Research Journal of Food Science and Nutrition
Volume 4(4), pages 82-89, August 2019
Article Number: 5FBEABF22
ISSN: 2536-7080
https://doi.org/10.31248/RJFSN2019.070
https://integrityresjournals.org/journal/RJFSN

Review

Aloe vera as a bio-preservative for keeping quality of horticultural products

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Received 19th May, 2019; Accepted 30th July, 2019

ABSTRACT: Postharvest periods are very challenging for marketing of horticultural commodities that are more perishable. Fruit decay is the major postharvest constraint responsible for negative return of horticultural commodities that is expressed by weight loss, color changes, softening and microbial spoilage. Different postharvest techniques like waxing, chemical coating and dip techniques are in practice to avoid the losses but due to the hazardous nature of chemicals to human health, the concept of bio preservation has been developed. Replacing of chemical preservation with bio preservation strategies are user friendly and has great potential if constraints in production and application techniques studied completely. Among the various bio preservative plants, *Aloe vera* plant has a great history for its medicinal use against wide range of ailments and fruit preservation. It prevents loss of moisture and firmness, control respiration rate and maturation development, delay oxidative browning, reduce microorganism proliferation and other parameters like titratable acidity, soluble solids content, ascorbic acid content, firmness and decay percentage also controls significantly.

Keywords: *Aloe vera* gel, alternative to chemicals, bio preservation, fruit decay, horticultural commodities, post-harvest losses.

INTRODUCTION

Bio preservation is an approach for extending shelf life of perishable horticultural commodities against microbial decay using natural or controlled microbiota and/or antimicrobial compounds (Ananou et al., 2007). In postharvest technology, application of phytochemicals and plant based material is safe for extending storage/shelf life of fruits and vegetables. *Aloe vera* gel as bio preservative is preferred for fruits and vegetable because of its colorless mucilaginous gel obtained from the parenchymatous cells in the fresh leaves. Since centuries, it is used for cosmetics, antiaging, regeneration and rejuvenation of human skin in civilizations of China, Japan and India (Boudreau and Beland, 2006). The other uses reported of mucilaginous gel obtained from the parenchymatous cells in the fresh leaves of *Aloe vera* are for constipation, radiation injury, inflammatory effect, healing wounds and burns, ulcer and diabetes (Yagi et al., 1998; Klein et al., 1988). The gel stimulates cell growth and enhances the restoration of damaged skin and moisturizes because of longer water holding capacity. As a drink, it protects the mucous membrane of the stomach especially when irritated or damaged. Also, there has been increasing interest for the use of *A. Vera* gel in the food industry as a functional ingredient in drinks, beverages, and ice creams (Moore and MacAnalley, 1995).

In the recent years, though mostly used for medical studies (Rosca-Casian et al., 2007), the *Aloe vera* gel has been tested for few fresh fruits by a postharvest research group from Spain since 2005 (Valverde et al., 2005). This research group registered that Aloe vera extracts suppressed/retarded postharvest quality losses in 'Crimson Seedless' grapes and 'Star King' cherries (Valverde et al., 2005; Serrano et al., 2006; Martínez-Romeroa et al., 2006; Castillo et al., 2010). Furthermore,

Aloe vera extracts were reported to be useful for 'Kensington Pride' mangoes (Dang et al., 2008) and 'Artic Snow' nectarines (Ahmed et al., 2009) for retaining quality losses after harvest. Romero (2003) has also filed a patent for the use of *A. Vera* gel as an edible coating for postharvest treatment on fruits and vegetables. *Aloe vera* gel is applied to fruits as an edible coating which has been widely used for most fruits and vegetables. Edible coatings have a various favorable effect on fruits such as imparting a glossy appearance, and better colour, retarding weight loss, or prolonging storage/shelf life by preventing microbial spoilage (Dang et al., 2008). Treatments of chemicals for the extension of shelf life and preservation is very much hazardous to health that's why the concept of bio preservation is develop to decrease health problems and also provide an edible coating material which not only increase the post-harvest life of fruits and vegetables but also have positive impact on human health. The performance of *Aloe vera* gel as edible coating is dependent on its composition (Dang et al., 2008). Its use offers an option to film packaging owing to their environmentally friendly characteristic (Argudo et al., 2005).

