Effect of Low-Density Polyethylene on shelf life and fruit quality of Indian gooseberry (*Emblica officinalis* Gaertn.)

Abstract

Indian gooseberry (*Emblica officinalis* Gaertn.) is an indigenous important hardy underutilized important fruit crop of India. The objective of the present investigation was to evaluate the effects of Modified Atmospheric Packaging- Low Density Polyethylene (MAP-LDPE) on storage life and fruit quality (physico-chemical attributes) of different cultivars of Aonla fruits up to 12 days. Physico-chemical attributes such as Physiological Loss in Weight (PLW), Decay loss, Total Soluble solids Acidity, Ascorbic acid and Sugars were determined for Aonla cultivars viz. NA-6, NA-7, NA-10, NA-25, NA-26, NA-27 and Francis in this experiment. The pooled results revealed that MAP-LDPE was able to reduce the Physiological Loss in Weight and Decay loss of Aonla fruits up to twelfth day of storage. Higher retention of Ascorbic acid and Acidity content was observed during 12 days of storage. Total Soluble solids and Sugars content was low in LDPE-MAP as compared to control storage condition in different cultivars of Aonla. The findings of the study will be useful in increasing the availability of Aonla fruits and enable for its long-distance transportation and subsequent marketing.

Keywords; MAP, Low Density Polyethylene, TSS, PLW, Decay loss, Sugars, Acidity.

Introduction

Indian gooseberry also known as ‘Amritphal’ well known for its hardiness, adaptability for cultivation in a variety of agroclimatic conditions, and its wide use in the pharmaceutical, nutraceuticals, cosmetics as well as post-harvest processing industries. After harvest, perishable fruits sustain significant losses, particularly during postharvest handling operations. However, perishability of the fruits can be determined by physiological as well as biochemical changes in fruits (Firmin, 1997). Some of the crucial physico-chemical changes such as higher respiration rate, moisture loss, inadequate relative humidity, enhanced ethylene biosynthesis, rapid oxidation reactions, and increased pathogen susceptibility attributed to these losses, which decreases the market value of produce after harvest. Therefore, suitable temperature and adequate humidity conditions have been reported to be important factors for maintaining tropical and subtropical fruits in ideal condition throughout the storage period

(Pal, 1999). Furthermore, adequate storage practises and processing techniques can reduce post-harvest losses by up to 30% (*Goyal et al.*, 2008).

It is necessary to formulate packaging and storage strategies for Aonla fruits with a longer shelf life in order to ensure a better price for Aonla growers which enhances its utilization by reducing post-harvest losses. Packaging materials have a substantial impact on the quality and storage life of fruits ultimately reaching into the market (Krishnamurthy and Rao 2001; Neeraj and Kumar 2004; Kumar *et al.*, 2000, 2005). Fruit packaging is one of the most commonly used postharvest techniques since it provides convenience handling of given unitized amounts while also protecting them from transportation risk and storage hazards. The physico-chemical characteristics of Aonla fruits were significantly influenced by packing material, and storage period (Arora *et al*., 2019). Modified atmosphere refers to a conservation strategy that is used to prolong the postharvest life of a plant's product while maintaining its quality (Kader, 2002). The primary purpose of employing modified atmosphere is to establish an equilibrated or stabilized atmosphere inside packaging that is advantageous to the product without causing any injury (Zagory and Kader, 1998). A modified atmosphere has been employed on a variety of products (Sandhya, 2010). Creating an equilibrium atmosphere inside a package of vegetables and fruits is affected by the product's respiration rate, weight, storage temperature, relative humidity, and the permeability of the packing material and the modified atmosphere method entails altering the environment around a food product through vacuum, passive, gas flushing, or regulated permeability of the pack, which in turn controls the enzymatic, biochemical as well as microbiological activity to prevent or minimize the main degradations that may occur. Appropriate packaging protects the fruits from physiological, pathological, and physical deterioration which maintain their market acceptability. Polyethylene bags effectively extended the shelf-life of fruits, due to a lower rate of water loss. Hence, fruit packaging act as vital component of post-harvest management practices as it aids in assembling the produce in convenient units and protects it from degradation during handling, transportation and marketing. Modifying the gas composition around the Aonla fruits during packing could help to extend storage and shelf life of Aonla fruits which ultimately prolong the postharvest life of fruits enabling benefits for transport as well as storage purpose. Low-density polyethylene (LDPE) film is the most commonly employed packaging material for packing fresh fruits as well as vegetables due to its numerous benefits such as flexibility, softness, strength, transparency, heat sealability, moisture resistance, chemical resistance, high ratio of CO2 to O2 permeability, economical, and recyclable as well. Although LDPE is a good barrier against water vapour but not enough efficient barrier against oxygen, carbon dioxide, odour, and flavour compounds (Mangaraj *et al.*, 2009).

