PLOS ONE

RESEARCH ARTICLE

Physical and chemical properties of aloe-vera coated guava *(Psidium guajava)* fruit during refrigerated storage

Debashis Kumar Dutta Roy[1], **Md. Asaduzzaman**[1,2]*, **Tanny Saha**[1], **Mst. Nazma Khatun**[1,3]

1 Department of Food Processing and Preservation, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, **2** Department of Food Engineering and Technology, State university of Bangladesh, Dhaka, Bangladesh, **3** Department of Food Technology, Chapainawabganj Polytechnic Institute, Chapainawabganj, Bangladesh

* bitatipu@gmail.com

Citation: Dutta Roy DK, Asaduzzaman M., Saha T, Khatun M.N (2023) Physical and chemical properties of aloe-vera coated guava *(Psidium guajava)* fruit during refrigerated storage. PLoS ONE 18(11): e0293553. https://doi.org/10.1371/journal.pone.0293553

Editor: Awatif Abid Al-Judaibi, University of Jeddah, SAUDI ARABIA

Received: April 27, 2023

Accepted: October 14, 2023

Published: November 1, 2023

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0293553

Data Availability Statement: All relevant data are within the paper and its Supporting information files.

Abstract

Guavas (Psidium guajava) are regarded as one of the most perishable commodities, primarily owing to their climacteric characteristics and heightened metabolic processes, resulting in a faster rate of softening. Edible coating is a natural ingredient that is employed as an alternative to extend the shelf life of fruits while also providing bioactive and functional compounds. Aloe vera gel is predominantly used for this purpose due to its widespread availability. Various concentrations of aloe vera-based coating formulation (25%, 50%, 75%, and 100%) were applied on fresh whole guava by dipping method. The guava was stored at a refrigerated condition (4˚C) and weight loss, color, firmness, vitamin C, total phenol, and pH change were observed in this research. A significant effect of aloe vera coating was found over the storage period. Aloe vera treatment lowered the weight loss, and retarded the texture and color compared to the control sample throughout the 28 days of storage. Vitamin C and total phenol content remined high at 141.4 mg/100g and 219.6 mg GAE/100g respectively in a 100% aloe vera coated sample after 28 days of storage compared to the control. Among 25%, 50%, 75%, and 100% aloe vera coated sample, 100% aloe vera was found to be the best coating material to prevent physical changes in fresh guava.

Introduction

Guava (*Psidium guajava*) is one of the most common tropical fruits in Bangladesh. Guava is popular for its high content of antioxidants such as vitamin C, 260 mg per 100 gm [1, 2]. It is also rich in antioxidant and bioactive compounds which can retard aging by reducing oxidative damage of lipids, protein and nucleic acid [2]. According to Hossen, 2012, the annual production of guava is about 145,000 m tons in an area of about 10,000 hectors per year on an average of which 30–40% is wasted due to several causes in Bangladesh due to highly perishable and low shelf-life ranges from 3 to 10 days at room temperature [3]. Without any treatment guava is spoiled very easily because of its high respiration rates, mechanical damage, and microbial decomposition. Different method including ionizing radiation, preservatives, and controlled atmosphere are used for the preservation of guava [4–6].

Funding: The author(s) received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

Additionally application of edible films and coating can increase the shelf life of guava by reducing moisture content and gas loss as well as improve the quality, safety, transportation, storage, and display of a wide range of fresh and processed fruits [7–9]. However, edible films and coatings also may prevent moisture loss and contamination of fruits and vegetables [9]. They can act as moisture and oxygen barrier during processing, handling, transportation [8]. During storage, it helps to retard decomposition and enhance the safety of guava by improving antimicrobial functions [10]. In recent studies; the edible coating formulation is used as a new improved technique that acts as a packaging material. However, it has more functional properties than thermoplastic materials [11].

Different types of edible coating are used and aloe vera is one of them [7, 12]. Aloe vera gel is a polysaccharide-based edible coating material, which has a commercial application in the processing of fruits [13]. It has therapeutic values which can an innovative and interesting means for commercial application. *Aloe vera* has been used for centuries for its medicinal and therapeutic, antioxidant, and anti-microbial properties [14–17]. Various types of coating conditions and different coating materials can enhance the shelf life of different fruits [16]. The annual production of aloe vera exceeds 1000 metric tonnes, primarily utilized in Ayurvedic, Unani, and herbal treatments [18].

