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Shelf life and quality of apple at ambient conditions affected by different concentrations of *Aloe vera* gel and neem oil

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ABSTRACT

In the present investigation, four varieties of apple *viz*., Skyline Supreme, Starkrimson, Oregon Spur and Prima were treated with different concentrations of *Aloe vera* gel (0.0, 1.0, 2.0, 3.0, 4.0, 5.0 %) and neem oil (0.0, 0.5, 1.0, 1.5, 2.0, 2.5%) to study their effect on shelf life and quality during storage. The fruits were dipped in the aqueous solutions for half an hour, shade dried and subjected to storage at ambient temperature (18-20°C) having relative humidity of 80-85%. A significant difference in the physico-chemical characters of these varieties was recorded due to their genetic makeup. During storage PLW (%), TSS (°B), titratable acidity (%), ascorbic acid (mg/100g), carotene (µg/100g and total antioxidants (mMTE/L) were found to decrease significantly in all the treatments irrespective of concentration. However, the reduction was recorded faster in the control whereas it was slower with the increase in the concentration of *Aloe vera* gel and neem oil. Among the varieties, Starkrimson had minimum PLW (5.70%) followed by Oregon Spur (5.89%) and Skyline Supreme (6.62%) after 35 days of storage at ambient temperature. The study revealed that the postharvest shelf life of apple can be increased significantly by the application of *Aloe vera* gel or neem oil.

Key words: *Aloe vera* gel, neem oil, apple cultivars, ambient storage, physico-chemical characters.

INTRODUCTION

Apple (*Malus domestica* Borkh.) is one of the most important temperate fruit crops in the North-West and North-East Himalayan region of India covering an area of 0.32 million ha with an annual production of 2.87 million metric tonnes (Anonymous, 2). A number of commercial cultivars are being grown in J&K, H.P., Uttarakhand and few isolated places in North-Eastern states comprising Arunachal Pradesh and Nagaland. Although, the production of apple is increasing every year because of good quality cultivars and latest scientific production techniques but due to coinciding of the monsoon season (July-September) during harvesting and lack of sufficient storage structures in the country, a huge quantity (20-30%) of the perishable produce like apple is spoiled between harvest and consumption. The roads and transport facilities in the country are not upto the mark which also add to the spoilage of the produce. Fresh fruits and vegetables are living beings which have high moisture content (75-95%) and continue respiration thereby producing heat and water at the expense of reserve food. A number of postharvest chemicals and coatings have been used in various fruits to extend their shelf life. Recently, edible coatings are one of the most useful innovations for extending the shelf life of fresh fruits and vegetables. Edible coatings act as barrier to gases (O_2 and CO_2) and moisture; produce similar effects to storage as in controlled atmosphere. Edible coatings are thin layers that improve product quality which covers the surface of the food and it can be safely eaten as a part of the whole food. Edible coatings are new technique which is used to increase shelf life of whole or fresh-cut fruits & vegetables. These coatings have been developed for quality maintenance of fresh fruits and vegetables by preventing changes in color, aroma, appearance, taste & texture.

Aloe vera gel is composed mainly of polysaccharides and acts as a natural barrier to moisture and oxygen, which are the main agents of deterioration of fruits and vegetables. Further, it has antifungal and antibacterial property which provides a defensive barrier against microbial contamination of fruits and vegetables. Another advantage of this coating is totally harmless to the environment. Recently, edible coatings have been prepared by mixing extracts of various herbs including *Aloe vera* (Chauhan *et al*., 5). *Aloe vera* contains many beneficial complex components including glycoproteins, polysaccharides, salicylic acids, phenolic compounds, lignins, amino-acids, vitamins, saponins and enzymes which provide *Aloe vera* its many beneficial properties including anti-fungal, anti-bacterial and anti-inflammatory and a good moisture and gas barrier. Ewekeye *et al*. (8) analyzed the effects of biodegradable *Aloe*

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vera gel coating on apple and determined antifungal and antibacterial properties against pathogenic microbes like *Rhizopus*, *Aspergillus*, *Trichoderma* and *Mucor*. *Aloe vera* gel also prevents softening, oxidative browning and reduced the risk of microbial contamination in apple fruits. Similarly, neem oil is a medicinal and also a non-toxic plant extract which possesses excellent- antimicrobial properties. To restrict the postharvest spoilage of apple a number of postharvest chemicals have been used (Ergun and Satici, 7). In Royal Delicious apple 1.5-2.0% concentration of neem oil as a surface coating along with cooling was most effective for retaining the physico-chemical characteristics and lowering the disease incidence (Nilanthi *et al*., 13). Keeping in view the beneficial effects of *Aloe vera* gel and neem oil for restricting the spoilage and increasing the post harvest shelf life of various fruits, the present study was undertaken using different concentrations of *Aloe vera* gel and neem oil in four varieties of apple for recording the postharvest changes in the physico-chemical characteristics which were stored at ambient temperature.

MATERIALS AND METHODS

Four varieties of apple *viz*., Skyline Supreme, Starkrimson, Oregon Spur and Prima harvested at full maturity (similar days from full bloom to maturity) from the orchard of ICAR-Central Institute of Temperate Horticulture, Regional Station, Mukteshwar situated at 2250 m above mean sea level in Nainital district of Uttarakhand, India were used in the present study during 2015-16. The *Aloe vera* gel was extracted manually from the freshly harvested *Aloe vera* leaves excluding the yellow fluid (bitter in taste). The extracted gel was kept in clean and dried glass bottles and stored in the refrigerator. The aqueous solutions of different concentrations of *Aloe vera* gel (0.0, 1.0, 2.0, 3.0, 4.0, 5.0 %) were prepared with the clean tap water. Similarly, neem oil concentrations (0.0, 0.5, 1.0, 1.5, 2.0, 2.5%) from Indo-neem (Indore Biotech Inputs and Research (Pvt.) Ltd.) were also prepared. In total 48 treatments were formed (12 concentrations, six each of *Aloe vera* and neem oil and 4 varieties of apple) All the varieties of apple were dipped for 30 minutes (as the aqueous solution was absorbed slowly) in the above concentrations, shade dried and stored in CFB boxes at ambient (18-20°C) temperature having relative humidity of 80-85% for further evaluation.