In the fruits packed in LDPE film, the concentration of oxygen declines continuously due to the fruit's respiration process, while the CO2 concentration increases inside the package (Paull, 1999). As a consequence, the respiration rate of packed fruits gradually decreases, and O2 and CO2 concentration ranges between the package and the ambient atmosphere begin to form. After a certain period of time a temporary state of equilibrium within the package is established, which is typically low in O2 and high in CO2 (Caleb *et al*., 2012).

Low Density Polyethylene (LDPE) was reported to improve shelf-life of fruits such as mango (Illeperuma and Jayasuriya, 2002); atemoya (Yamashita et al., 2002), pear (Nath et al.,2012) and jujube (Padmaja and Bosco. 2014).

Materials and Methods

Sample preparation and experimental design

The experiments were performed over two consecutive years, 2021 and 2022. During both the years, different cultivars of Aonla fruits viz., Narendra Aonla-6, Narendra Aonla -7, Narendra Aonla -10, Narendra Aonla-25, Narendra Aonla -26, Narendra Aonla -27 and Francis were harvested at commercial maturity in first week of November from orchard of Main Experimental Station Horticulture (26.47° N latitude, 82.12°E longitude) Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya and immediately transported to the postharvest laboratory. Selected fruit were mature, homogeneous in size and free from blemishes. They were cleaned under running tap water to remove dirt and dust and thereafter, the fruits were allowed to dry in shade before imposing treatments.

The fruits were packed in commercially available packaging materials in the market i.e Low density polyethylene of Low-density polyethylene (LDPE) of size 8 cm× 6 cm of each pack and fruits samples were taken at 4, 8 and 12th day of storage, analysed and observations were recorded.

Determination of weight loss

The weight loss (WL) was determined by considering the initial weight (Wo) and Wf is the final weight of fruits (4th, 8th and 12th day)

$$\text{WL \%} = (Wo-Wf)/Wo\times100$$

Evaluation of decay percentage

The decay percentage of fruit during storage was calculated using the following formula:

$$\text{Decay \%} = \text{Number of decayed fruit/Total number of fruit} \times100$$

The decayed fruits were removed to restrict further contamination.

Determination of Soluble solids content

Extracted juice of six fruits from each treatment batch was used to determine the TSS For assessment, hand Refractometer of 0-32 per cent range was used. The values were corrected at 20 ^{0}C and expressed as (°Brix) T.S.S. of the fruit pulp (Ranganna, 2010).

Determination of Titratable acidity (TA)

Titratable acidity was determined by taking fruit juice (2 mL) in a volumetric flask, adding two drops of phenolphthalein indicator, and titrating this solution against 0.1 N sodium hydroxide (NaOH). The appearance of light pink color was marked as the end point. This was expressed in terms of percentage by using the formula given by (Ranganna, 2007).

Determination of Ascorbic acid

Vitamin C content was estimated by using 2, 6-Dichlorophenol indophenol (DCPIP) visual titration method. This method involves reduction of 2,6-Dichlorophenol indophenol (standard dye) to deep blue in alkaline solution and a pink end pointed in ascorbic acid. The titre values were recorded and calculated according to the method described by (Ranganna, 2000) and expressed as mg ascorbic acid per 100g of fruit pulp.

Determination of Sugars

Reducing sugars, non-reducing sugars (%) and total sugars (%) were estimated as per the method described by Ranganna (1994).

Statistical Analysis

The experiment followed a Factorial Completely Randomized Design (FRCD); each treatment was replicated four times. Data were obtained from the two consecutive years (2020-21 and 2021-22) of investigation and were analysed using Statistix 10 software. Differences among the means assessed by the LSD test with a P value of 0.05

Result and Discussion

Physiological loss in weight (%)

The data pertaining to the effect of Low-Density Polyethylene Packaging on physiological loss in weight of Aonla fruit revealed a significant increasing trend during storage (Figure 1). Fruits packed in MAP-LDPE condition registered lowest mean weight loss which ranges from 2.87% to 4.23% as compared to control (Figure 2) or unpacked fruits which bears range from 5.11% to 7.54% among different cultivars of Aonla during storage period. The interaction between treatments and storage interval was found to be significant. This could be due to fact that plastic covering plays an essential role in preventing dehydration by establishing a saturated micro-atmosphere around the fruit Thus, minimizes the respiration rate and release of free water and inhibited catabolic activities (Baswal *et al.*, 2020). These results are in corroboration with the findings of Kumar *et al.*, 2005, who studied the effect of various packaging materials on shelf life of Aonla and recommended that polyethylene packaging was effective in minimizing physiological loss in weight and maintaining good marketability after 18 days of storage.