As concern with the bio preservation, horticulture is an important sector where fruits and vegetables occupy an important position and provide livelihood to thousands of families in Pakistan as well as all over the world. Efforts for the post-harvest losses is the responsible reason for increasing their economic status (Admassu, 2003). These efforts decrease quantitative as well as qualitative losses and food insecurity, increase food availability and conserve the natural and financial resources. Using of *Aloe vera* extract (*Aloe vera* Gel) as a bio preservative is the best source of solving the problems as well as health complications. The present article briefly explains about the *Aloe vera* plant, its importance and use, gel preparation method from *Aloe vera* leaves and the results of previous works of using *Aloe vera* gel as a bio-preservative.

PLANT DESCRIPTION

Aloe vera is a tropical and sub-tropical green succulent plant having more than 400 species that are *Aloe vera* Linn. *A. barbadensis* Miller, *A. ferox* Miller, *A. chinensis* Baker, *A. indica* Royle, *A. perryi* Baker, etc., belonging to family liliaceae (Asphodelaceae). The best biologically active species is *A. barbadensis* Miller. Due to its water holding capacity, it can also be grown in arid regions. It can tolerate the thrilling temperature ranging from 104^0F to below freezing temperature. It is mainly propagated by root suckers or rhizome cuttings. The suckers are planted mainly in monsoon season (July to August) however planting can be done around the year except winter months (November to February). After 18 months, the plant matures and ready for harvesting. Matured leaves from the base are harvested leaving the young leaves on the top. *Aloe vera* is planted in 15 cm deep pits having 60 x 60 row to row and plant to plant distance (Rajeswari et al., 2012; Sharma and Gautam 2013).

ALOE VERA EXTRACTS

Yellow latex (exudate) and clear gel (mucilage) are the two major liquid constituents of *Aloe* v*era*, which can be extract from the large leaf parenchymatic cells (Valverde et al., 2005). The *Aloe vera* leaf extracts are *Aloe vera* gel and *Aloe vera* Juice that are used for medicinal purpose and as a bio-preservative for horticultural commodities. Matured leaves of *Aloe vera* plants are used for the extraction of gel. There are four layers in the *Aloe vera* leaf. First ayer is hard greenish gray outer protective layer of the leaf called rind, second layer is the bitter liquid under the rind surrounding the gel called sap (mostly yellow in color and toxic), third layer is inner area of the leaf contains mucilage gel and the final (fourth) layer is the location of gel called colorless hydro parenchyma (Mohebbi et al., 2012). The *Aloe vera* gel is extracted from this outer cortex of colorless hydro parenchyma and *Aloe vera* Jiuce can also be made from this gel by adding natural additives (Figure 1).

ALOE VERA GEL PREPARATION PROCEDURE

Cut matured leaves of the plant from the base and stand them upright for 15 to 20 minutes to drain the sap. Cut off the two sides of the leaf and then make slices of the leaf. Now, slice off the skin layer of the leaf to separate the *Aloe vera* gel matrix from the outer cortex of leave and this colorless hydro parenchyma. Grind this matrix in a blender and filter with thin and soft cloth the resulting mixture to remove fibers. This liquid is fresh *Aloe vera* gel. For the purpose of preservation, heat the gel matrix at 70^0C for 45 minutes in oven and immediately cool it to an ambient temperature. Add ascorbic acid in the range of 1.9 to 2.0 gL^{-1} and cool it to about 23^0C in less than 15 minutes. Also, add citric acid (4.5 to 4.6g gL^{-1}) to this gel to maintain the pH at 4. Store this gel in brown jars to prevent spoilage and kept it in refrigerator (Mohebbi et al., 2011; Adetunji et al., 2012a,b; Marpudi et al., 2013) (Figure 2).

CHEMICAL COMPOSITION AND IMPORTANCE OF *ALOE VERA*

Aloe Vera plant constitute many multifarious ingredients including glycoproteins, phenolic compounds, lignins, hormones, polysaccharides, amino acids, vitamins, saponins, salicylic acid, and enzymes. These constituents give very much beneficial characteristics to *Aloe vera.* By