The physiological loss in weight (% PLW) of the treated fruits of all the varieties were recorded as per the standard methods at regular intervals during storage described by Ranganna (15). Brix of the extracted juice from different treatments was measured at 20°C using Abbe's refractometer (Atago, Tokyo, Japan). Similarly, the titratable acidity (%), ascorbic acid and total carotenoid contents of all the treatments were estimated at regular interval as per the methods given by Ranganna (15) and expressed as mg and µg/100 ml respectively. For estimation of total carotenoids in 25 g crushed fruit 5 g anhydrous sodium sulphate was added followed by grainding. The mixture was extracted with 3% acetone 4-5 times and the final volume was made to 50 ml. The excess acetone was separated in separating funnel with water and the OD was taken at 452 nm using petroleum ether as blank in Nano drop 200°C spectrophotometer (Model No. ND 2000c). The CUPRAC assay was carried out by the method given by Apak *et al*. (2) using copper (II) chloride, neocuproine and ammonium acetate buffer solutions. The antioxidant activity was expressed as mmol Trolox®/litre, or mMTE/L.

The experiment was laid out in completely randomized design (CRD) replicated thrice and the data recorded were analysed as per the method given by Cochron and Cox (6).

RESULTS AND DISCUSSION

During storage at ambient conditions the PLW (%) was found significantly different among all the treatments. With the increase in the concentration of *Aloe vera* gel and neem oil the PLW was found to decrease significantly. The fruits treated with higher concentration of neem oil were found to have less PLW compared to *Aloe vera* gel and it was maximum in control (Table 1). The minimum PLW with the coating of neem oil and *Aloe vera* gel could be attributed due to reduced respiration rate thereby maintaining the turgidity of cells and increasing the shelf life significantly. The quality characteristics of pear fruits were found bettere stored for 70 days at low temperature after treating with oxalic acid (6 mmol/litre) as reported by Kaur *et al*. (11). It was found that 20 per cent coating concentration of *Aloe vera* is the most effective and appropriate for the extension of shelf life of grapes (Ali *et al.*, 1). The weight loss for *Aloe vera* coated oranges was 29.20+ 0.55%, while that of uncoated oranges was 53.30+ 1.17% at the end of storage with retention of TSS, acidity, weight, firmness, pH and vitamin C (Arowora *et al*., 4). Strawberry fruits were dipped directly in 25, 50, 75 and 100% *Aloe vera* gel (v/v). Fruit weight loss, firmness, titratable acidity, sugar content and vitamin C were determined during 1, 2, 3, 4 and 5 days after treatments. Coating fruits with *A. vera* significantly reduced weight loss as compared to the control.

The progressive increase in total soluble solids (TSS°B) on the untreated fruits of all the varieties was

Table 1. Physiological loss in weight (%PLW) in four varieties of apple treated with different concentrations of *Aloe vera* gel and neem oil stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	0.0	4.51	7.16	10.38	13.69	25.36	10.35
$T_2(SSAV_1)$	0.0	4.13	6.76	10.02	13.26	24.27	9.74
$T_3(SSAV_2)$	0.0	3.80	6.54	9.79	12.91	24.08	9.52
$T_4(SSAV_3)$	0.0	3.51	6.31	9.68	12.37	18.88	8.45
$T_5(SSAV_4)$	0.0	3.16	6.08	9.59	12.23	17.15	8.04
$T_6(SSAV_5)$	0.0	3.14	5.84	9.33	11.96	16.78	7.84
$T_7(SSNO_0)$	0.0	3.91	6.73	9.99	13.02	29.83	10.58
$T_8(SSNO_{0.5})$	0.0	3.25	5.50	8.30	12.69	25.39	9.18
$T_9(SSNO_{1.0})$	0.0	3.19	5.26	8.14	12.08	24.01	8.78
$T_{10}(SSNO_{1.5})$	0.0	3.01	5.17	8.06	10.06	23.04	8.22
$T_{11}(SSNO_{2.0})$	0.0	2.46	4.61	7.28	9.88	20.32	7.43
$T_{12}(SSNO_{2.5})$	0.0	2.22	4.08	6.50	8.92	18.01	6.62
$T_{13}(SKAV_0)$	0.0	4.18	6.76	10.01	13.29	16.37	8.44
$T_{14}(SKAV_1)$	0.0	3.23	5.37	8.16	11.03	14.16	7.00
$T_{15}(SKAV_2)$	0.0	3.16	5.24	7.99	10.87	13.98	6.87
$T_{16}(SKAV_3)$	0.0	3.06	5.06	7.70	10.72	13.44	6.66
$T_{17}(SKAV_4)$	0.0	2.71	4.80	7.48	10.28	13.24	6.41
$T_{18}(SKAV_5)$	0.0	2.42	4.31	7.03	10.18	12.90	6.14
$T_{19}(SKNO_0)$	0.0	3.49	6.39	9.20	12.71	16.80	8.09
$T_{20}(SKNO_{0.5})$	0.0	3.11	5.41	8.14	10.66	16.04	7.23
$T_{21}(SKNO_{1.0})$	0.0	2.96	5.07	7.47	9.18	15.07	6.63
$T_{22}(SKNO_{1.5})$	0.0	2.69	4.54	7.25	8.78	14.43	6.28
$T_{23}(SKNO_{2.0})$	0.0	2.56	4.38	6.77	8.20	14.15	6.01
$T_{24}(SKNO_{2.5})$	0.0	2.30	4.17	6.29	7.50	13.94	5.70
$T_{25}(OSAV_0)$	0.0	5.77	10.84	15.01	20.73	26.98	13.22
$T_{26}(OSAV_1)$	0.0	2.90	4.71	7.13	15.58	23.30	8.94
$T_{27}(OSAV_2)$	0.0	2.83	4.36	6.84	14.78	20.14	8.15
$T_{28}(OSAV_3)$	0.0	2.68	4.07	6.41	12.93	18.02	7.35
$T_{29}(OSAV_4)$	0.0	2.59	3.80	6.20	10.50	16.63	6.62
$T_{30}(OSAV_5)$	0.0	2.53	3.73	6.01	8.75	14.88	5.98
$T_{31}(OSNO_0)$	0.0	5.34	10.24	13.95	17.56	27.03	12.35
$T_{32}(OSNO_{0.5})$	0.0	2.83	4.62	7.00	14.42	24.14	8.34
$T_{33}(OSNO_{1.0})$	0.0	2.73	4.32	6.80	13.93	20.83	8.10
$T_{34}(OSNO_{1.5})$	0.0	2.35	3.98	6.56	12.79	18.29	7.33
$T_{35}(OSNO_{2.0})$	0.0	2.57	3.53	6.15	10.09	16.95	6.54
$T_{36}(OSNO_{2.5})$	0.0	2.48	3.49	5.82	8.28	15.31	5.89
$T_{37}(PAV_0)$	0.0	4.20	7.00	12.15	16.11	20.54	10.00
$T_{38}(PAV_1)$	0.0	3.69	6.28	9.65	12.72	16.76	8.18
$T_{39}(PAV_2)$	0.0	3.65	6.05	9.14	12.46	16.39	7.94
$T_{40}(PAV_3)$	0.0	3.45	5.70	8.96	12.27	16.13	7.75
$T_{41}(PAV_4)$	0.0	3.36	5.61	8.55	12.02	15.69	7.53
$T_{42}(PAV_5)$	0.0	3.26	5.12	8.32	11.79	15.25	7.29