Decay Loss (%)

Significant gradual increasing trend among treatments in LDPE was observed in the average cumulative spoilage per cent (Figure 3). In general, an abrupt decay loss was noticed after 4 days of storage which further increased till end of the storage i.e., 12 days. Fruits packed in MAP-LDPE condition registered lowest decay loss which ranges only from 1.74 % to 3.75% as compared to control or unpacked fruits (Figure 4) in which major incidence of spoilage loss was observed i.e., from 13.88% to 38.34% among different cultivars of Aonla during storage. The interaction between treatments and storage interval was found to be significant. Average rate of decay loss in LDPE-MAP storage was lower as compared to ambient storage condition. This could be due to reason that to limited interaction of fruits with microflora and atmospheric oxygen, as well as the accumulation of CO_2 within the poly bags and its preservative effect. (Hardenburg, 1956). The results in the present study are in conformity to the findings of Neeraj and Kumar (2004) who investigated on fully mature Aonla fruits which were packed in three different plastic bags with two thicknesses and recorded minimum fruit decay in fruits packed in MAP bags after 30 days of storage period.

Total soluble solids (°brix)

A progressive rise in Total soluble solids content was noticed till 12 days of storage in both MAP-LDPE and control storage condition (Figure5 and Figure6). The pooled mean analysis of both the years revealed that fruits packed in MAP-LDPE condition render minimum change in TSS which ranges from 8.07°brix to 11.05°brix whereas unpacked fruits registered maximum TSS content of fruit i.e., from 9.09°brix to 11.91°brix among different cultivars of Aonla. The interaction between treatments and storage interval was found to be significant. Total soluble solids in LDPE-MAP storage were lower as compared to ambient storage due to reason that fruits packed in LDPE-MAP undergo a slow increase in T.S.S. during storage because LDPE-MAP modifies the atmosphere around the fruit by lowering O_2 levels and raising CO_2 levels, which ultimately slows respiration and limits fruit ripening (Nath *et al.*, 2012). The result is in close proximity with findings of Akbudak and Eris (2003) who also observed delay in increase in T.S.S. in peach and nectarine fruits packed in MAP compare to control storage condition.

Titratable acidity (%)

The level of acid content of Aonla fruits followed a decline trend with advancement in storage period irrespective of treatments (Figure 7 and Figure 8). The average lowest mean acid content was recorded in the unpacked or control fruits which ranges from 0.97% to 1.93% whereas highest range of acidity content was recorded in fruits packed into MAP-LDPE (1.14% to 2.30%) among different cultivars of Aonla. The higher level of acidity inside MAP might be due to the lower rate of respiration during storage as affected by film permeability to atmospheric gas (Nath *et al.*, 2012 in pear and this is in consonance with the findings of Akbudak and Eris (2003) in peaches and nectarines.

Ascorbic acid (mg/100g)

The pooled data pertaining to ascorbic acid content influenced by MAP Low-Density Polyethylene Packaging revealed a decreasing trend during storage (Figure 9). Fruits packed in MAP-LDPE retain highest mean ascorbic acid which ranges from 301.88 mg/100g to 509.17 mg/100g content. However, unpacked fruits (Figure10) exhibited an abrupt decreasing trend in ascorbic acid content at faster pace therefore recorded the lowest mean ascorbic acid which ranges from 297.06 mg/100g to 502.36 mg/100g content. The interaction between the treatments and storage period for ascorbic acid content was found to be non- significant for both years of study. Aonla fruits stored in LDPE-MAP condition exhibited higher retention of ascorbic acid when compared with ambient storage condition due to reduction in activities of oxidizing enzymes in packed fruits that resulted in higher retention of ascorbic acid up to last day of storage (*Nath et al.*, 2012). The finding of this study is in agreement with the findings of (*Azene et al.*, 2014). who observed the maximum retention of ascorbic acid content in the papaya fruits wrapped in LDPE-MAP than those of unwrapped fruits or control fruits. Similar observations were made by Mahajan and Singh (2014) in Kinnow fruits during storage.

Sugars

The pooled data pertaining to the effect of LDPE-MAP on reducing sugars, non-reducing sugar and total sugars revealed significant increasing trend during entire storage period. Table number 1, 2 and 3 indicates that the maximum increase in reducing sugars, non-reducing sugars and total sugars content of Aonla fruits varieties was recorded in control or unpacked fruits which ranges from 2.68% to 3.91%, 1.83% to 3.46%, and 5.13 to 7.26% respectively. However, packed fruits exhibited lowest amount of in reducing sugars, non-reducing sugars and total sugars content of Aonla fruits varieties which ranges from 2.21% to 3.74%, 1.69% to 3.31%, and 4.52% to 6.98% respectively. Sugars content of Aonla fruits in LDPE-MAP condition was less than ambient storage condition might be due to higher rates of respiration and metabolic activity resulting in rapid hydrolysis of sugar under ambient temperature (Wills *et al.*, 1989). The results were also in conformity with Narayana (2002) who reported that total sugars of ‘Karpuravalli’ variety of banana fruits increased gradually throughout the storage period and was maximum in the control and ventilated bags than the unvented polybags.