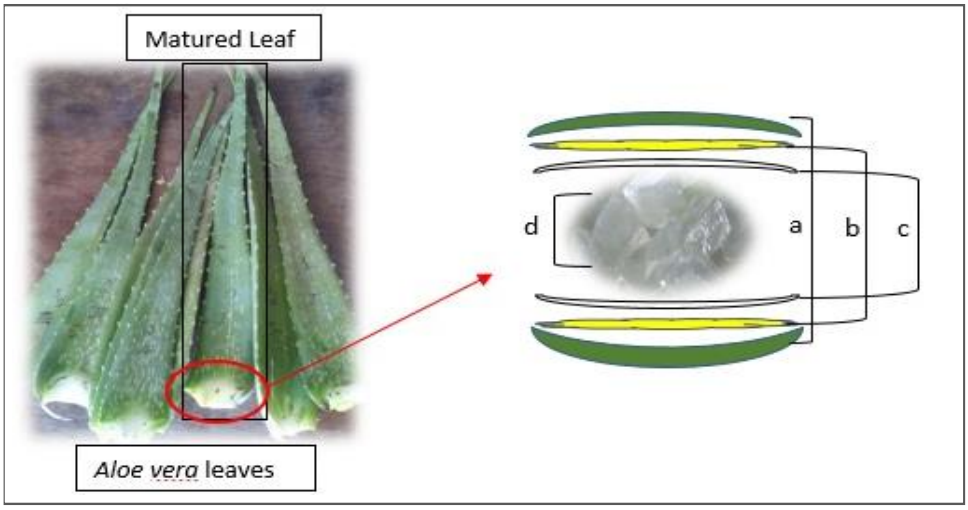

Figure 1. Layers of *Aloe vera* leaf. a: 1st layer called grind, b: 2nd layer called sap, c: 3rd Layer called mucilage, and d: colorless hydro-parenchyma cells containing actual gel.

Cutting the Aloe vera levaes from the base

⇩

Washing with tap water

⇩

Standing up the matured leaves in upright position for 15-20 minutes

⇩

Cutting the two sides of the leaves

⇩

Making slices of the leaves

⇩

Slicing off the skin of leaves

⇩

Collecting the *Aloe vera* gel matrix (colorless hydro parenchyma)

⇩

Blending the matrix

⇩

Filtration for removing fibers

⇩

Keeping the filtrate in oven at 70^0C for 45 minutes to preserve

⇩

Cooling at ambient temperature

⇩

Addition of citric acid and ascorbic acid as preservative

⇩

Addition of buffers to keep the pH 4

Figure 2. Step wise understanding of *Aloe vera* gel preparation method.

this, *Aloe Vera* plant got a great importance in medicinal use, curing many diseases and solving most of health problems. It is used as anti-inflammatory, antibacterial and antifungal. It is also used as a treatment for stomach ailments, gastrointestinal problems, skin disease, constipation, radiation injury, healing wounds and burns, ulcer and diabetes. *Aloe vera* is also been a considerable product for cosmetic, pharmaceutical and food industries. *Aloe vera* extracts also have antimicrobial activity against bacterial pathogens from gram positive and gram negative. Due to its therapeutic and functional properties and useful aspects, the use of *Aloe vera* as a bio preservative in many food products is increased (Rajeswari et al., 2012; Sharma and Gautam, 2013; Yagi et al., 1998).

ROLE OF *ALOE VERA* IN BIO-PRESERVATION OF HORTICULTURAL COMMODITIES

Aloe vera played an important role in preservation of food products and extend the shelf life of various horticultural commodities. Several experimental researches are done using *Aloe vera* gel for the preservation of various horticultural commodities. The results of some experimental works are presented below:

Adetunji et al. (2012c) concluded that *Aloe vera* gel is edible, healthy and environment friendly treatment and a very good alternative of postharvest chemicals. They applied *Aloe vera* gel on pineapple (*Ananas comosus*) for the extension of its postharvest life. They studied the effect of *Aloe vera* gel on the postharvest life of pineapple stored at the temperature of 27±2^{o}C and relative humidity of 55 to 60% for seven weeks. The parameters of the study were weight loss, ascorbic acid, pH and firmness of the fruit which were significantly controlled.

Ergun and Satici (2012) used *Aloe vera* gel as a bio preservative to control postharvest quality losses in fruits. For this work, they selected two different cultivars of Apple i-e 'Granny Smith' (green in colour) and 'Red Chief' (red in colour) and coated the fruits of cultivars 'Granny Smith' and 'Red Chief' with 0, 1, 5 and 10% w/v *Aloe vera* gel and stored it at the temperature of 2^{o}C for six months. They concluded that the soluble solids content and percentage titratable acidity was high for 'Granny Smith' apples treated with 5 and 10% of *Aloe vera* gel during storage, weight loss and green colour was prevented or suppressed in 'Granny Smith' apples while there were no changes noted in 'Red Chief' apples. The pH value of 'Granny Smith' was increased while decreased for 'Red Chief' apples.