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_{43}(PNO_0)$	0.0	3.66	6.56	10.66	13.96	20.85	9.28
$T_{44}(PNO_{0.5})$	0.0	3.51	6.09	9.33	12.56	17.37	8.14
$T_{45}(PNO_{1.0})$	0.0	3.24	5.71	8.94	12.24	16.58	7.79
$T_{46}(PNO_{1.5})$	0.0	3.11	5.60	8.55	11.46	16.45	7.52
$T_{47}(PNO_{2.0})$	0.0	2.97	5.13	8.16	11.14	16.20	7.27
$T_{48}(PNO_{2.5})$	0.0	2.79	4.67	7.71	10.59	15.91	6.95
CD at 5%	-	0.58	0.65	0.76	0.84	0.92	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

recorded upto 21 days followed by decline whereas the TSS in treated fruits continue to increase upto 35 days. The TSS in untreated fruits was found to increase significantly faster than the fruits treated with *Aloe vera* gel and neem oil during storage. Among the botanicals retention of TSS was found better in the fruits treated with *Aloe vera* gel as compared to neem oil (Table 2). Change in TSS content as observed in the present study might be due to the hydrolytic conversion of polysaccharides into soluble sugars as is the case in many climacteric fruits during ripening process. The increase in TSS and sugar contents during the initial period of storage is mainly attributed to breakdown of starch and other complex carbohydrates into simple sugars due to the increased activity of amylase and other enzymes resulting in gluceneogenesis and conversion into sucrose, glucose and fructose during storage (Rathore *et al*., 16).

A significant effect on the titratable acidity of apple fruits treated with *Aloe vera* gel and neem oil was also recorded during the storage period. It was found that the acidity decreased faster in the untreated fruits whereas retention of acidity was better in the *Aloe vera* gel treated fruits compared to neem oil (Table 3). The reduction in titratable acidity during storage might also be due to the conversion of organic acids into sugars to meet the energy demands in fruits undergoing the ripening process. The edible coatings like carboxymethyl cellulose, *Aloe vera* gel and chitosan had significant effect on different quality parameters of pear fruits during storage at low temperature as compared to control (Jawandha *et al*., 10). Krishna and Rao (12) found that guava fruits treated with 1% chitosan and stored ate ambient temperature maintained various quality parameters for 21 days compared to control. Out of different concentrations (0, 25, 50 and 75%) of *Aloe vera* gel and chitosan (1%), 50 and 75% concentrations of *Aloe vera* significantly increased the shelf life evidenced by reduced decrease in titratable acidity both at 15-25°C and 13°C. The titratable acidity, colour and ascorbic acid in mango decreased at a slow rate as compared to control. Soluble solid contents and percentage titratable acidity was recorded higher for 'Granny Smith' apple fruits treated with *Aloe vera* gel (5 and 10%) as reported by Ergun and Satici (7).

Further, the ascorbic acid (mg/100g) content in the apple fruits treated with the botanicals was found to reduce significantly during storage with better retention in the fruits treated with *Aloe vera* gel compared to neem oil (Table 4). The reduction

Table 2. Effect of different concentrations of *Aloe vera* gel and neem oil on the total soluble solids (TSS°B) of four varieties of apple stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	13.0	13.6	14.2	15.0	14.6	14.2	14.1
$T_2(SSAV_1)$	13.0	13.4	14.0	14.4	14.6	14.8	14.0
$T_3(SSAV_2)$	13.0	13.3	13.8	14.0	14.4	14.6	13.8
$T_4(SSAV_3)$	13.0	13.2	13.6	13.8	14.0	14.4	13.7
$T_5(SSAV_4)$	13.0	13.1	13.4	13.6	13.8	14.0	13.5
$T_6(SSAV_5)$	13.0	13.0	13.2	13.4	13.6	13.8	13.3
$T_7(SSNO_0)$	13.0	13.5	14.0	14.6	15.0	14.6	14.1