Conclusion

Shelf life of different cultivars of Aonla was extended up to 12th day of storage without much compromising in overall physico-chemical attributes of fruits. It was observed that fruits packed in MAP-LDPE condition was able to reduce significant weight loss among Aonla fruit cultivars up to 12th day of storage, exhibited minimum incidence of spoilage loss, minimum change in total sugar content, retained maximum ascorbic acid as well as acidity content of fruits compared to unpacked or control fruits. Hence it can be concluded that fruits packed in MAP-LDPE could help the farmers to minimize the losses occurred during storage of fruits which would in turn help farmers to store fruits during peak glut situation of market which ultimately led to higher remuneration and would help farmers to get maximum profit and hence doubling of farmers' income. Also, LDPE film packaging significantly improves the shelf life and storability of fresh fruits therefore, it has a higher potential in management of supply chain of fresh horticultural produce.

Recommendation

Low-density polyethylene (LDPE) film can be used effectively among the packaging materials for packing of fresh fruits of Aonla for maintaining its quality parameters as well as shelf life up-to 12 days of storage without compromising its consumable quality.

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Tables and Figures

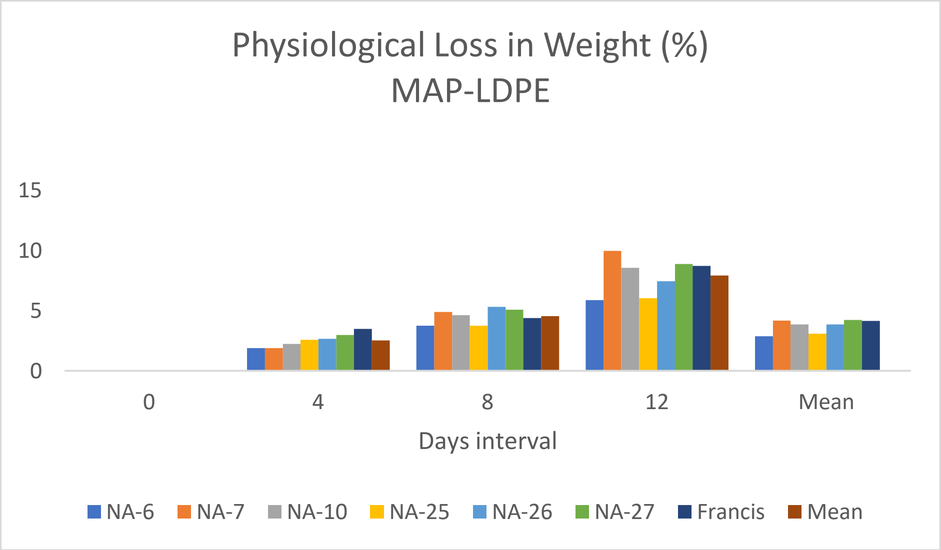

Figure 1: Effect of MAP-LDPE storage conditions on physiological loss in weight (%) of different cvs. of Aonla

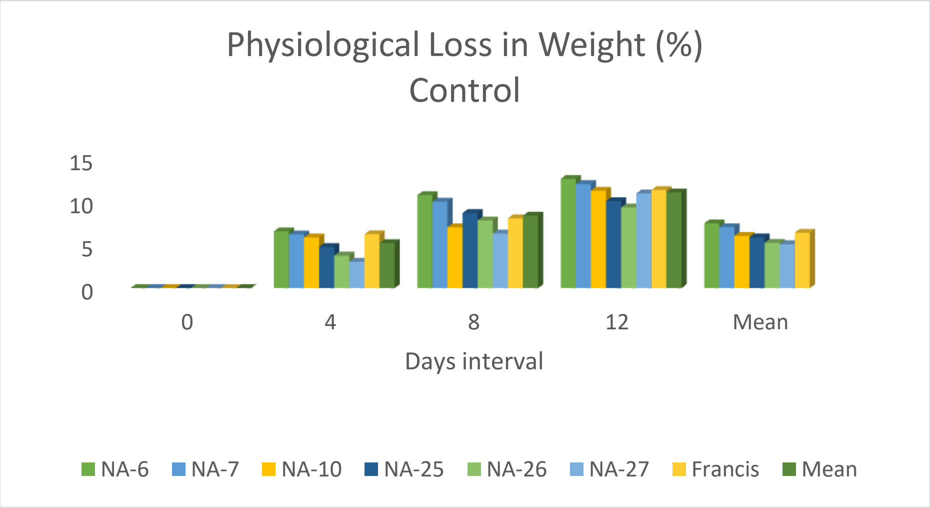

Figure 2: Effect of Ambient storage conditions on physiological loss in weight (%) of different cvs. of Aonla