Though a large quantity of guava is wasted during post-harvest handling, coating of guava can reduce this type of loss, so in this study, we will evaluate the concentration of aloe vera coating for guava as well as analyze the effect of various concentrations of aloe vera on physical and chemical properties of fresh and coated guava over the storage period.

Materials and methods

Experimental site

The study was conducted in the laboratory of Food Engineering & Technology and Food Processing & Preservation department under the Faculty of Engineering of Hajee Mohammad Danesh Science and Technology University, Dinajpur. The study was conducted in the chemistry laboratory of this university. Samples and chemical collection Fresh guava and Aloe vera leaves were bought from local market, Dinajpur. Guava fruits of uniform size and shape were selected. All analytical grade chemicals such as Glycerol, methanol, Glacial acetic acid, Meta phosphoric acid were supplied by the food processing laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Preparation of aloe vera gel

Aloe vera leaves were washed with water and skins were peeled. The gels were separated, collected and ground in a blender. Then aloe vera pulp was filtered to remove the fibres [19].

Preparation of coating materials

Edible coating material was made by adding 1% glycerol (used as plasticizing agent), 5% Corn starch (used as a thickening agent), 5% ethanol (used for fast drying of coating), and 1% acetic acid with Aloe vera gel and stirred evenly for 20 minutes. Then the aloe vera gel solution was heated at a temperature of 70˚C for 45 minutes to pasteurize it and cooled to room temperature and stored in the refrigeration temperature.

Guava coating process

Fresh guavas were then dipped into with different concentrations of aloe vera (T_0 = No Aloe Vera, T_1 = 25%, T_2 = 50%, T_3 = 75%, and T_4 = 100%) for 2 minutes and then dried naturally for 30 minutes.

After drying the coated guavas were packed using LDPE and stored refrigerated at 4˚C for 30 days.

Physical properties

Determination of pH. The pH of the selected samples was determined by the conventional procedure of a pH meter.

Weight loss. Sample weight loss was determined by comparing the weights of coated guava after storage with initial weights and expressing the results as a percentage (Chen *et al*., 2007). The results are calculated with the following equation where W_1 was the Initial weight and $W_2$was the Final weight.

$$Weight\ loss = \frac{W_1 - W_2}{W_1} \times 100$$

Firmness. The firmness of Guava was determined by using a penetrometer. The firmness test was done by penetrating the stainless steel probe 3.5 mm in diameter. The probe was penetrating up to three different locations in each sample. The data was recorded as a force expressed as a unit of Newtons (N).

Color. The color property of guava was determined with a Colorimeter Minolta CM-2500d (Konica Minolta Optics, Inc. Japan). Color attributes were recorded as L* (lightness), a* (redness), and b* (yellowness). Here the change in lightness and Hue angle is calculated. The equation used for hue is as follows where h = Hue angle, b = yellowness, and a = redness

$$h = \tan^{-1}(b/a).$$

Chemical properties

Proximate composition. Moisture, crude protein, fat, and ash content of flours were determined by official methods (AOAC, 1998) [20].

Vitamin C. The vitamin C content of guava was measured using the AOAC method (2,6-Dichloroindophenol titrimetric method, 2006).

Total phenol. Total phenol was determined according to the method described by Lin &Tang, 2007., with slight modifications [21]. The absorbance was taken at 760 nm. The phenol content was determined using the Gallic acid standard curve and was expressed as ppm.

Total phenol content was calculated by the following formula:

$$\%\ \text{Phenol} = X\ (\text{ppm}) \times \frac{\text{Total volume made up}}{\text{Weight of sample(mg)}} \times 100$$

Statistical analysis

Each experiment included three replications. Data were analyzed using statistical software (R-version 3.2.2.). A multifactorial analysis of variance was carried out. Individual effects of the factors have been calculated at a particular point in time during the study. Differences were considered to be significant at $P<0.05$.

Results and discussion

Physical properties

pH. The pH content of guava decreased gradually with the increase of storage time (Fig 1). The 100% aloe vera coated sample (Treatment 04) shows the lowest pH 3.62 at day 28 compared with the others with significantly different (P>0.05). Normally the lower pH is create difficult condition to grow microorganisms which means 100% aloe vera controls microbial growth of microbes [17]. According to Keditsu, this pH change due to presence of the organic acids and conversion of sugar into acid and metabolic processes [22].