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_8(SSNO_{0.5})$	13.0	13.4	13.8	14.2	14.6	15.0	14.0
$T_9(SSNO_{1.0})$	13.0	13.4	13.7	14.0	14.4	14.8	13.9
$T_{10}(SSNO_{1.5})$	13.0	13.3	13.6	13.8	14.2	14.6	13.8
$T_{11}(SSNO_{2.0})$	13.0	13.2	13.4	13.6	14.0	14.4	13.6
$T_{12}(SSNO_{2.5})$	13.0	13.1	13.3	13.5	13.8	14.0	13.4
$T_{13}(SKAV_0)$	10.0	10.6	11.0	11.4	12.2	11.8	11.1
$T_{14}(SKAV_1)$	10.0	10.5	10.8	11.2	11.6	12.2	11.0
$T_{15}(SKAV_2)$	10.0	10.4	10.6	10.8	11.2	11.8	10.8
$T_{16}(SKAV_3)$	10.0	10.3	10.5	10.6	11.0	11.6	10.6
$T_{17}(SKAV_4)$	10.0	10.2	10.4	10.5	10.8	11.4	10.5
$T_{18}(SKAV_5)$	10.0	10.0	10.2	10.4	10.6	11.0	10.3
$T_{19}(SKNO_0)$	10.0	10.5	10.8	11.4	12.4	12.0	11.2
$T_{20}(SKNO_{0.5})$	10.0	10.4	10.7	11.2	11.8	12.4	11.1
$T_{21}(SKNO_{1.0})$	10.0	10.3	10.6	11.0	11.6	12.2	11.0
$T_{22}(SKNO_{1.5})$	10.0	10.2	10.4	10.8	11.4	12.0	10.8
$T_{23}(SKNO_{2.0})$	10.0	10.1	10.3	10.6	11.2	11.8	10.7
$T_{24}(SKNO_{2.5})$	10.0	10.0	10.2	10.4	11.0	11.6	10.5
$T_{25}(OSAV_0)$	12.0	12.8	13.4	13.8	14.4	14.0	13.4
$T_{26}(OSAV_1)$	12.0	12.6	13.2	13.6	14.0	14.4	13.3
$T_{27}(OSAV_2)$	12.0	12.5	13.0	13.4	13.8	14.2	13.1
$T_{28}(OSAV_3)$	12.0	12.4	12.8	13.2	13.6	14.0	13.0
$T_{29}(OSAV_4)$	12.0	12.2	12.5	13.0	13.3	13.8	12.8
$T_{30}(OSAV_5)$	12.0	12.1	12.4	12.8	13.0	13.2	12.6
$T_{31}(OSNO_0)$	12.0	12.6	13.4	14.0	14.6	13.8	13.4
$T_{32}(OSNO_{0.5})$	12.0	12.4	13.0	13.8	14.2	14.6	13.3
$T_{33}(OSNO_{1.0})$	12.0	12.3	12.8	13.6	14.0	14.4	13.2
$T_{34}(OSNO_{1.5})$	12.0	12.2	12.6	13.4	13.8	14.2	13.0
$T_{35}(OSNO_{2.0})$	12.0	12.1	12.4	12.8	13.6	14.0	12.8
$T_{36}(OSNO_{2.5})$	12.0	12.0	12.2	12.6	13.2	13.4	12.7
$T_{37}(PAV_0)$	11.0	11.8	12.6	13.2	13.8	13.4	12.6
$T_{38}(PAV_1)$	11.0	11.6	12.4	13.0	13.6	14.0	12.6
$T_{39}(PAV_2)$	11.0	11.4	12.2	12.8	13.4	13.8	12.4
$T_{40}(PAV_3)$	11.0	11.3	12.0	12.6	13.2	13.6	12.3
$T_{41}(PAV_4)$	11.0	11.2	11.8	12.4	13.0	13.4	12.1
$T_{42}(PAV_5)$	11.0	11.1	11.6	12.2	12.8	13.2	12.0
$T_{43}(PNO_0)$	11.0	11.6	12.4	13.2	14.0	13.2	12.5
$T_{44}(PNO_{0.5})$	11.0	11.5	12.2	13.0	13.8	14.2	12.6
$T_{45}(PNO_{1.0})$	11.0	11.4	12.0	12.8	13.6	14.0	12.4
$T_{46}(PNO_{1.5})$	11.0	11.3	11.8	12.6	13.4	13.8	12.3
$T_{47}(PNO_{2.0})$	11.0	11.2	11.6	12.4	13.2	13.6	12.2
$T_{48}(PNO_{2.5})$	11.0	11.0	11.4	12.0	12.6	13.4	12.0
CD 0.05	0.14	0.18	0.21	0.25	0.28	0.34	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

