

Full length Research paper

# The Effect of *Aloe vera* gel coating on Postharvest Quality of Avocado (*Persea americana* Mill.) Fruits.

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**Aloe vera gel has been proven one of the best edible and biologically safe preservative coatings for different types of foods because of its film-forming properties, antimicrobial actions, biodegradability and biochemical properties. It 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. This study was planned to investigate the role of aloe gel coating in improving post harvest quality, shelf life, sugar and antioxidant (as carotenoid) content of avocado fruit. The experiment was laid in completely randomized design (CRD) in two replications. The result indicated that significant difference between control and aloe gel treated groups were observed for all physico-chemical fruit quality parameters including weight loss, % vitamin C, %chlorophyll, % carotenod, % titrable acidity and %reducing sugar contents during postharvest storage of avocado fruit samples. It was demonstrated that ascorbic acid content was increasing in control group during postharvest avocado fruit ripening but no significance difference in ascorbic acid content among treatments. Carotenoid and reducing sugar contents were increasing while weight loss, chlorophyll and vitamin C contents were decreasing during postharvest ripening of avocado fruits. The highest mean vitamin C, carotenoid and sugar contents were observed for control group showing that treatment with aloe gel solution can delay ripening of avocado fruit. Principal component analysis (PCA) indicated reducing sugars, carotenoid and total acidity having close PC1 and PC2 scores (with vector angle  $<90^{\circ}$ ) showing similar/correlated effects while reducing sugars and/or carotenoids with chlorophyll content, weight loss and vitamin C contents have vector angle greater than  $90^{\circ}$  showing opposite effects or more divergence. Further studies are required on the effect of storage conditions, cultivar differences and environments on fruit quality parameters.**

**Keywords:** Carotenoid content, physico-chemical property, Reducing sugars, shelf life, Total acidity, Vitamin C.

## INTRODUCTION

Avocado (*Persea americana* Mill) is the only one commercial important member between edible fruit which belong to *Lauraceae* family, it is originated in Central America and Mexico( Garbanzo, 2010). Avocado is a sub-tropical, climacteric fruit that is exported in large quantities from sub- tropical countries such as Mexico and South Africa (FAO, 2013). However, the fruit has a very fast ripening rate and suffers flesh browning and softening, all of which reduce their quality and marketability.

Generally the quality of any fresh fruit deteriorates

when it comes out of the producers storage facilities and is transferred to the wholesalers storage. Also, interruptions can occur in the cold chain occur during transit and have a detrimental effect on fruit quality (Dodd *et al.*, 2007).

The application of exogenous organic acids such as gibberellic acid, malic acid, oxalic acid, citric acid, and salicylic acid, calcium chloride ( $\text{CaCl}_2$ ) has been found to affect fruit quality and induce stress tolerance (Zheng *et al.*, 2011). These organic acids mainly function in maintaining the ability to inhibit  $\text{O}_2^-$  accumulation, delaying  $\text{H}_2\text{O}_2$  decrease (Ding *et al.*, 2007), enhancing antioxidant enzyme activities and increasing the expression of senescence-related proteins or defense proteins (Wang *et al.*, 2009) to keep the fruit in good quality during storage. *Aloe vera* gel-based edible coatings have been

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shown to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in fruits such as table grapes (Castillo *et al.*, 2010), sweet cherries Martinez-Romero *et al.*, 2006) and nectarines (Ahmed *et al.*, 2009).

Reduction of post-harvest losses and quality deterioration are essential in increasing food availability from the existing production. Minimizing this loss has a great significance for food security, economic growth and welfare of the society. In Ethiopia, limited studies are found on postharvest management of horticultural crops despite huge potential for production of horticultural crops such as avocado. In light of this justification, the present study was planned to investigate the effect of aloe vera gel coatings on postharvest management of avocado fruits.

## MATERIALS AND METHODS

The experiment was conducted in Biotechnology Laboratory, Haramaya University. Avocado fruits were collected from farm land in Erere district, Harari Regional State, Ethiopia. The mature green fruits were collected and immediately brought in a polystyrene bag to Biotechnology Laboratory of the university. Fruits were left for 22 hrs (after harvest) at room temperature in order to stabilize ethylene evolution caused by wounding.