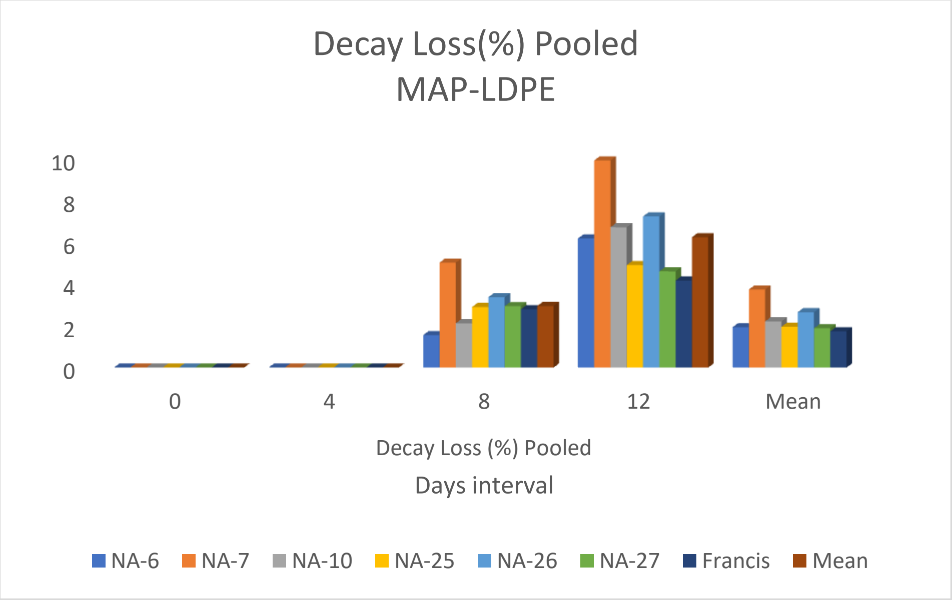

Figure 3: Effect of MAP-LDPE storage conditions on decay loss (%) of different cvs. of Aonla

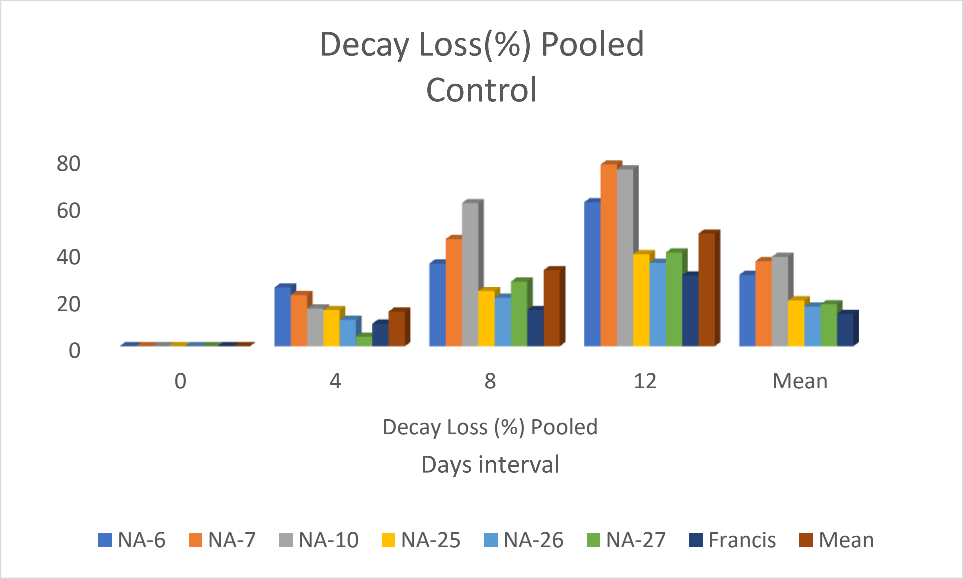

Figure 4: Effect of Ambient storage conditions on decay loss (%) of different cvs. of Aonla

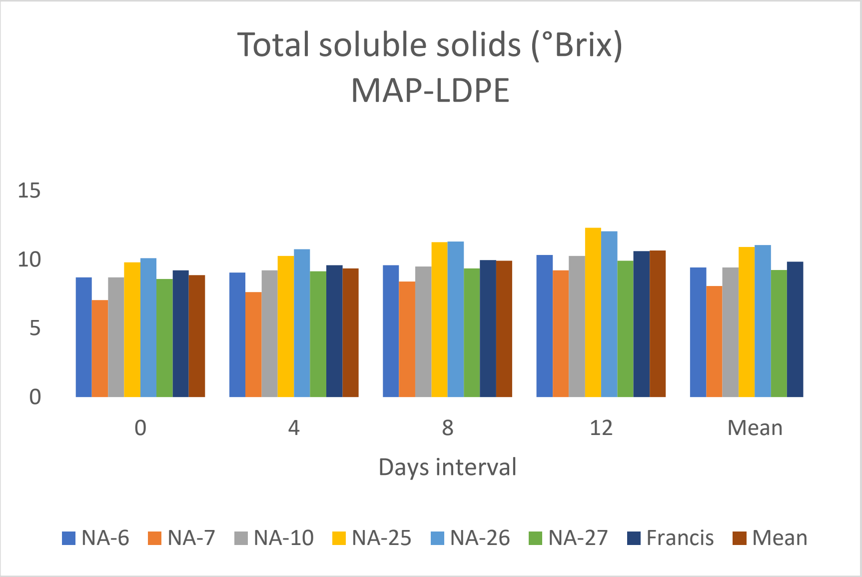

Figure 5: Effect of MAP-LDPE storage conditions on Total soluble solids (°Brix) of different cvs. of Aonla