Table 3. Titratable acidity (%) of four varieties of apple affected by different concentrations of *Aloe vera* gel and neem oil stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	0.502	0.495	0.482	0.469	0.457	0.448	0.475
$T_2(SSAV_1)$	0.502	0.498	0.486	0.474	0.464	0.456	0.480
$T_3(SSAV_2)$	0.502	0.499	0.490	0.482	0.474	0.464	0.485
$T_4(SSAV_3)$	0.502	0.500	0.494	0.488	0.479	0.470	0.488
$T_5(SSAV_4)$	0.502	0.501	0.496	0.490	0.484	0.474	0.491
$T_6(SSAV_5)$	0.502	0.502	0.498	0.492	0.488	0.482	0.494
$T_7(SSNO_0)$	0.502	0.496	0484	0.472	0.460	0.446	0.476
$T_8(SSNO_{0.5})$	0.502	0.498	0.488	0.476	0.468	0.454	0.481
$T_9(SSNO_{1.0})$	0.502	0.499	0.492	0.484	0.478	0.460	0.485
$T_{10}(SSNO_{1.5})$	0.502	0.500	0.496	0.490	0.482	0.474	0.490
$T_{11}(SSNO_{2.0})$	0.502	0.501	0.498	0.494	0.480	0.470	0.492
$T_{12}(SSNO_{2.5})$	0.502	0.502	0.500	0.496	0.490	0.480	0.495
$T_{13}(SKAV_0)$	0.402	0.394	0.380	0.370	0.358	0.346	0.375
$T_{14}(SKAV_1)$	0.402	0.396	0.384	0.374	0.364	0.356	0.379
$T_{15}(SKAV_2)$	0.402	0.398	0.388	0.379	0.370	0.364	0.383
$T_{16}(SKAV_3)$	0.402	0.399	0.390	0.384	0.376	0.370	0.386
$T_{17}(SKAV_4)$	0.402	0.400	0.394	0.388	0.380	0.374	0.389
$T_{18}(SKAV_5)$	0.402	0.401	0.398	0.390	0.384	0.368	0.399
$T_{19}(SKNO_0)$	0.402	0.392	0.384	0.372	0.368	0.352	0.378
$T_{20}(SKNO_{0.5})$	0.402	0.393	0.386	0.378	0.372	0.360	0.381
$T_{21}(SKNO_{1.0})$	0.402	0.395	0.389	0.386	0.378	0.366	0.386
$T_{22}(SKNO_{1.5})$	0.402	0.396	0.392	0.388	0.382	0.374	0.389
$T_{23}(SKNO_{2.0})$	0.402	0.398	0.394	0.390	0.386	0.378	0.391
$T_{24}(SKNO_{2.5})$	0.402	0.400	0.396	0.392	0.388	0.390	0.394
$T_{25}(OSAV_0)$	0.502	0.494	0.486	0.472	0.460	0.452	0.477
$T_{26}(OSAV_1)$	0.502	0.496	0.488	0.476	0.470	0.466	0.483
$T_{27}(OSAV_2)$	0.502	0.497	0.490	0.482	0.476	0.474	0.486
$T_{28}(OSAV_3)$	0.502	0.498	0.494	0.486	0.480	0.478	0.489
$T_{29}(OSAV_4)$	0.502	0.499	0.496	0.490	0.488	0.486	0.493
$T_{30}(OSAV_5)$	0.502	0.500	0.498	0.494	0.492	0.490	0.496
$T_{31}(OSNO_0)$	0.502	0.492	0.486	0.474	0.462	0.454	0.478
$T_{32}(OSNO_{0.5})$	0.502	0.494	0.488	0.479	0.468	0.462	0.482
$T_{33}(OSNO_{1.0})$	0.502	0.495	0.491	0.484	0.474	0.470	0.486
$T_{34}(OSNO_{1.5})$	0.502	0.496	0.492	0.486	0.478	0.474	0.488
$T_{35}(OSNO_{2.0})$	0.502	0.498	0.494	0.488	0.482	0.478	0.490
$T_{36}(OSNO_{2.5})$	0.502	0.500	0.498	0.492	0.488	0.486	0.494
$T_{37}(PAV_0)$	0.670	0.662	0.654	0.648	0.640	0.634	0.651
$T_{38}(PAV_1)$	0.670	0.664	0.658	0.650	0.643	0.637	0.653
$T_{39}(PAV_2)$	0.670	0.665	0.660	0.654	0.648	0.642	0.656
$T_{40}(PAV_3)$	0.670	0.666	0.662	0.656	0.652	0.645	0.658
$T_{41}(PAV_4)$	0.670	0.668	0.664	0.659	0.653	0.649	0.660
$T_{42}(PAV_5)$	0.670	0.670	0.668	0.662	0.656	0.652	0.663

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_{43}(PNO_0)$	0.670	0.663	0.655	0.649	0.641	0.635	0.652
$T_{44}(PNO_{0.5})$	0.670	0.665	0.659	0.653	0.647	0.639	0.655
$T_{45}(PNO_{1.0})$	0.670	0.666	0.662	0.655	0.650	0.644	0.657
$T_{46}(PNO_{1.5})$	0.670	0.667	0.664	0.657	0.654	0.647	0.659
$T_{47}(PNO_{2.0})$	0.670	0.668	0.666	0.659	0.656	0.649	0.661
$T_{48}(PNO_{2.5})$	0.670	0.669	0.667	0.661	0.659	0.657	0.663
CD 0.05	0.012	0.014	0.015	0.017	0.019	0.022	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

may be attributed to the oxidation of ascorbic acid to dehydro-ascorbic acid during storage. The untreated fruits in all the varieties of apple showed a faster reduction in the ascorbic acid content. Ascorbic acid is sensitive to storage temperature and availability of free oxygen which may cause accelerated enzymatic oxidation of L-ascorbic acid into dehydro ascorbic acid (Piga *et al*., 14).

