



## Effects of *Psidium guajava* L. Leaf Powder and *Aloe vera* L. Gel on Shelf Life of *Citrus sinensis* L. Fruits

Ewekeye Tolulope Seun <sup>a\*</sup>, Abdulrazaq Khadijah Omolade <sup>a</sup>,  
Sharaibi Olubunmi Josephine <sup>a</sup>, Chijindu Pass Chidiebere Iyamah <sup>b</sup>,  
Esan Oyekunle Olatunde <sup>a</sup>, Ogun Mautin Lawrence <sup>a</sup>,  
Fadiora Adewumi <sup>a</sup> and Oke, Oyedamola Adebowale <sup>a</sup>

<sup>a</sup> Department of Botany, Faculty of Science, Lagos State University (LASU), Ojo, Lagos, Nigeria.  
<sup>b</sup> Department of Biology, College of Education, Warri, Delta State, Nigeria.

### Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

Postharvest loss of fruits is a critical problem due of rapid deterioration during handling, transportation and warehousing. Edible coating over fruits is utilised to boost their quality and shelf life. The effects of leaf extracts of *Psidium guajava* and *Aloe vera* gel on the elongation of the shelf life of orange fruits were evaluated. Orange fruits were treated with Guava leaf powder and *A. vera* gel to assess their effectiveness in extending their shelf life and quality in storage. Weight loss, firmness, post-harvest decay, marketability and shelf life of uncoated and coated samples were evaluated all through the period of this study. Fungi were also isolated from deteriorating samples. *A. vera* was able to preserve the orange samples for 21 days; *P. guajava* preserved them for 17 days while the untreated fruit samples stayed for 14 days. Three fungi viz: *Botryodiplodia theobromae*, *Fusarium oxysporum* and *Rhizopus stolonifer* were isolated from the decomposing orange fruits. The result shows that orange fruits coated with *A. vera* gel and guava leaf powder is effective in extending the shelf-life of orange fruits when compared to untreated fruit (control) in the following order: *A. vera*>*P. guajava* > control. The findings from this study indicate that plant extracts could be employed to prolong the shelf life and improve quality of orange fruits.

\*Corresponding author: Email: [tolulope.ewekeye@lasu.edu.ng](mailto:tolulope.ewekeye@lasu.edu.ng);

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## 1. INTRODUCTION

*Citrus sinensis* L.(Sweet orange) which belongs to the family Rutaceae is one of the most widely grown fruit crops. Citrus is produced globally at 102 million metric tons annually and is significantly more than other common fruits like banana, mango and apple [1]. Citrus production is reportedly carried out in about 140 countries [2], and it is estimated that up to 45% of the world's orange production comes from just Brazil and the United States [3]. Nigeria is the world's ninth-biggest producer of citrus fruits, and the continent of Africa's greatest growing area [4]. Sweet orange is the most prevalent and frequently grown and consumed citrus fruit in Nigeria. In a less developed country like Nigeria, the fruit and vegetable sector play a vital part in home nutrition, income generation, poverty mitigation, food availability and sustainable agriculture [5]. However, most of these fruits are lost after harvest because of poor preservation method; high moisture content and nutrient composition make these fruits more susceptible to fungal contamination [6].

Citrus fruit's post-harvest physico-chemical properties play a key role in the development of a variety of handling, packing, storage, and transportation methods.. It was reported by Saleh [7] that the carbohydrates, amino acids, organic acids and phenolic compounds are important components of fruit juices and their concentrates. The health benefits of fruits make its preservation and storage an important area as it also adds to the incomes of individual household, breeder and the nation at large [8].

In folk medicine, *P. guajava* (guava) is used as a phytotherapeutic plant as it helps to treat and manage various diseases because it is believed to have active components and *A. vera* gel coatings has various favourable effects on fruits like imparting a shiny outlook and enhanced colour, slowing down loss of weight, or lengthening storage time by impeding deterioration by microbes [9]. Natural-based coatings are often safe for consumption by humans and are also environmentally friendly [10]. Several researchers have recently investigated *A. vera* gel coatings for fruits as various pathogenic and foodborne spoilage organisms, including *Staphylococcus aureus*, *Salmonella*, *Streptococcus*, *Escherichia coli*, *Aspergillus niger*, and *Candida* were shown to be

inhibited by *A. vera* gel [11]. This shows that the application of an edible coating is a newly developed strategy that is affordable, accessible, and efficient in extending the shelf life of agricultural products. Thus, the aim of this study was to assess the effect of *A. vera* gel and *P. guajava* leaf powder to enhance the postharvest quality and shelf life of orange fruit in storage.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Fruits and Plant Extracts

Thirty orange fruits were bought from Iyana Iba market, Lagos Nigeria. Clean, unwrinkled and uninfected fruits were used, fresh leaves of *P. guajava* were placed in a 1.5 L blender (Binatone, China) to be ground, sieved and the pulverized sample were kept away in tight containers while *A. vera* leaves were rinsed with sterile distilled water, the leaf skins were peeled and the resulting mixture was filtered with Whatman filter paper No 1 (Whatman, United Kingdom) to remove the fibres. The liquid obtained constituted the fresh *A. vera* gel extracted into a bowl. Authentication and identification of the plants was done at the Botany Department, LASU, Ojo Lagos, Nigeria.