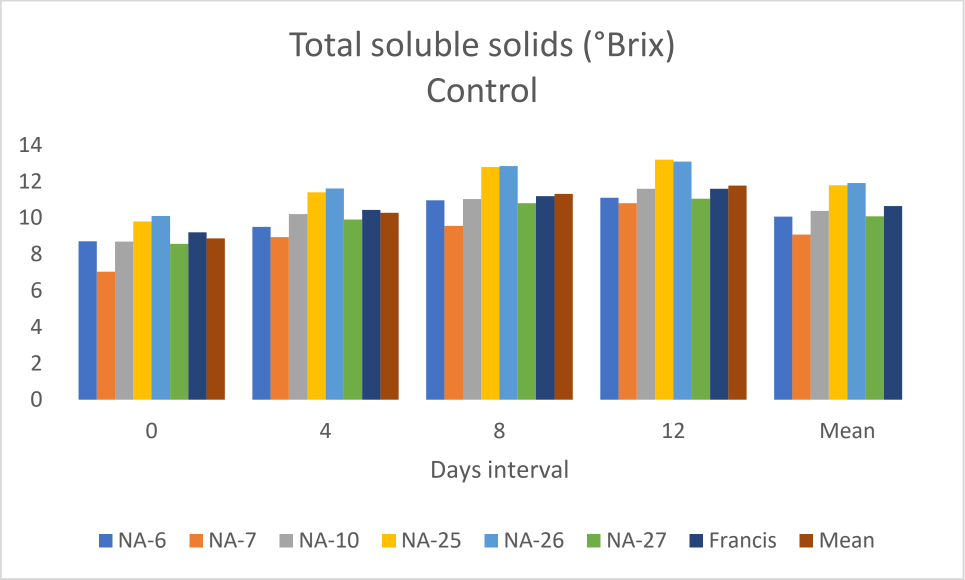

Figure 6: Effect of Ambient storage conditions on Total soluble solids (°Brix) of different cvs. of Aonla

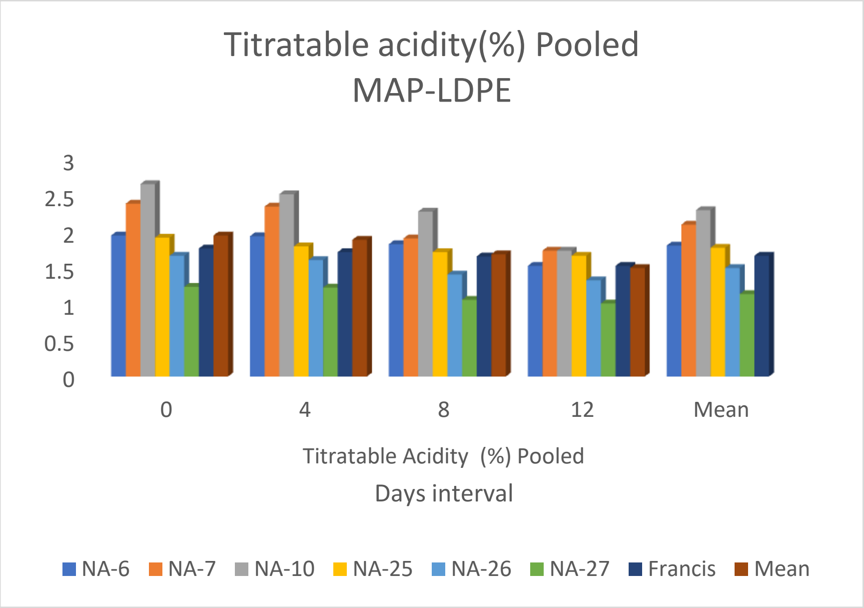

Figure 7: Effect of MAP-LDPE storage conditions on Titratable acidity(%) of different cvs. of Aonla