Marpudi et al. (2013) suggested the *Aloe vera* gel application as an economical and environment friendly treatment for controlling the postharvest losses, quality characteristics and extending shelf life of fig and other tropical and subtropical fruits and vegetables. They selected two sets of fig fruits, one set was coated with *Aloe vera* gel and the other set was dipped in distilled water which acted as control and stored at room temperature (29±3^{o}C). They collected data from these two sets of fruit every second day and observed that the weight loss was reduced in the set of fruits which was coated with *Aloe vera* gel and there were also very minute changes in other physiochemical parameters such as pH, titratable acidity and total soluble solids (TSS). They also observed that *Aloe vera* gel application reduces fruit decay and shriveling and browning of the fruit peel.

Chauhan et al. (2014) treated green grape berries with *Aloe vera* gel to analyze its effect on the postharvest life of green grape berries. They coated green gape berries with 0, 1, 5 and 10% w/v *Aloe vera* gel and stored it in an air tight container for 40 days at the temperature of 15^{o}C. They noted that there was minute weight loss, lesser browning, cracking, damage and fungal attack in the berries treated with 5% and 10% *Aloe vera* gel. The flavor factors (TSS and titratable acidity) were maximum. They also stated that *Aloe vera* gel is the healthy, friendly to environment, edible and very safe biodegradable coating for increasing the storage life of fruits.

Shahkoomahally and Ramezanian (2014) stored table grape (*Vitis vinifera* L. cv. Askari) treated with *Aloe vera* gel in combination with 2% $Cacl_2$ and 1% citric acid at the temperature of 4^{o}C and 85±5% relative humidity for 35 days in a cold storage. They concluded that the TSS and weight loss of table grape were reduced with *Aloe vera* gel application. The ascorbic acid and titratable acidity were also retained and browning and dehydration was delayed by the application of *Aloe vera* gel to the fruits.

Asghari et al. (2013b) stated that *Aloe vera* gel has the ability to retain the quality and increase the shelf life and market value of grapes. They applied *Aloe vera* gel on the harvested clusters of Gizel Uzum in Iran of (1:3) and (1:4) with salicylic acid of 0, 1 and 2 mmol/L concentrations and stored at the temperature of 0±0.5^{o}C for 90 days. They observed that the phenolic contents, soluble solids and oxidants were conserved by 33% *Aloe vera* gel and 2 $mmolL^{-1}$ salicylic acid during the storage.

Benítez et al. (2013) used *Aloe vera* gel as an edible coating on fresh sliced kiwi fruit in four different concentrations i-e 0, 1, 5, 15% (v/v) to maintain its quality. They packed these slices after *Aloe vera* gel application and kept it at the temperature of 4± 1^{o}C. The respiration rate and microbial spoilage was reduced in slices of kiwi fruit with the application of *Aloe vera* gel. After seven days, they observed that one logarithmic unit mesophilic load for 15 and 5% coated slices was dropped.

Mohebbi et al. (2012) stored Button Mushrooms at 4, 10 and 15°C for 13 days after treatment with *Aloe vera* gel, gum tragacanth and the combination of both. They were analyzed after 2, 4, 6, 8, 10 and 13 days of the storage for physiochemical characteristics. They observed that during cold storage the weight loss, color change and accelerated softening of Mushrooms was delayed with the application

of edible coatings.

Guillen et al. (2013) treated peaches and plums with *Aloe vera* gel and Aloe arborescens gel. They kept it at the temperature of 20°C for six days. The ethylene production and postharvest quality parameters such as colour change, reduction of acidity and increase in ripening index (total soluble solids/total acidity ratio) were delayed with both treatments. Both the treatment reduced the weight loss but the effect of Aloe arborescens gel was more effective than the *Aloe vera* gel.

Romero et al. (2013) revealed that the application of *Aloe vera* gel alone and with the combination of 0.5% ascorbic acids and 1% of citric acids before the storage on pomegranate arils increased its shelf life up to 12 days when stored at 3°C. All the physicochemical analysis like firmness, phenolic components and anthocyanins were maintained during storage. Moreover, there was a high score of sensory evaluations like color, texture, flavor and aroma during this period.