### 2.2 Treatment and Storage of Orange Fruits using Plant Extracts

The guava leaf powder was mixed with 250 mL of sterile distilled water and the resulting mixture was divided into ten (10) equal portions used to coat ten (10) orange samples by rubbing. Five (5) oranges were used as control for this treatment. Another ten (10) oranges were coated with *A. vera* gel and five (5) oranges were used as control. All oranges were arranged and labelled in a fruit rack and stored at normal temperature ( $28 \pm 2^{\circ}\text{C}$ ). Data collected included:

**Weight Loss Percentage (WLP):** Orange fruits were initially measured and during the storage period using a Kern analytical balance (Sigma-Aldrich).

$$\text{WLP} = \frac{\text{Original weight} - \text{final weight}}{\text{Original weight}} \times 100$$

**Postharvest decay percentage (PDP):** Postharvest decomposition was evaluated

physically for symptoms during the storage period.  $PDP = \frac{\text{No. of decayed fruits}}{\text{Total no. of fruits}} \times 100$

**Shelf life:** Shelf lives of orange fruits were estimated by examining the marketable fruits per day and this was done on physical appearance and decayed fruits [12].

**Texture evolution:** Firmness of orange fruits was ascertained by physical counting using a rating scale of 1 to 5. Where 1= extremely bad, 2= bad, 3= satisfactory, 4= fine, and 5= splendid.

**Marketability:** Using survey features such as intensity of noticeable blemish, shriveling, smoothness and freshness of fruit, % of saleable fruits during the study.

$\text{Marketability} = \frac{\text{No. of saleable fruits}}{\text{Total no. of fruits}} \times 100$

### 2.3 Isolation of Fungi Associated with Spoilage of Orange Fruits

Potato Dextrose Agar was used to isolate fungi from Citrus fruits. The method of isolation used was the Agar plate method. The fungal isolates were identified using their cultural and morphological characteristics as well as microscopic identification with reference to standard texts [13,14].

### 2.4 Statistical Analysis

Data were computed using SPSS version 20. Data were expressed as mean  $\pm$  standard error and were subjected to one way analysis of variance (ANOVA). Where there is considerable difference, Fisher's Least Significance Difference (LSD) was applied at  $\alpha = 0.05$ .

## 3. RESULTS

### 3.1 Weight Assessment/Shelf Life of Orange Fruits in Storage

There was considerable variation ( $p < 0.05$ ) between the untreated samples and those treated with *A. vera* and *P. guajava* extracts from Day 13 upward (Table 1). Comparing the differences, it was observed that the weight of the orange fruits treated with *A. vera* and *P. guajava* was still above 70g while the untreated orange (weight) was 47g at Day 21. The extracts made the orange weight to still remain well

above 50g but there was high reduction per day especially from day 11, this is to suggest that orange fruit will be unable to stay in form after day 11. The weight difference between day 11 and day 13 is about 14g while for the treated samples; it was just around 4 g difference.

Result obtained showed that the Orange fruits coated with *Aloe vera* had a higher shelf life of 21 days compared with 14 days for control fruits. For Orange fruits coated with Guava extract, it has a higher shelf life of 17 days compared with 14 days for the control fruits.

### 3.2 Postharvest Decay of Orange Fruits in Storage

Postharvest deterioration of orange fruits in storage revealed that there was considerable variation in orange fruit coated with *Aloe vera* gel and control fruits (Table 2) except on day 3, 5 and 7. On days 9, 11, 13, 15 and 17 the maximum postharvest decomposition was recorded on control fruits as against the coated fruits. On day 19 and 21, the maximum postharvest decay was observed on the treated fruits compared with the control fruits. No fruit decay was observed on treated fruits on day 3 and control fruits on day 21.

For orange fruit treated with *P. guajava*, significant difference in decomposition was observed in all the days when coated and control orange fruits were compared except on day 3, 5, 7, 11 and 21. On days 9, 13, 15, 17 and 19 the maximum postharvest decay was recorded on the control fruits compared with the treated fruits. No fruit decay was observed on treated fruits on day 3 and control fruits of day 21.