Weight loss. The weight loss was measured up to 35 days, here the data is shown28 days (Fig 2). The change in weight loss was increased through the storage period. The highest weight loss was found in the control sample compared with the coated ones. The highest weight loss was 14.17% in control where the lowest value was 6.36% for 100% Aloe vera coated guava Though the weight loss is different is different coating percentages but 100% Aloe vera achieved the lowest weight loss in 28 days which ensures he weight loss was minimized by aloe vera coating. Similar observation proved by Dorria (2007) & Zuraidah (2015) [23, 24]. Normally, Weight loss of guava occurs due to dehydration, respiration, and physical cell disruption [25].

Firmness. Weight loss can affect the firmness of guava. The softness of guava is also affected by ethylene activity which is highest at room temperature within 4 days at room temperature [26, 27]. Fig 3 represents that the firmness is gradually lowered by increasing the storage period. In the case of coated samples the firmness is higher than the uncoated ones and 100% aloe vera coating restricts the firmness loss during the 28 days of storage period.

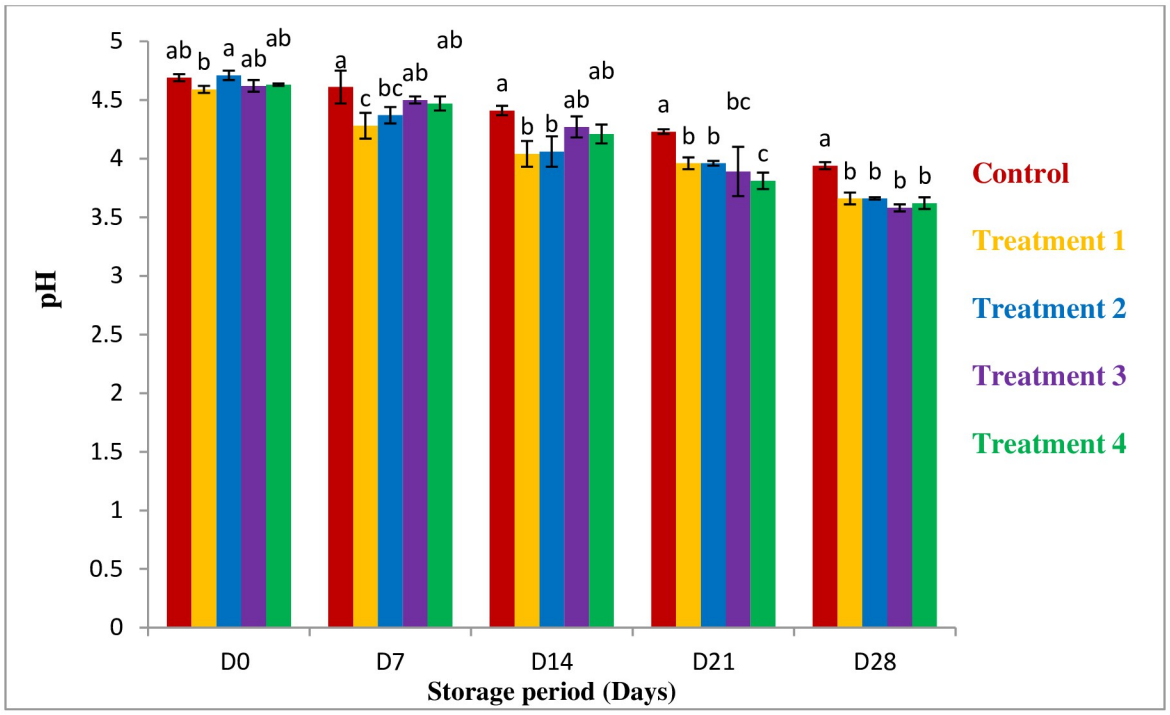

Fig 1. pH values in different storage period. *All values are express as mean ± SD. *Mean followed by different superscript letters in each raw are significantly different (p<0.05).