Paladines et al. (2014) suggested that when *Aloe vera* gel is applied with addition of 10 or 2% rosehip oil, it maintained the postharvest quality attributes of prunus species and cultivars. They applied *Aloe vera* gel on peaches ('Roma' and 'B-424-16' flat type), plums ('Red Beauty' and 'Songria'), nectarine ('Garofa') and sweet cherry ('Brooks') and stored these fruits at the temperature of 20°C for 6 days. The analysis of fruits showed that in peaches, plums and nectarine (climacteric fruits) the respiration rate and ethylene production was reduced and the quality parameters such as weight loss, softening, colour change and ripening index was delayed as compared to the control.

Asghari et al. (2013a) treated sweet cherry (*Prunus avium* cv. Napoleon) with *Aloe vera* gel and nitric oxide by applying 0, 1, 5 and 10 µmol L-1 nitric oxide and 25 and 33% of *Aloe vera* gel on the sweet cherry and stored it at the temperature of 1± 0.5°C for 30 days. Due to this treatment the fruit marketability, total phenolics content, vitamin C, catalas enzyme activity, decay index and weight loss is effectively preserved and the postharvest life was increased with treated fruits.

Romero et al. (2006) used *Aloe vera* gel as an edible coating for the first time as an alternative to postharvest chemical treatment for sweet cherry. The application of *Aloe vera* gel on sweet cherry extended its storability and delayed the postharvest quality losses like increase in respiration rate, rapid weight loss and colour change, accelerated softening and ripening, stem browning and increased microbial populations in sweet cherry in cold storage.

Castillo et al. (2010) reported that *Aloe vera* gel is an excellent pre harvest treatment for maintaining the postharvest quality of table grapes. First, they added different concentrations of *Aloe vera* gel on potato dextrose agar (PDA) for testing the inhibition of mycelium growth of two very common fungi, *Penicillium digitatum* and *Botrytis cinerea* which cause fruit decay. The mycelium growth rate of both fungi decreased with *Aloe vera* concentrations. But to achieve the same growth inhibition, the *Aloe vera* concentration was 3-fold higher for *Botrytis cinerea* than *Penicillium digitatum*. Reduction of mycelium growth for *Penicillium digitatum* was 4 logarithmic units and 2 logarithmic units for *Botrytis cinerea* was 250 mmol L^{-1}. They applied this dose of *Aloe vera* gel on table grapes vineyard 7 days before harvesting. The respiration rate and weight loss were reduced and ripening rate such as color and firmness were delayed in table grapes when stored for 35 days in cold storage after harvest.

Valverde et al. (2005) treated table grapes cv. Crimson (seedless table grapes) with *Aloe vera* gel due to which the weight loss, color change, accelerated softening and ripening, rachis browning and berry decay was significantly delayed and its shelf life was extended up to 35 days at 1°C.

Ochiki et al. (2014) conducted an experiment on mango fruit (Var. Ngowe) keeping in view its perishable nature and short post-harvest life. The Aloe vera gel at the concentrations of 0, 25, 50 and 75% were applied to the mango fruits with the combination of 1% chitosan and stored at the temperature of 13°C for 20 days. It was concluded that both 50 and 75% of *Aloe vera* gel prolonged the shelf life of mango. Percent weight loss, total soluble solids and fruit firmness reduced during storage with this treatment, however, 50% concentration of *Aloe vera* gel also maintained the pH of mango fruits during storage.

Arowora et al. (2013) stored three hundred and twenty (320) oranges (Var. Valencia) in refrigerator for eight (8) weeks. Half of these fruits were treated with Aloe vera gel and half remained untreated as a control. It was revealed that the orange fruits that were treated with the *Aloe vera* gel showed the best result regarding to the post-harvest life as compared with the control. The percentage of weight loss was conserved by the application of *Aloe vera* gel. While there was a line increase in the other parameters like sugar acid ratio and total soluble solids. pH of the orange was also maintained with the application of *Aloe vera* gel.