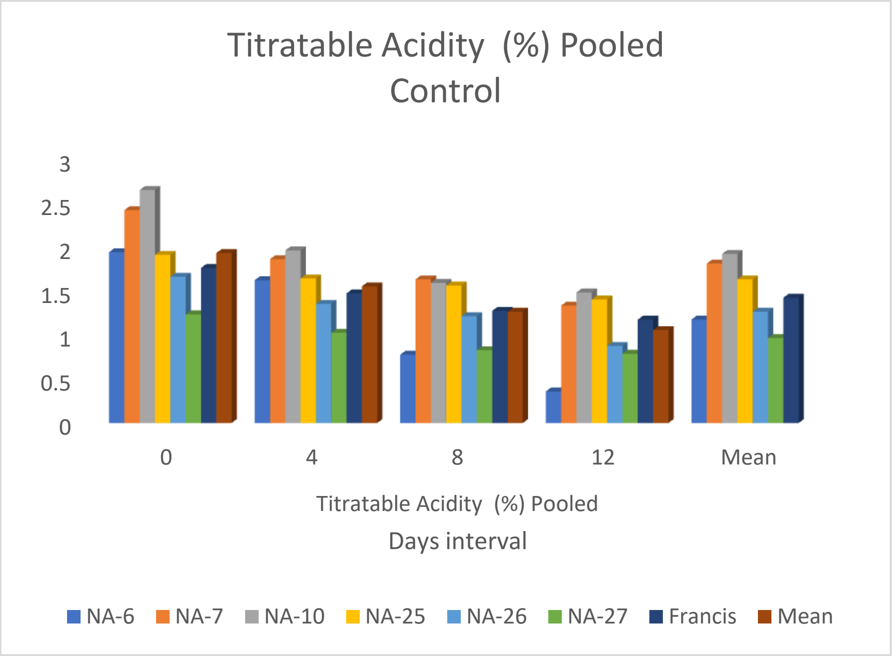

Figure 8: Effect of Ambient storage conditions on Titratable acidity(%) of different cvs. of Aonla

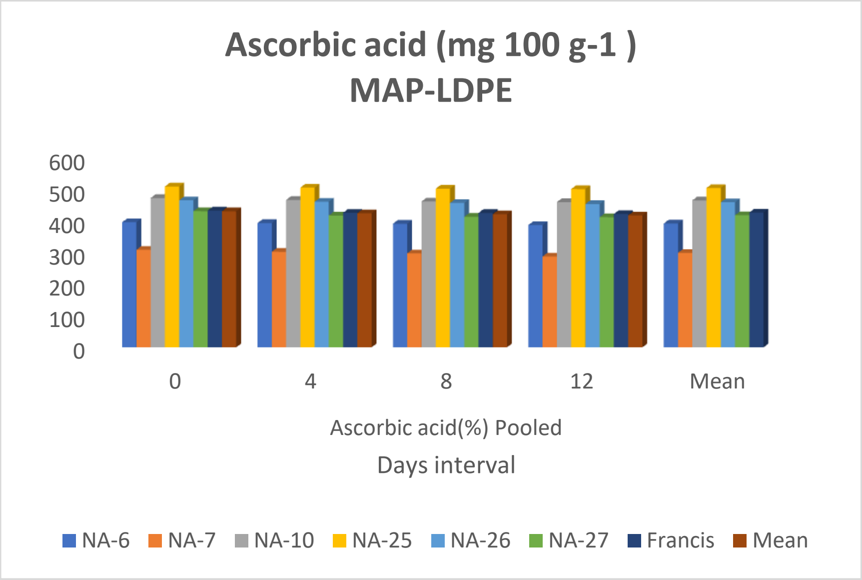

Figure 9: Effect of MAP-LDPE storage conditions on Ascorbic acid (mg 100 g-1) of different cvs. of Aonla

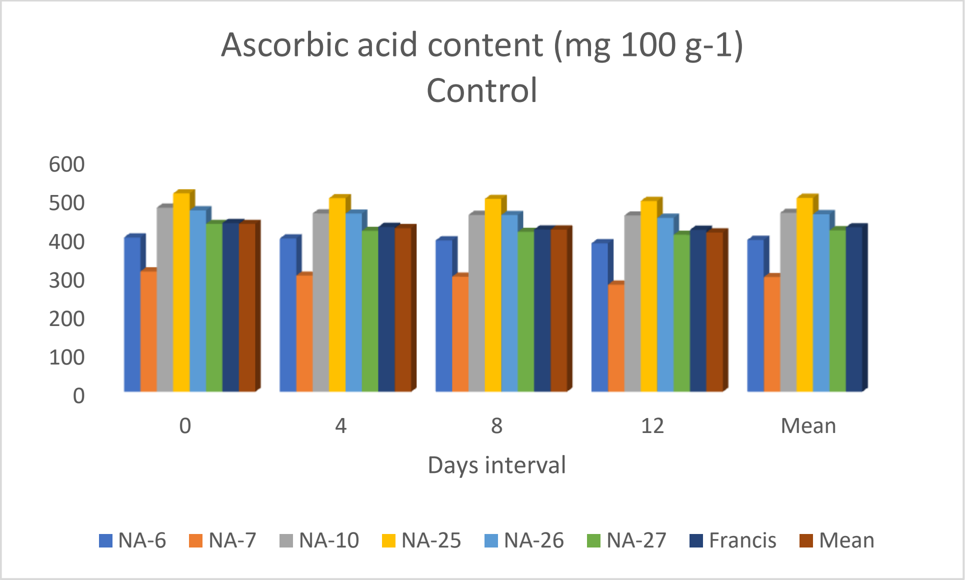

Figure 10: Effect of Ambient storage conditions on Ascorbic acid (mg 100 g-1) of different cvs. of Aonla