Table 4. Effect of different concentrations of *Aloe vera* gel and neem oil on the ascorbic acid (mg/100g) contents of four varieties of apple stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	9.09	8.82	8.60	8.42	8.27	8.14	8.55
$T_2(SSAV_1)$	9.09	8.87	8.69	8.55	8.45	8.37	8.67
$T_3(SSAV_2)$	9.09	8.90	8.74	8.61	8.51	8.44	8.72
$T_4(SSAV_3)$	9.09	8.92	8.77	8.64	8.53	8.46	8.74
$T_5(SSAV_4)$	9.09	8.92	8.81	8.70	8.61	8.54	8.77
$T_6(SSAV_5)$	9.09	8.94	8.85	8.76	8.69	8.64	8.82
$T_7(SSNO_0)$	9.09	8.96	8.62	8.44	8.30	8.17	8.60
$T_8(SSNO_{0.5})$	9.09	8.83	8.71	8.58	8.48	8.35	8.67
$T_9(SSNO_{1.0})$	9.09	8.91	8.75	8.66	8.54	8.42	8.72
$T_{10}(SSNO_{1.5})$	9.09	8.93	8.79	8.69	8.57	8.44	8.75
$T_{11}(SSNO_{2.0})$	9.09	8.95	8.83	8.73	8.65	8.49	8.79
$T_{12}(SSNO_{2.5})$	9.09	8.98	8.87	8.79	8.69	8.58	8.83
$T_{13}(SKAV_0)$	7.27	7.02	6.80	6.62	6.48	6.38	6.76
$T_{14}(SKAV_1)$	7.27	7.04	6.84	6.67	6.53	6.44	6.79
$T_{15}(SKAV_2)$	7.27	7.07	6.88	6.71	6.57	6.49	6.83
$T_{16}(SKAV_3)$	7.27	7.10	6.91	6.75	6.62	6.54	6.86
$T_{17}(SKAV_4)$	7.27	7.13	6.95	6.79	6.67	6.59	6.90
$T_{18}(SKAV_5)$	7.27	7.17	7.02	6.85	6.77	6.65	6.95
$T_{19}(SKNO_0)$	7.27	7.03	6.82	6.65	6.51	6.35	6.77
$T_{20}(SKNO_{0.5})$	7.27	7.05	6.86	6.69	6.57	6.40	6.80
$T_{21}(SKNO_{1.0})$	7.27	7.08	6.90	6.73	6.61	6.46	6.84
$T_{22}(SKNO_{1.5})$	7.27	7.11	6.93	6.77	6.65	6.51	6.87
$T_{23}(SKNO_{2.0})$	7.27	7.15	6.97	6.83	6.69	6.56	6.91
$T_{24}(SKNO_{2.5})$	7.27	7.19	7.05	6.88	6.81	6.62	6.97
$T_{25}(OSAV_0)$	7.27	7.01	6.82	6.64	6.50	6.41	6.77
$T_{26}(OSAV_1)$	7.27	7.05	6.85	6.67	6.55	6.46	6.80
$T_{27}(OSAV_2)$	7.27	7.08	6.89	6.71	6.59	6.51	6.84
$T_{28}(OSAV_3)$	7.27	7.11	6.93	6.75	6.62	6.56	6.87
$T_{29}(OSAV_4)$	7.27	7.15	6.96	6.81	6.69	6.62	6.91
$T_{30}(OSAV_5)$	7.27	7.18	7.00	6.89	6.78	6.67	6.96
$T_{31}(OSNO_0)$	7.27	7.01	6.79	6.61	6.51	6.42	6.76
$T_{32}(OSNO_{0.5})$	7.27	7.03	6.85	6.70	6.55	6.47	6.81
$T_{33}(OSNO_{1.0})$	7.27	7.05	6.85	6.70	6.55	6.47	6.82
$T_{34}(OSNO_{1.5})$	7.27	7.08	6.89	6.73	6.60	6.51	6.84
$T_{35}(OSNO_{2.0})$	7.27	7.11	6.93	6.77	6.65	6.56	6.88
$T_{36}(OSNO_{2.5})$	7.27	7.15	7.00	6.83	6.75	6.63	6.93
$T_{37}(PAV_0)$	4.85	4.60	4.37	4.16	3.97	3.80	4.29
$T_{38}(PAV_1)$	4.85	4.64	4.43	4.25	4.05	3.87	4.34
$T_{39}(PAV_2)$	4.85	4.69	4.47	4.29	4.08	3.95	4.38
$T_{40}(PAV_3)$	4.85	4.73	4.53	4.34	4.12	3.99	4.42
$T_{41}(PAV_4)$	4.85	4.77	4.59	4.39	4.17	4.04	4.46
$T_{42}(PAV_5)$	4.85	4.80	4.65	4.45	4.27	4.13	4.52
$T_{43}(PNO_0)$	4.85	4.62	4.40	4.21	4.01	3.85	4.32
$T_{44}(PNO_{0.5})$	4.85	4.67	4.45	4.29	4.07	3.89	4.37
$T_{45}(PNO_{1.0})$	4.85	4.71	4.50	4.33	4.11	3.97	4.41
$T_{46}(PNO_{1.5})$	4.85	4.76	4.56	4.37	4.15	4.03	4.45
$T_{47}(PNO_{2.0})$	4.85	4.80	4.63	4.45	4.20	4.07	4.50
$T_{48}(PNO_{2.5})$	4.85	4.83	4.67	4.49	4.33	4.17	4.55
CD 0.05	0.16	0.19	0.23	0.26	0.28	0.31	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

A significant effect on the carotene content of different varieties of apple fruits treated with botanicals was recorded. The fruits treated with *Aloe vera* gel showed better retention of total carotene content as compared to neem oil treated fruits whereas in the untreated fruits the carotene content was found to decrease very fast (Table 5). Better retention of total carotenoid contents in the fruits treated with *Aloe vera* gel could be attributed due to checking of respiration rate during storage. The total antioxidants (mMTE/L) in the apple fruits treated with the botanicals were also found to decrease significantly during storage with a faster rate in the untreated fruits as compared to *Aloe vera* gel and neem oil. Among the botanicals *Aloe vera* gel showed better retention of antioxidants as compared to neem oil (Table 6) which could be attributed due to slow respiration in the former than latter. The guava fruits treated with 300 ppm n-propyl gallate had a better shelf life of for 3 weeks compared to control (Gill *et al*., 9).

