NA-10 | | | | | |
| Control | 15.8(23.4) | 54.0 (47.3) | 99.7 (86.9) | 36.0 (36.9) | 51.4 (45.2) |
| 2% Vent.LDPE($T_1$) | 0.0 (0.0) | 0.0 (0.0) | 3.1 (10.1) | 29.0 (32.6) | 8.0 (16.7) |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 0.0 (0.0) | 0.0 (0.0) | 1.7 (7.5) | 9.0 (17.5) | 2.7 (9.5) |

**Table 3:** Effect of MAP and $Ca(OH)_2$ on spoilage (%) of aonla cvs during storage.

| Treatments | Storage period (days) | | | | |
|---|---|---|---|---|---|
| | 6 | 9 | 12 | 15 | Mean |
| **NA-7** | | | | | |
| Control | 8.5 (16.9) | 31.0 (33.8) | 69.0 (56.2) | 99.6 (86.3) | 52.0 (46.3) |
| 2% Vent.LDPE($T_1$) | 1.4 (6.8) | 13.8 (21.8) | 49.8 (44.9) | 88.1 (69.8) | 38.3 (38.2) |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 0.0 (0.0) | 0.0 (0.0) | 1.8 (7.7) | 17.0 (24.4) | 4.7 (12.5) |
| **NA-10** | | | | | |
| Control | 0.0 (0.0) | 12.1 (20.6) | 59.3 (50.4) | 97.6 (80.1) | 42.3 (40.2) |
| 2% Vent.LDPE($T_1$) | 1.5 (7.0) | 2.7 (9.5) | 12.1 (20.4) | 28.3 (32.1) | 11.2 (19.6) |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 0.0 (0.0) | 1.4 (6.8) | 12.5 (20.7) | 18.5 (25.5) | 8.1 (16.5) |

**Table 4:** Effects of MAP and $Ca(OH)_2$ on TSS content (%)of aonla cvs during storage.

| Treatments | Storage period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | CD at 5% |
| NA-7 | | | | | | | |
| Control | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 10.0 | T = 0.03 |
| 2% Vent.LDPE($T_1$) | 6.0 | 6.0 | 7.0 | 8.0 | 8.0 | 8.0 | S = 0.05 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 6.0 | 6.0 | 7.0 | 7.0 | 7.0 | 7.0 | TXS=0.08 |
| **NA-10** | | | | | | | |
| Control | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | T = 0.01 |
| 2% Vent.LDPE($T_1$) | 7.0 | 7.0 | 8.0 | 9.0 | 9.0 | 10.0 | S = 0.02 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 7.0 | 7.0 | 8.0 | 8.0 | 8.0 | 8.0 | TXS=0.03 |

**Table 5:** Effects of MAP and $Ca(OH)_2$ on titratable acidity (%)of aonla cvs during storage.

| Treatments | Storage period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | CD at 5% |
| **NA-7** | | | | | | | |
| Control | 1.50 | 1.57 | 1.61 | 1.68 | 1.72 | 1.68 | T = 0.007 |
| 2% Vent.LDPE($T_1$) | 1.50 | 1.52 | 1.58 | 1.63 | 1.67 | 1.68 | S = 0.009 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 1.50 | 1.50 | 1.53 | 1.59 | 1.63 | 1.59 | TXS=0.016 |
| **NA-10** | | | | | | | |
| Control | 1.53 | 1.67 | 1.74 | 1.78 | 1.80 | 1.78 | T = 0.007 |
| 2% Vent.LDPE($T_1$) | 1.53 | 1.59 | 1.66 | 1.72 | 1.75 | 1.73 | S = 0.009 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 1.53 | 1.54 | 1.58 | 1.63 | 1.68 | 1.64 | TXS=0.017 |

**Table 6:** Effects of MAP and $Ca(OH)_2$ on ascorbic acid (mg/100g)of aonla cvs during storage.

| Treatments | Storage period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | CD at 5% |
| **NA-7** | | | | | | | |
| Control | 396.38 | 320.3 | 312.7 | 306.4 | 297.0 | 291.3 | T = 0.675 |
| 2% Vent.LDPE($T_1$) | 396.38 | 367.4 | 361.2 | 354.3 | 347.8 | 339.8 | S = 0.955 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 396.38 | 391.5 | 383.4 | 377.3 | 369.2 | 359.4 | T X S =1.654 |
| **NA-10** | | | | | | | |
| Control | 479.33 | 410.2 | 404.4 | 398.2 | 388.2 | 384.1 | T = 0.909 |
| 2% Vent.LDPE($T_1$) | 479.33 | 440.8 | 435.2 | 428.3 | 425.3 | 419.4 | S = 0.643 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 479.33 | 459.2 | 456.4 | 448.2 | 442.5 | 436.7 | TXS=1.58 |

**Table 7:** Effects of MAP and $Ca(OH)_2$ on polyphenols(GAE)of aonla cvs during storage.

| Treatments | Storage period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | CD at 5% |
| **NA-7** | | | | | | | |
| Control | 1.95 | 2.46 | 2.63 | 2.77 | 2.84 | 2.88 | T = 0.007 |
| 2% Vent.LDPE($T_1$) | 1.95 | 2.25 | 2.35 | 2.44 | 2.59 | 2.74 | S = 0.010 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 1.95 | 1.97 | 2.09 | 2.17 | 2.25 | 2.32 | TXS=0.018 |
| **NA-10** | | | | | | | |
| Control | 1.65 | 2.23 | 2.29 | 2.34 | 2.39 | 2.44 | T = 0.007 |
| 2% Vent.LDPE($T_1$) | 1.65 | 1.98 | 2.03 | 2.10 | 2.15 | 2.20 | S = 0.010 |
| ($T_1$)+2%$Ca(OH)_2$($T_2$) | 1.65 | 1.69 | 1.77 | 1.87 | 1.92 | 2.12 | TXS=0.017 |

## Conclusion

Aonla fruits dipped in 2% $Ca(OH)_2$ for 30 minutes and packed in 2% ventilated LDPE film was most effective to prolong the shelf life for 15 days. Packaging alone has also reduced loss in weight and browning and ascorbic acid content up to 9 days of storage with more spoilage. However, control fruits deteriorate heavily and could hardly be stored for 9 days. Cultivar NA-10 had a shelf life of 15 days as compared to NA-7. Thus, it is inferred that for extending the storability, aonla fruits should be packed in 2% ventilated LDPE film bags after treating with 2% calcium hydroxide solution.

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