	Reducing Sugars (%)									
	MAP LDPE					CONTROL				
Treatment/ DAS	0	4	8	12	Mean	0	4	8	12	Mean
NA-6	2.87	2.92	3.23	3.4	3.10^{c}	2.87	3.41	3.67	3.74	3.41^{c}
NA-7	3.48	3.59	3.7	3.86	3.66^{ab}	3.48	3.77	3.91	4.49	3.91^{a}
NA-10	1.87	1.98	2.39	2.62	2.21^{e}	1.87	2.93	2.96	2.99	2.68^{e}
NA-25	3.56	3.64	3.84	3.94	3.74^{a}	3.56	3.72	3.82	4.13	3.80^{b}
NA-26	3.41	3.53	3.61	3.74	3.57^{b}	3.41	3.7	3.85	3.95	3.72^{b}
NA-27	2.92	3.1	3.21	3.34	3.14^{c}	2.92	3.27	3.57	4.01	3.44^{c}
Francis	2.37	2.45	2.98	3.55	2.83^{d}	2.37	2.99	3.89	3.95	3.30^{d}
Mean	2.92^{d}	3.02^{c}	3.27^{b}	3.49^{a}		2.92^{d}	3.39^{c}	3.66^{b}	3.89^{a}	
LSD (0.05%)	Treatment = 0.095 DAS= 0.062 Treatment × DAS= 0.241					Treatment = 0.103 DAS= 0.068 Treatment × DAS= 0.264				

Table 1: Effect of storage conditions on Reducing sugars (%) content of different cvs. of Aonla

	Non-Reducing Sugars (%)									
	MAP LDPE					CONTROL				
Treatment/ DAS	0	4	8	12	Mean	0	4	8	12	Mean
NA-6	2.29	2.49	2.81	3.3	2.72^{c}	2.29	2.62	2.84	3.46	2.80^{c}
NA-7	3.03	3.17	3.38	3.67	3.31^{a}	3.03	3.37	3.51	3.95	3.46^{a}
NA-10	1.73	1.93	2.61	2.96	2.30^{d}	1.73	2.41	3.03	3.21	2.59^{d}
NA-25	2.84	3.21	3.42	3.5	3.24^{a}	2.84	3.46	3.57	3.67	3.38^{a}
NA-26	2.82	2.82	2.83	2.86	2.83^{b}	2.82	2.98	3.07	3.11	2.99^{b}
NA-27	2.24	2.64	2.88	2.95	2.68^{c}	2.24	2.9	2.96	3.19	2.82^{c}
Francis	0.77	1.35	2.18	2.48	1.69^{e}	0.77	1.6	2.33	2.63	1.83^{e}

Mean	2.24^{d}	2.51^{c}	2.87^{b}	3.10^{a}	2.24^{d}	2.76^{c}	3.04^{b}	3.31^{a}
LSD (0.05%)	Treatment = 0.085 DAS= 0.056 Treatment × DAS= 0.217				Treatment = 0.089 DAS= 0.058 Treatment × DAS= 0.228			

Table2: Effect of storage conditions on Non-Reducing sugars (%) content of different cvs. of Aonla

Total Sugars

	MAP LDPE					CONTROL				
Treatment/ DAS	0	4	8	12	Mean	0	4	8	12	Mean
NA-6	5.16	5.41	6.04	6.7	5.82^{c}	5.16	6.03	6.51	7.2	6.22^{c}
NA-7	6.51	6.76	6.97	7.53	6.93^{a}	6.51	6.66	7.42	8.44	7.26^{a}
NA-10	3.59	3.91	5	5.58	4.52^{d}	3.59	5.34	5.93	6.2	5.27^{d}
NA-25	6.4	6.85	7.26	7.43	6.98^{a}	6.4	7.18	7.39	7.79	7.19^{a}
NA-26	6.22	6.35	6.44	6.6	6.40^{b}	6.22	6.68	6.92	7.06	6.72^{b}
NA-27	5.16	5.74	6.08	6.29	5.81^{c}	5.16	6.17	6.53	7.2	6.26^{c}
Francis	3.14	3.8	5.16	6.03	4.53^{d}	3.14	4.59	6.22	6.58	5.13^{d}
Mean	5.16^{d}	5.55^{c}	6.13^{b}	6.59^{a}		5.16^{d}	6.09^{c}	6.71^{b}	7.20^{a}	
LSD (0.05%)	Treatment = 0.176					Treatment = 0.193				
	DAS= 0.116					DAS = 0.126				
	Treatment × DAS= 0.450					Treatment × DAS= 0.492				

Table 3: Effect of storage conditions on Total sugars (%) content of different cvs. of Aonla