Brishti et al. (2013) treated papaya fruit with *Aloe vera* gel at the concentration of 100% and also with the papaya leaf extract in combination with Aloe vera gel at the ratio of 1:1 and stored it at room temperature of 25 to 29°C with the relative humidity of 82 to 84% for 16 days. It was concluded that *Aloe vera* gel alone and with the combination of papaya leaf extract prolonged the shelf life of papaya and significantly affected its physicochemical characteristics as compared to the control. The decay of papaya fruits started on the 6th day of storage and completed in 12 days in the control. However, the treated fruits did not show any sign of decay up to 12 days and on the 16th day of the storage the treated papaya fruits

decayed. The color score, fruit firmness, ascorbic acid and flavor of the treated papaya fruits maintained up to 12 days. There were 27% of disease incidence in the papaya fruits treated with *Aloe vera* gel alone and 13% disease incidence was recorded in the papaya fruits treated with papaya leaf extract with the combination of *Aloe vera* gel. While there was 100% disease incidence in the papaya fruits remained untreated.

Sing et al. (2011) declared *Aloe vera* gel as an edible coating and the best alternative for the chemicals used in the post-harvest treatment for the horticultural commodities. They treated strawberry fruits with the *Aloe vera* gel and refrigerate it for 16 days. It was concluded from the physicochemical analysis that the application of *Aloe vera* gel extend the postharvest life of strawberry fruits. There was an increase in the color change, weight loss, decay and loss of firmness in the strawberry fruits remained uncoated during cold storage. On the other hand, the strawberry fruits treated with *Aloe vera* gel (1:3) reduced the weight loss, firmness and TSS. Sensory evaluations such as aroma, color, taste and flavor are also maintained by *Aloe vera* gel during storage.

Padmaja and Bosco (2014a) applied Aloe vera gel (1:3) on the postharvest life of Jujube fruits and stored it at the temperature of 5±2^{o}C for 45 days. The organoleptic and physicochemical analysis of Jujube fruits showed that *Aloe vera* gel maintained all the postharvest parameters of Jujube fruits treated with *Aloe vera* gel while the untreated fruits lose their physical as well as chemical characteristics after 21 days of storage. They also revealed that *Aloe vera* gel has antifungal properties and reduced the microbial growth of fungi and bacteria. *Aleo vera* gel also signify-cantly affected the sensory evaluation of Jujube fruits.

Padmaja and Bosco (2014b) used *Aloe vera* gel (1:2) on the Sapota (*Manilkara zapota*) fruits to prolong its shelf life, reduce the fungal and bacterial growth and maintain all its quality attributes including sensory evaluation. They used dip technique for this purpose and dipped all the fruits in the *Aloe vera* gel for 7 minutes and then stored it in cool temperature of 5±2^{o}C for 20 days. The comparison of both the treated and untreated fruits showed that the quality attributes of untreated sapota fruits loss all the quality attributes after 10 days of storage however the sapota fruits treated with *Aloe vera* gel retained all its quality attributes up to 20 days.

Misir et al. (2014) reviewed that *Aloe vera* gel have the antifungal and antibacterial properties and used as an edible coating for the horticultural commodities for prolonging the shelf life. They stated that *Aloe vera* gel has polysaccharide and act as a barrier for the moisture loss and oxygen for fruits and vegetables. *Aloe vera* gel prolonged the shelf life of fruits and vegetables and all the quality attributes such as color, appearance, aroma and flavor are maintained. *Aloe vera* gel also decrease the disease incidence within the horticultural commodities.

Adetunji et al. (2014) applied *Aloe vera* gel with the combination of chitosan on the cucumber to improve its quality and extend it postharvest life. They stored the treated cucumber at the temperature of 25^{o}C for 7 weeks. The post-harvest quality attributes like TSS, firmness, ascorbic acid contents, acidity and weight loss were maintained with *Aloe vera* gel treatment as compared to the control.

Adetunji et al. (2012a) investigated the effect of *Aloe vera* gel on the postharvest life of oranges. They treated orange fruits with *Aloe vera* gel and stored at the temperature of 27^{o}C. There was an increase in the weight loss, firmness and TSS in the untreated fruits while retained in the fruits treated with *Aloe vera* gel. The shelf life of oranges increased up to 5 days without any negative changes in its quality parameters.

CONCLUSIONS

Aloe vera gel could be used as a bio preservative for preservation and extension of shelf life of all horticultural commodities. It is safe and has no residual toxicity but there is need to bringing more area under *Aleo vera* farming and finding efficient and economical ways for the preparation of gel and using it as a bio preservative for the shelf life extension of fruits and vegetables to increase its market value.

Recommendations

Aloe vera gel is recommended to be used as an edible coating material for the extension of shelf life of all horticultural commodities because of its high medicinal value and non-hazardous nature to human health.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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