### Experimental Design and Treatments

The experimental design was completely randomized design (RCBD) in two replications. Of the collected avocado fruit samples, 20 fruits of uniform size with no bruises or damage were selected. Fruit sample was surface sterilized with sodium hypochlorite solution (500 ppm) for 10 minutes so as to reduce fungal infection and air-dried for approximately 15 minutes.

### Sample Preparations

Fresh *Aloe vera* leaves were harvested. Aloe gel matrix lies underneath the green outer leaf rind. The gel matrix was separated from the outer cortex of leaves and this colorless hydroparenchyma was ground in a blender. The resulting mixture was then filtered to remove the fibers. The liquid obtained was the fresh Aloe gel (AG; 100%). The Aloe gel was pasteurized at 70°C for 45 min. It was then cooled immediately at ambient temperature. Aloe gel concentrations of 30%, 40%, and 50% (v/v) were prepared by dissolving respective volume of homogenized aloe gel in hot distilled water. After surface sterilization, the fruit sample was immersed for five minutes in solutions of 0%, 30%, 40%, 50%(v/v) aloe gel, and air-dried at room temperature for 1h. The surface-dried fruit sample was individually packaged in perforated

plastic bags to maintain relative humidity. Each bag was packaged in a 1L disposable container. All packages were sealed and stored at room temperature for 12 days. The treated groups were evaluated in each treatment at 1st, 6th and 12th days of treatment, and fruits were assessed for different quality parameters such as physiological weight loss, vitamin C (ascorbic acid) content, titratable acidity, total carotenoids, and chlorophylls, reducing sugars on 1st, 6th and 12th days following the method used by Alberio *et al.* (2015).

## Data Collection and Analysis

### Physiological Loss of Weight

Weight loss was determined by using method indicated by Akbudak, (2007) periodically (on 1st, 6th, and 12th days of storage) by weighing avocado fruit samples using digital balance (Denver Instrument XL-1810). Percentage weight loss was calculated using the following formula:

$$\%WL = \frac{W_i - W_f}{W_i} \times 100\%$$

Where: WL=Weight loss;  $W_i$ = Initial weight;  $W_f$ = Final weight

### Ascorbic Acid Analysis

The ascorbic acid content was determined by the 2, 6-dichlorophenol indophenol (DCPIP) dye method (AOAC, 2000). 5 ml of the standard ascorbic acid solution was pipetted into a 100 ml conical flask and 5ml of the 3%  $HPO_3$  solution was added. The ascorbic acid solution was titrated with the dye solution to a pink colour, which should persist for 15sec. The titre value was recorded. The dye factor was calculated by dividing 5ml volume of ascorbic acid solution taken for titration by titrant volume of dye solution. Dye factor was expressed as mg of ascorbic acid per ml of the dye. Since 5ml of the standard ascorbic acid solution contains 0.5 mg ascorbic acid:

$$\text{Dye factor (mg ascorbic acid per dye)} = \frac{0.5\text{mg}}{\text{titrant volume}}$$

An aliquot of 5ml avocado juice extract was diluted to 50 ml with 3% metaphosphoric acid in a 50ml volumetric flask. The aliquot was then centrifuged (Model, Z300, 580W, 3052 Nm, German) for 15 minutes and titrated with the standard dye to a pink end point (persisting for 15 seconds). The ascorbic acid content was calculated from the titration value, dye factor, dilution volume of the sample as follows:

$$\% A.A = \frac{(\text{ABR}) \times \text{dye factor} \times \text{volume of initial test solution}}{\text{volume of test solution titrated}} \times 100\%$$

Where: A.A=Ascorbic Acid; ABR= Average Burette reading.