From the study it can be concluded that apple fruits which are spoiled very fast after harvest could

Table 5. Total carotenoids (µg/100g) content of four varieties of apple affected by different concentrations of *Aloe vera* gel and neem oil stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	38.57	38.22	37.92	37.62	37.32	37.00	37.77
$T_2(SSAV_1)$	38.57	38.30	38.06	37.85	37.70	37.57	38.00
$T_3(SSAV_2)$	38.57	38.37	38.10	37.92	37.78	37.65	38.06
$T_4(SSAV_3)$	38.57	38.43	38.15	37.97	37.84	37.72	38.11
$T_5(SSAV_4)$	38.57	38.47	38.22	38.04	37.93	37.79	38.17
$T_6(SSAV_5)$	38.57	38.52	38.29	38.12	37.98	37.89	38.22
$T_7(SSNO_0)$	38.57	38.25	37.97	37.67	37.38	37.04	37.81
$T_8(SSNO_{0.5})$	38.57	38.28	38.08	37.87	37.74	37.52	38.01
$T_9(SSNO_{1.0})$	38.57	38.40	38.13	37.96	37.81	37.62	38.08
$T_{10}(SSNO_{1.5})$	38.57	38.45	38.19	38.02	37.89	37.69	38.13
$T_{11}(SSNO_{2.0})$	38.57	38.49	38.27	38.08	37.98	37.77	38.19
$T_{12}(SSNO_{2.5})$	38.57	38.54	38.37	38.20	38.05	37.86	38.26
$T_{13}(SKAV_0)$	15.23	14.87	14.53	14.18	13.95	13.67	14.40
$T_{14}(SKAV_1)$	15.23	14.98	14.67	14.29	14.07	13.83	14.51
$T_{15}(SKAV_2)$	15.23	15.04	14.78	14.43	14.18	13.96	14.60
$T_{16}(SKAV_3)$	15.23	15.09	14.87	14.59	14.27	14.04	14.68
$T_{17}(SKAV_4)$	15.23	15.12	14.94	14.67	14.43	14.12	14.75
$T_{18}(SKAV_5)$	15.23	15.15	15.06	14.89	14.73	14.23	14.88
$T_{19}(SKNO_0)$	15.23	14.90	14.59	14.24	13.99	13.65	14.43
$T_{20}(SKNO_{0.5})$	15.23	15.02	14.73	14.35	14.12	13.80	14.54
$T_{21}(SKNO_{1.0})$	15.23	15.07	14.84	14.49	14.23	13.90	14.62
$T_{22}(SKNO_{1.5})$	15.23	15.11	14.92	14.62	14.34	14.00	14.70
$T_{23}(SKNO_{2.0})$	15.23	15.14	14.98	14.76	14.49	14.08	14.78
$T_{24}(SKNO_{2.5})$	15.23	15.18	15.09	14.93	14.79	14.15	14.89
$T_{25}(OSAV_0)$	19.29	19.02	18.78	18.53	18.27	18.02	18.65
$T_{26}(OSAV_1)$	19.29	19.07	18.87	18.59	18.39	18.18	18.73
$T_{27}(OSAV_2)$	19.29	19.11	18.95	18.63	18.47	18.27	18.78
$T_{28}(OSAV_3)$	19.29	19.15	19.00	18.77	18.60	18.42	18.87
$T_{29}(OSAV_4)$	19.29	19.19	19.06	18.86	18.69	18.53	18.93
$T_{30}(OSAV_5)$	19.29	19.23	19.12	18.98	18.77	18.65	19.00
$T_{31}(OSNO_0)$	19.29	19.04	18.80	18.57	18.34	17.97	18.66
$T_{32}(OSNO_{0.5})$	19.29	19.09	18.90	18.64	18.43	18.15	18.75

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_{33}(OSNO_{1.0})$	19.29	19.12	18.97	18.69	18.54	18.23	18.80
$T_{34}(OSNO_{1.5})$	19.29	19.17	19.05	18.84	18.65	18.37	18.89
$T_{35}(OSNO_{2.0})$	19.29	19.20	19.14	18.94	18.85	18.50	18.98
$T_{36}(OSNO_{2.5})$	19.29	19.25	19.17	19.05	18.90	18.57	19.03
$T_{37}(PAV_0)$	37.80	37.40	37.05	36.76	36.52	36.18	36.95
$T_{38}(PAV_1)$	37.80	37.54	37.26	37.03	36.83	36.60	37.17
$T_{39}(PAV_2)$	37.80	37.65	37.38	37.12	36.97	36.76	37.28
$T_{40}(PAV_3)$	37.80	37.67	37.49	37.19	37.00	36.87	37.33
$T_{41}(PAV_4)$	37.80	37.72	37.57	37.28	37.09	36.96	37.40
$T_{42}(PAV_5)$	37.80	37.75	37.65	37.38	37.17	37.05	37.46
$T_{43}(PNO_0)$	37.80	37.43	37.09	36.87	36.60	36.12	36.98
$T_{44}(PNO_{0.5})$	37.80	37.59	37.34	37.07	36.89	36.48	37.20
$T_{45}(PNO_{1.0})$	37.80	37.67	37.45	37.10	37.00	36.70	37.28
$T_{46}(PNO_{1.5})$	37.80	37.69	37.51	37.23	37.05	36.75	37.33
$T_{47}(PNO_{2.0})$	37.80	37.74	37.60	37.34	37.13	36.85	37.41
$T_{48}(PNO_{2.5})$	37.80	37.77	37.69	37.45	37.24	36.94	37.48
CD 0.05	0.782	0.797	0.812	0.831	0.847	0.865	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

Table 6. Effect of different concentrations of *Aloe vera* gel and neem oil on the total antioxidants (mMTE/L) of four varieties of apple stored at ambient temperature.