### 3.3 Marketability of Orange Fruits during the Time of Storage

Marketability of orange fruit coated with *Aloe vera* extract within the storage duration revealed considerable variation ( $p < 0.05$ ) (Table 3) between coated and control orange fruits except on days 3, 5 and 7. On day 9, 11, 13, 15, 17, 19 and 21 the maximum marketability was seen on the treated fruits in relation to the control.

For the orange fruit coated with *P. guajava* extract, no considerable variation ( $p < 0.05$ ) in marketability was observed between treated and control orange fruits but for days 9, 11, 13, 15 in which the highest marketability was observed on the treated fruits compared to the control fruits.

**Table 1. Effects of *Aloe vera* gel and *Psidium guajava* leaf extracts on shelf life of *Citrus sinensis***

Days	Control	Vera	<i>P. guajava</i>
1	114.57±2.49 <sup>a</sup>	115.30±6.06 <sup>a</sup>	122.18±7.32 <sup>a</sup>
3	108.80±2.64 <sup>a</sup>	112.15±6.30 <sup>a</sup>	117.30±7.32 <sup>a</sup>
5	104.18±2.86 <sup>a</sup>	107.73±6.11 <sup>a</sup>	117.2±7.20 <sup>a</sup>
7	97.11±2.36 <sup>b</sup>	104.25±6.16 <sup>a</sup>	105.80±7.06 <sup>a</sup>
9	91.03±32.32 <sup>b</sup>	99.34±6.02 <sup>a</sup>	99.63±6.92 <sup>a</sup>
11	83.81±2.15 <sup>d</sup>	96.58±7.05 <sup>a</sup>	94.58±7.05 <sup>a</sup>
13	69.70±8.04 <sup>c</sup>	92.48±6.03 <sup>ab</sup>	90.91±7.19 <sup>b</sup>
15	64.41±7.48 <sup>c</sup>	89.06±5.76 <sup>ab</sup>	82.38±6.40 <sup>ab</sup>
17	58.89±6.90 <sup>c</sup>	85.11±5.98 <sup>ab</sup>	82.38±6.40 <sup>ab</sup>
19	53.23±6.35 <sup>c</sup>	81.35±5.96 <sup>a</sup>	77.5±6.53 <sup>b</sup>
21	47.49±5.72 <sup>c</sup>	77.79±5.91 <sup>a</sup>	74.11±6.53 <sup>ab</sup>

Means with the same superscript alphabets and in the same row are not significantly different ( $p>0.05$ )

**Table 2. Postharvest Decay Percentage of Orange Fruit Coated with *A. vera* and *P. guajava* Extracts during Storage**

Extracts	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13	Day 15	Day 17	Day 19	Day 21
<i>A. vera</i>	0.0 <sup>a</sup>	20.0 <sup>a</sup>	20.0 <sup>a</sup>	30.0 <sup>a</sup>	40.0 <sup>a</sup>	50.0 <sup>a</sup>	50.0 <sup>a</sup>	60.0 <sup>a</sup>	60.0 <sup>a</sup>	70.0 <sup>a</sup>
Control	10.0 <sup>a</sup>	30.0 <sup>a</sup>	40.0 <sup>b</sup>	50.0 <sup>b</sup>	70.0 <sup>c</sup>	80.0 <sup>b</sup>	90.0 <sup>c</sup>	90.0 <sup>b</sup>	100.0 <sup>c</sup>	*
<i>P. guajava</i>	0.0 <sup>a</sup>	20.0 <sup>a</sup>	20.0 <sup>a</sup>	30.0 <sup>a</sup>	50.0 <sup>b</sup>	50.0 <sup>a</sup>	60.0 <sup>b</sup>	60.0 <sup>a</sup>	70.0 <sup>b</sup>	80.0 <sup>b</sup>
Control	10.0 <sup>a</sup>	30.0 <sup>a</sup>	40.0 <sup>b</sup>	50.0 <sup>b</sup>	70.0 <sup>c</sup>	80.0 <sup>b</sup>	90.0 <sup>c</sup>	90.0 <sup>b</sup>	100.0 <sup>c</sup>	*

(\*) =Null fruits; Means with the same superscript alphabets and in the same column are not significantly different ( $p>0.05$ )