### Measurement of Total Acidity

The total acidity was determined by a standard titrimetric method. For the determination of total acidity, 5grams of extracted avocado juice was mixed with 100ml of distilled

water. In the presence of phenolphthalein as an indicator, the mixture was titrated by adding 0.1 N NaOH until the break of light pink color (pH 8.2) observed for 15 seconds. The volume of NaOH added to the solution was multiplied by the correction factor of 0.067 for the calculation of titratable acidity as %age of malic acid. Titratable acidity was expressed as %age of malic acid (AOAC, 2000).

$$\% \text{ acid} = \frac{\text{titrant volume} \times 0.1 \text{N NaOH} \times \text{acid factor} \times \text{titration volume}}{\text{weight of the sample}} \times 100\%$$

### Determination of Chlorophylls and Total Carotenoids

Chlorophylls and carotenoid contents were determined using spectrophotometric method following procedure of Nagata (1992) for the simultaneous determination of chlorophylls and total carotenoids in avocado fruits. 16ml of acetone-hexane (4:6) solvent was added to 1g of avocado juice homogenates. For this, the homogenous sample was prepared by Kenwood blender, (Model, BC311 P.R.C. China). The homogenate was centrifuged at 5000 rpm using centrifuge (Model, Z300, 580W, 3052 Nm, German) for 10 minutes at 20°C. Then after absorbance was measured at 663, 645 and 470nm in a Jenway model 6100 spectrophotometer. Total chlorophyll and carotenoid contents were calculated according to the equations indicated below, and the final results was expressed as µg/g for chlorophylls and mg/g for antioxidants.

$$\text{Chlorophyll a } (\mu\text{g/g}) = 0.999A_{663} - 0.989A_{645}$$

$$\text{Chlorophyll b } (\mu\text{g/g}) = 1.77A_{645} - 0.328A_{663}$$

$$\text{Total Chlorophyll(a+b)} (\mu\text{g/g}) = \text{chl a} + \text{chl b}$$

$$\text{TC (mg/g)} = \frac{1000A_{470} - 2.27(\text{chl a}) - 81.4(\text{chl b})}{227}$$

Where: A = absorbance; TC=Total carotenoids

### Sugar Analysis

Determination of sugar in avocado fruit juice sample solution.

Total reducing sugar was estimated by using the technique used by Gros (1987) with some modifications. For extraction of total reducing sugars from avocado juice sample, 5g of homogenized juice sample was dissolved in 15ml of 80% ethanol, then mixed and heated in boiling water bath for sufficient time until the ethanol odor went off. Then, the solution was filtrated by adding 1ml of saturated Pb (CH<sub>3</sub>COO)<sub>2</sub> and 1.5ml of NaHPO<sub>4</sub> and the content was mixed by gentle shaking on vortex shaker.

After filtration, the extract was made to 1: 10 dilution with distilled water. From this solution 0.8ml and 1.2ml of sample solution was taken and made up to 2ml with distilled water in labeled test tubes. Then after 1ml of copper reagent was added to both solutions and heated for 20 minutes in a boiling water bath. After heating, the contents were cooled under running tap water without shaking. Then after, 1ml of sodium acetate was added

(as a color reagent), mixed well, and left for about 10 minutes to allow color development. Then after, the absorbance was read using spectrophotometer at 540 nm.

Finally, the content of sugars in the unknown and standard solution (in mg/ml and mg %) was estimated by using the standard curve. The calculation of the concentration on the sample was done using the linear regression equation of standard solution obtained  $y = ax + b$  where Y is the absorbance of the measured sample solution, b is the y-intercept and X is the concentration of the sample solution (mg/ml):

$$X = (Y - b) / a$$

Conc of sugar in sample soln = (OD of test sample - OD of blank) / (OD of std - OD of blank) x conc of std

Mg of reducing sugar = (OD of test sample - OD of blank) / (OD of std - OD of blank) \* conc of std glucose \* df

Dilution factor = (final dilution volume) / (original volume of substance being diluted (aliquote vol))

% reducing sugar = (mg of reducing sugar) / (mg of original sample) x 100%

mg std glucose = concentration of working std solution x volume of standard solution

Data were subjected to ANOVA (Analysis of Variance) and mean separation based on LSD (Least Significance Difference) using SAS 9.1.2 statistical software. All significance tests was made at (P < 0.05) level.

## RESULT AND DISCUSSION

### Weight Loss and Vitamin C content

Weight loss was measured as the difference between the initial weight (weight before treatment) and final weight (weight taken after 12 days of storage). Statistical analysis showed that there was significant difference in weight loss between control and aloe gel treated groups (Table 1) during postharvest storage of avocado fruit samples. There was also significance difference between initial weight and final weight (measured on first and 12th days respectively) during postharvest storage of avocado fruits. Weight loss mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration (Vogler and Ernst, 1999). The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere. Aloe gel based edible coating act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries.