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_1(SSAV_0)$	4.95	4.69	4.42	4.11	3.83	3.48	4.24
$T_2(SSAV_1)$	4.95	4.77	4.55	4.27	4.05	3.79	4.39
$T_3(SSAV_2)$	4.95	4.81	4.63	4.35	4.09	3.87	4.45
$T_4(SSAV_3)$	4.95	4.85	4.69	4.39	4.16	3.94	4.49
$T_5(SSAV_4)$	4.95	4.87	4.73	4.45	4.23	3.98	4.54
$T_6(SSAV_5)$	4.95	4.91	4.79	4.52	4.28	4.06	4.58
$T_7(SSNO_0)$	4.95	4.71	4.47	4.16	3.87	3.55	4.28
$T_8(SSNO_{0.5})$	4.95	4.79	4.59	4.34	4.07	3.75	4.42
$T_9(SSNO_{1.0})$	4.95	4.86	4.71	4.43	4.21	3.85	4.50
$T_{10}(SSNO_{1.5})$	4.95	4.88	4.75	4.49	4.26	3.90	4.53
$T_{11}(SSNO_{2.0})$	4.95	4.90	4.77	4.52	4.28	3.96	4.56
$T_{12}(SSNO_{2.5})$	4.95	4.93	4.83	4.56	4.32	4.08	4.61
$T_{13}(SKAV_0)$	9.82	9.58	9.32	9.03	8.71	8.37	9.13
$T_{14}(SKAV_1)$	9.82	9.63	9.32	9.09	8.87	8.48	9.20
$T_{15}(SKAV_2)$	9.82	9.66	9.42	9.13	8.93	8.55	9.25
$T_{16}(SKAV_3)$	9.82	9.69	9.53	9.17	8.97	8.59	9.29
$T_{17}(SKAV_4)$	9.82	9.73	9.59	9.23	9.05	8.67	9.34
$T_{18}(SKAV_5)$	9.82	9.76	9.63	9.29	9.18	8.79	9.41
$T_{19}(SKNO_0)$	9.82	9.60	9.35	9.06	8.75	8.31	9.14
$T_{20}(SKNO_{0.5})$	9.82	9.65	9.47	9.12	8.91	8.43	9.23

Treatment	Storage period (Days)						
	0	7	14	21	28	35	Mean
$T_{21}(SKNO_{1.0})$	9.82	9.68	9.51	9.17	8.95	8.51	9.27
$T_{22}(SKNO_{1.5})$	9.82	9.71	9.55	9.21	9.01	8.56	9.31
$T_{23}(SKNO_{2.0})$	9.82	9.75	9.68	9.34	9.09	8.63	9.39
$T_{24}(SKNO_{2.5})$	9.82	9.77	9.71	9.37	9.22	8.75	9.44
$T_{25}(OSAV_{0})$	13.24	12.92	12.65	12.32	12.06	11.85	12.50
$T_{26}(OSAV_{1})$	13.24	12.98	12.74	12.39	12.11	11.97	12.57
$T_{27}(OSAV_{2})$	13.24	13.03	12.79	12.45	12.17	12.03	12.61
$T_{28}(OSAV_{3})$	13.24	13.08	12.85	12.51	12.22	12.08	12.66
$T_{29}(OSAV_{4})$	13.24	13.11	12.89	12.56	12.27	12.13	12.70
$T_{30}(OSAV_{5})$	13.24	13.15	12.96	12.63	12.33	12.19	12.75
$T_{31}(OSNO_{0})$	13.24	12.95	12.67	12.36	12.09	11.82	12.52
$T_{32}(OSNO_{0.5})$	13.24	13.00	12.83	12.44	12.21	11.98	12.61
$T_{33}(OSNO_{1.0})$	13.24	13.05	12.87	12.49	12.26	12.05	12.66
$T_{34}(OSNO_{1.5})$	13.24	13.11	12.91	12.56	12.33	12.08	12.70
$T_{35}(OSNO_{2.0})$	13.24	13.14	12.94	12.60	12.35	12.10	12.73
$T_{36}(OSNO_{2.5})$	13.24	13.18	13.00	12.65	12.39	12.15	12.77
$T_{37}(PAV_{0})$	3.86	3.60	3.32	3.07	2.82	2.64	3.22
$T_{38}(PAV_{1})$	3.86	3.63	3.38	3.12	2.89	2.69	3.26
$T_{39}(PAV_{2})$	3.86	3.67	3.43	3.16	2.94	2.73	3.29
$T_{40}(PAV_{3})$	3.86	3.70	3.47	3.24	2.99	2.75	3.34
$T_{41}(PAV_{4})$	3.86	3.73	3.51	3.29	3.04	2.79	3.37
$T_{42}(PAV_{5})$	3.86	3.79	3.57	3.35	3.09	2.85	3.42
$T_{43}(PNO_{0})$	3.86	3.62	3.35	3.10	2.86	2.61	3.23
$T_{44}(PNO_{0.5})$	3.86	3.65	3.43	3.15	2.93	2.65	3.27
$T_{45}(PNO_{1.0})$	3.86	3.68	3.45	3.19	2.98	2.69	3.31
$T_{46}(PNO_{1.5})$	3.86	3.72	3.49	3.27	3.03	2.73	3.35
$T_{47}(PNO_{2.0})$	3.86	3.75	3.57	3.32	3.07	2.76	3.39
$T_{48}(PNO_{2.5})$	3.86	3.82	3.61	3.39	3.11	2.80	3.43
CD 0.05	0.022	0.027	0.032	0.037	0.040	0.042	-

SS: Skyline Supreme, SK: Starkrimson, OS: Oregon Spur, P: Prima, AV: *Aloe vera*, NO: Neem oil, 0: Control, 1: 1%, 2:2%, 3: 3%, 4: 4%, 5: 5%, 0.5: 0.5%, 1.0: 1%, 1.5: 1.5%, 2.0: 2%, 2.5:2.5%

be stored between 28-35 days without much loss (5.70 to 6.95%) in the bio-chemical and quality parameters after treating with 5% *Aloe vera* gel and 2.5% neem oil. These botanicals are safe as there is no side effect after consuming the treated fruits. In fact, it can be considered as a green alternative to synthetic coatings and other postharvest chemical treatments. These natural coatings inhibit microbial spoilage and reduce decay incidence during postharvest storage of apple. *Aloe vera* gel and neem oil have different properties for which they were used to enhance the shelf life of apple separately. However, for their interaction effect on the shelf life and marketable quality of apple during storage needs further studies.

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