**Table 3. Marketability of Orange fruits Coated with *A. vera* and *P. guajava* Extracts within Storage Duration**

Extracts	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13	Day 15	Day 17	Day 19	Day 21
<i>A. vera</i>	100.0 <sup>a</sup>	80.0 <sup>a</sup>	80.0 <sup>a</sup>	70.0 <sup>a</sup>	60.0 <sup>a</sup>	50.0 <sup>a</sup>	50.0 <sup>a</sup>	40.0 <sup>a</sup>	40.0 <sup>a</sup>	30.0 <sup>a</sup>
Control	90.0 <sup>a</sup>	70.0 <sup>a</sup>	60.0 <sup>b</sup>	50.0 <sup>b</sup>	30.0 <sup>c</sup>	20.0 <sup>b</sup>	10.0 <sup>c</sup>	10.0 <sup>b</sup>	0.0 <sup>c</sup>	*
<i>P. guajava</i>	100.0 <sup>a</sup>	80.0 <sup>a</sup>	80.0 <sup>a</sup>	70.0 <sup>a</sup>	50.0 <sup>b</sup>	50.0 <sup>a</sup>	40.0 <sup>b</sup>	40.0 <sup>a</sup>	30.0 <sup>b</sup>	20.0 <sup>b</sup>
Control	90.0 <sup>a</sup>	70.0 <sup>a</sup>	60.0 <sup>b</sup>	50.0 <sup>b</sup>	30.0 <sup>c</sup>	20.0 <sup>b</sup>	10.0 <sup>c</sup>	10.0 <sup>b</sup>	0.0 <sup>c</sup>	*

(\*) =Null fruits; Means with the same superscript alphabets and in the same column are not significantly different ( $p>0.05$ )

**Table 4. Firmness of Orange fruit coated with *A. vera* and *P. guajava* Extracts During Storage**

Extracts	Day 3	Day 5	Day 7	Day 9	Day 11	Day 13	Day 15	Day 17	Day 19	Day 21
<i>A. vera</i>	4	4	4	3	3	3	3	3	2	2
Control	4	3	3	3	2	2	1	*	*	*
<i>P. guajava</i>	4	4	3	3	3	3	2	2	2	1
Control	4	4	3	3	2	2	1	1	*	*

KEY: 1=Very Poor, 2=Poor, 3=Acceptable, 4=Good, 5=Excellent; (\*) =Null fruits

### 3.4 Firmness of Orange Fruits during Storage

For orange fruits coated with *A. vera* extracts, there was no considerable variation ( $p > 0.05$ ) (Table 4) in firmness between coated and control fruits were noticed but for days 15 and 17. On days 15 and 17, the treated fruits had a value of 3 respectively whereas for control fruit day 15

had a score 1. The maximum firmness recorded in storage was 4, noticed on the coated fruits of days 3, 5, 7 and the control fruits of day 3.

For *P. guajava*, no considerable variation in firmness was recorded between coated and control fruits at ( $p > 0.05$ ). Though, the maximum firmness was reported on both treated and control fruits of day 3 with a rating of 4 respectively.

### 3.5 Isolated Fungi from Deteriorating Orange Fruits

Three fungi were isolated namely; *Botryodiplodia theobromae*, *Fusarium oxysporum* and *Rhizopus stolonifer*.

## 4. DISCUSSION

*Aloe vera* and guava leaf powder can possibly help to avert decomposition of orange caused by disease causing agents like fungi. This statement concurs with the documentation of [15] who pointed out that extracts from botanicals like *Allium sativum* (cloves), neem leaves, *Mentha arvensis* (leaves) and *Psoralea corylifolia* were mostly potent in protecting crop plants from attack by biotic (fungi) and abiotic factors. It was discovered that *A. vera* gel and guava leaf powder had a significant effect in the extension of the storage life in relation to the control. The result of this study is in accordance with the findings of [16], who reported that treatment of orange fruits with *A. vera* gel significantly prolonged their shelf life. There was significant difference between the weight loss of the coated orange fruit and the uncoated orange fruits which showed the effectiveness of the coatings on the orange fruits. This significant difference was seen from Day 15 to day 21. Related studies were also documented to show that loss of weight of fruits increased as storage period progressed [17].

This study revealed that several fungi could be associated with decomposition of stored orange fruits and these fungi include *R. stolonifer*, *F. oxysporum* and *B. theobromae*; and were formerly documented as pathogens of fruits by Onuorah and Orji [18] in which *Aspergillus niger* and *Fusarium* spp. were isolated from decaying tomato fruits. These results clearly established that these disease-causing organisms are widely present regardless of geographical area and invariably exert decay in fruits such as orange.

## 5. CONCLUSION

From the findings of this study, the results show that *Psidium guajava* leaf powder and *Aloe vera* gel are capable of prolonging the storage life and appearance of the orange fruits. Treatments with the *P. guajava* leaf powder and *A. vera* gel prevented weight loss of the orange fruits and *A. vera* gel proved to be more effective in prolonging the shelf life of the oranges than the guava powder. This has increased the

awareness on the use of plant leaves as a biocontrol method of postharvest preservation of fruits instead of using synthetic compounds which might have adverse effects on human health. Thus, this study therefore recommends that more research should be carried out on the use of chemical-free edible coatings (especially *A. vera* gel) on other citrus fruit types such as lemons, limes, grapefruits and tangerines to evaluate their shelf life and quality after harvest.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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