The ascorbic acid (vitamin C) content of avocado fruit during postharvest storage of avocado fruit was indicated in Table 2. Significance difference between aloe gel treated and control groups was observed for ascorbic acid content during 6th and 12th days of storage of avocado fruit samples. However, no significance differences were observed among treatments. It was also

**Table 1:** Percentage weight loss during post harvest ripening of avocado fruit as treated by different concentrations of aloe gel

Treatment	Wi(gm)(1st day)	Wf(gm)(12th day)	Weight loss (%)
0 %	1426.10±6.65aA	1233.40±11.46bB	13.51±0.40a
30%	1437.00±18.38aA	1371.25±9.83aB	4.56±1.90b
40%	1383.15±53.53aA	1306.15±22.70abB	5.53±2.02b
50%	1379.35±71.63aA	1318.10±81.60abB	4.47±0.95b

Wi: initial weight; Wf: final weight. Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). Small letters: significance within column; capital letters: significance within row.

**Table 2:** Vitamin C content during postharvest ripening of avocado fruit as treated by different concentrations of aloe gel solution

Treatment	1st day	6th day	12th day
0 %	2.17±0.06aB	4.46±0.29aA	0.76±0.18bC
30%	2.15±0.31aA	2.17±0.07bA	1.63±0.10aB
40%	2.18±0.07aA	2.18±0.07bA	1.85±0.10aB
50%	2.17±0.07aA	2.17±0.07bA	1.85±0.10aB

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). Small letters: significance within column; capital letters: significance within row.

demonstrated that ascorbic acid content was increasing in control group during postharvest avocado fruit ripening but no significance difference in ascorbic acid content among treatments. The highest mean vitamin C content was observed for control than treated groups indicating that aloe gel treatment has slowed down change in percent ascorbic acid. Thus, aloe gel coating plays role in increasing shelf life during postharvest storage of avocado fruits. Similar finding was in agreement with Hall *et al* (1955), who suggested avocados are rich in vitamin B6 (3.9–6.1 µg/g pyridoxine) and contain lesser amounts of biotin, folic acid, thiamin, riboflavin (Hall *et al.* 1955), calciferol (vitamin D), α-tocopherol (vitamin E) and 2-methyl-1, 4-naphthoquinone (vitamin K) (Kadam & Salunkhe 1995).

### Chlorophyll and Carotenoid Contents

Mean values for total chlorophyll and carotenoid content was shown in Table 3. There was significance difference in total chlorophyll and carotenoid contents between control and aloe gel treated groups after 6th days of storage avocado fruits. It was also observed from mean values in Table 3 that carotenoid content was increasing while chlorophyll content was decreasing during postharvest ripening of avocado fruits. The highest mean carotenoid content was observed for control group showing that treatment with aloe gel solution can delay

ripening of avocado fruit. Finally, carotenoid content was decreasing during 12th day of storage showing deterioration in fruit quality. This finding was supported by Kumar *et al* (2018) who reported progressive increase in physiological lycopene content, β-carotene content, total sugars, reducing sugars and non-reducing sugars contents during postharvest ripening of tomato fruit.

### Titrateable Acidity

Mean values based on Duncan's Multiple Range Test (DMRT) for total acidity as indicated in Table 4. It was observed that there was no significance difference in total acidity (predominantly malic acid) between control and aloe gel treated groups in freshly harvested (1st day treatment) banana fruit. However, significance differences between control and aloe gel treated groups were observed after 6th day of treatment. It was also observed from mean values in Table 4 that total titrateable acidity was increasing during postharvest ripening of avocado fruit. The highest mean total acidity was observed for control group showing that treatment with aloe gel solution slowing increase of total acidity in avocado fruit. Tripathi and Dubey (2004) reported that *A. vera* led to a lower increase in TSS (Total Soluble Solid) and greater TA content (Titrateable Acidity) retention of coated berries, which indicated that control (uncoated fruits) fruits presented a more pronounced maturation

**Table 3:** Mean comparison for chlorophyll and carotenoid content during post harvest ripening of avocado fruit as treated by different concentrations of aloe gel solution

Treatment	Chlorophyll			Carotenoid		
	1st day	6th day	12th day	1st day	6th day	12th day
0%	0.61±0.01aA	0.29±0.02cB	0.06±0.03cC	0.84±0.01aC	2.66±0.03aA	2.05±0.03aB
30%	0.52±0.06aA	0.46±0.01aA	0.18±0.01bB	1.14±0.02aC	2.27±0.02bA	1.96±0.01bB
40%	0.55±0.07aA	0.44±0.01bA	0.23±0.01aB	0.82±0.02cC	2.02±0.01cA	1.80±0.04cB
50%	0.65±0.01aA	0.42±0.01bB	0.21±0.02abC	0.99±0.03bC	2.02±0.03cA	1.75±0.02cB

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). Small letters: significance within column; capital letters: significance within row.

**Table 4:** Mean comparison for total acidity during post harvest ripening of avocado fruit as treated by different concentrations of aloe gel

Treatment	1st day	6th day	12 day
0%	21.11±1.42aA	23.12±0.47aA	22.11±0.95aA
30%	20.10±0.01abB	21.11±0.47bA	20.10±0.02bB
40%	17.76±1.42bA	19.77±0.47cA	19.60±0.24bA
50%	19.10±0.47abA	19.94±0.24bcA	18.86±0.33bA

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). Small letters: significance within column; capital letters: significance within row.

development than coated berries during storage periods. TTA is directly related to the concentration of organic acids present in the fruits. No significant difference was found in titratable acidity of coated and uncoated grapes. The decreasing acidity at the end of storage might be due to the metabolic changes in fruits resulting from the use of organic acids in respiratory process; this observation was in agreement with the findings of Chauhan *et al* (1987).

Fruits are essential for the proper maintenance of human health. Fruits are foods rich in vitamins, minerals and supply arrays of colors, flavor, texture and bulkiness to the pleasure of eating. Tripathi and Dubey (2004) reported that *A. vera* led to a lower increase in TSS (Total Soluble Solid) and greater TA content (Titrable Acidity) retention of coated berries, which indicated that control (uncoated fruits) fruits presented a more pronounced maturation development than coated berries during storage periods (1°C, 95% RH+ 4 days at 20°C, 90% RH). In case of Aloe coated and uncoated oranges (12°C, 96-98 %RH), there were no significant differences in TSS and TA content of fruits during storage periods. The value of ascorbic acid content for coated oranges was found to be higher than that of uncoated fruits (Arowora *et al.*, 2013). Brishti *et al* (2013) found that ascorbic acid content was higher in Aloe coated papaya fruits (86.55 mg) than the control fruits (61.10 mg) during the storage

period at temperatures 25°C-29°C and 82-84% RH. A similar result was found in Aloe gel coated nectarines (Ahmed *et al.*, 2009). This was due to low oxygen permeability of coating which delayed the deteriorative oxidation reaction of ascorbic acid content Ayranci and Tunc, 2003). Srinu *et al* (2012) also reported that coating reduces respiration of the fruits and retains the ascorbic acid in the fruits.

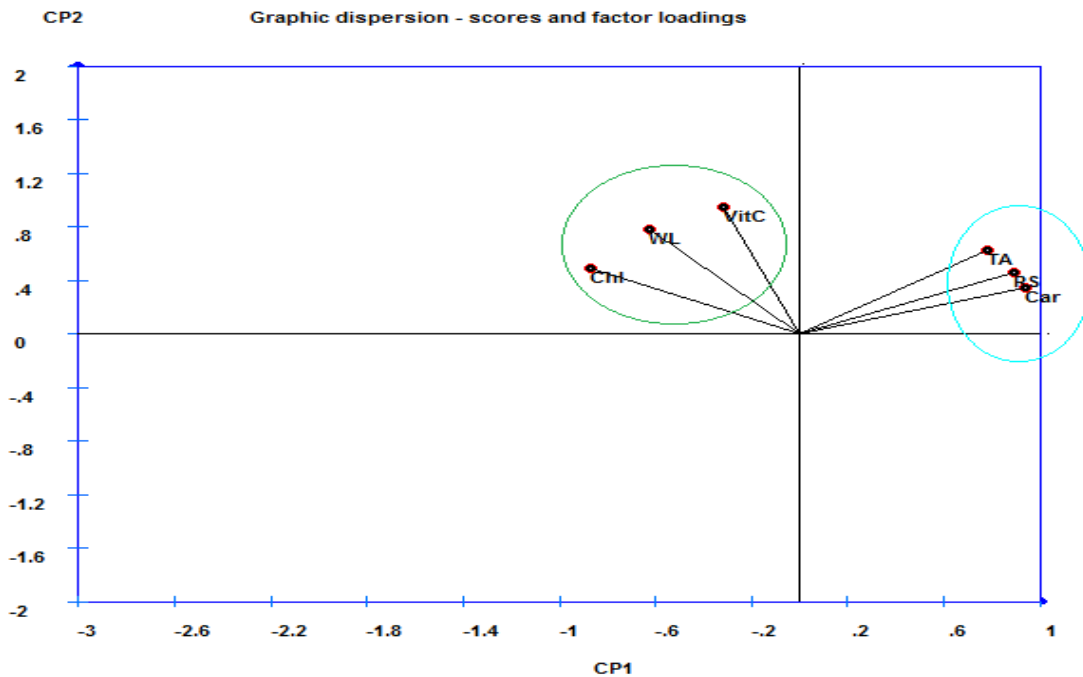
### Total Reducing Sugars

It was observed from Table 5 that there was no significance difference in total reducing sugars between control and aloe gel treated groups in freshly harvested (0 day treatment) avocado fruit. However, significance differences, in sugar content between control and aloe gel treated groups, were observed after 6th day of treatment. It was also observed from mean values in Table 5 that total reducing sugars was increasing during postharvest ripening of avocado fruit. The highest mean reducing sugar was observed for control group showing that treatment with aloe gel solution total slowed down increase in reducing sugar in avocado fruit. The low sugar content in aloe gel treated group showing that aloe gel delays postharvest ripening and increases shelf life of avocado fruit. Related work was done by Aziz (2011) who found that the total sugar percentage of untreated fruits

**Table 5:** Percentage reducing sugar during post harvest ripening of avocado fruit as treated by different concentrations of aloe gel solution

Treatment	1st day	6th day	12th day
0 %	4.11±0.29aC	21.39±0.29aA	11.14±0.64bB
30%	4.33±0.29aC	18.75±0.69bA	13.86±0.24aB
40%	4.24±0.37aC	18.71±0.27bA	13.74±0.56aB
50%	4.16±0.05aC	17.68±0.24bA	14.93±0.48aB

Means followed by same letter within a column were not significantly different at 0.05. Probability level based on DMRT (Duncan's Multiple Range Test). Small letters: significance within column; capital letters: significance within row.



**Figure 1:** PCA scores for six fruit quality parameters measured for avocado fruit. RS: total reducing sugars; Car: carotenoid content; TA: total titratable acidity; VitC: vitamin C content; WL: weight loss; and Chl: total chlorophyll content.

showed a sharp increment and it was highest compared to the treated fruits in all days of storage.

Based on the plot for PC2 vs PC1 for D statistics (Figure.1), reducing sugars, carotenoid and total acidity having close PC1 and PC2 scores (with vector angle <math><90^{\circ}</math>) showing similar/correlated effects while reducing sugars and/or carotenoids with chlorophyll content, weight loss and vitamin C contents have vector angle greater than

**CONCLUSION**

*A. vera* gel, applied as edible coating has beneficial effects in retarding the ripening process of avocado fruit. This treatment was effective as a physical barrier and thus reduced the weight loss and lowered the decay rate during postharvest storage. The results of this paper show that *A. vera* gel could be applied as a postharvest treatment to enhance quality and shelf life during postharvest storage of avocado fruits. The present study has generated quantitative data on major avocado fruit quality parameters including weight loss, vitamin C content, total chlorophyll and carotenoids, total acidity and reducing sugars. However, due to resource limitation fruit sample was taken from one location. Further studies

are required by considering fruits grown in diverse environments. There may also differences among cultivars in physicochemical and organoleptic properties of avocado fruits. Studies are also required to evaluate differences among avocado fruit cultivars with respect to physicochemical properties. Comparison of edible coatings and other postharvest treatment agents have to be evaluated so that some of the most effective treatment methods can be implemented during postharvest management of avocado fruits.

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