https://doi.org/10.1371/journal.pone.0293553.g001

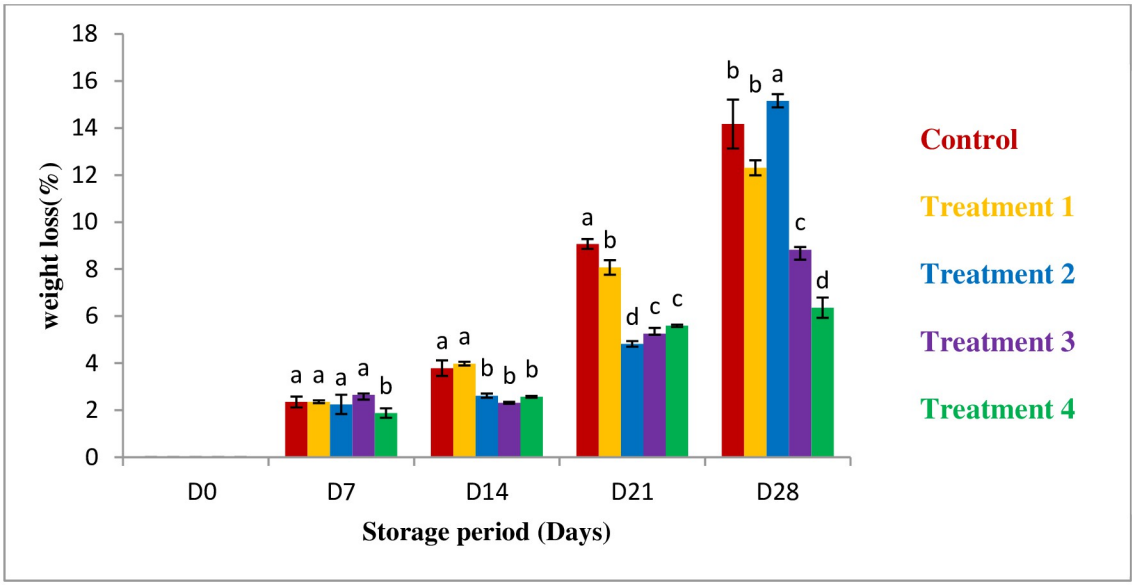

Fig 2. Effect of coating on weight loss. *All values are express as mean ± SD. *Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

https://doi.org/10.1371/journal.pone.0293553.g002

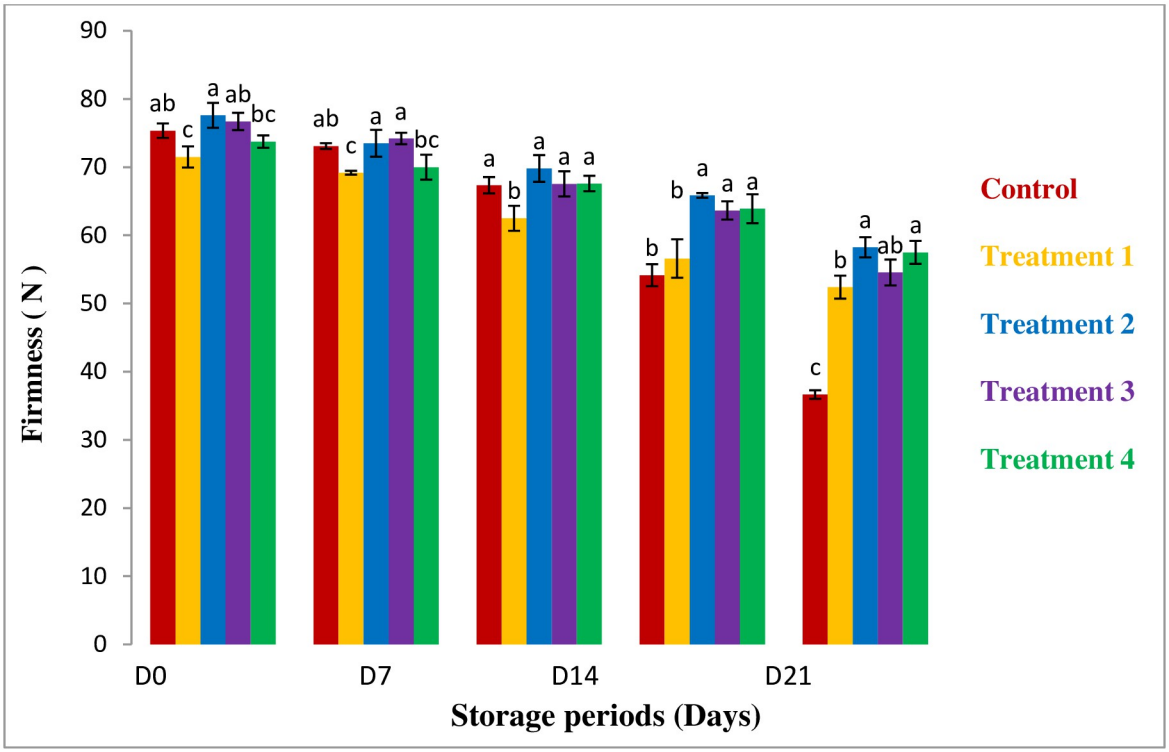

Fig 3. Changes in firmness in the coating samples. *All values are express as mean ± SD. *Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

https://doi.org/10.1371/journal.pone.0293553.g003

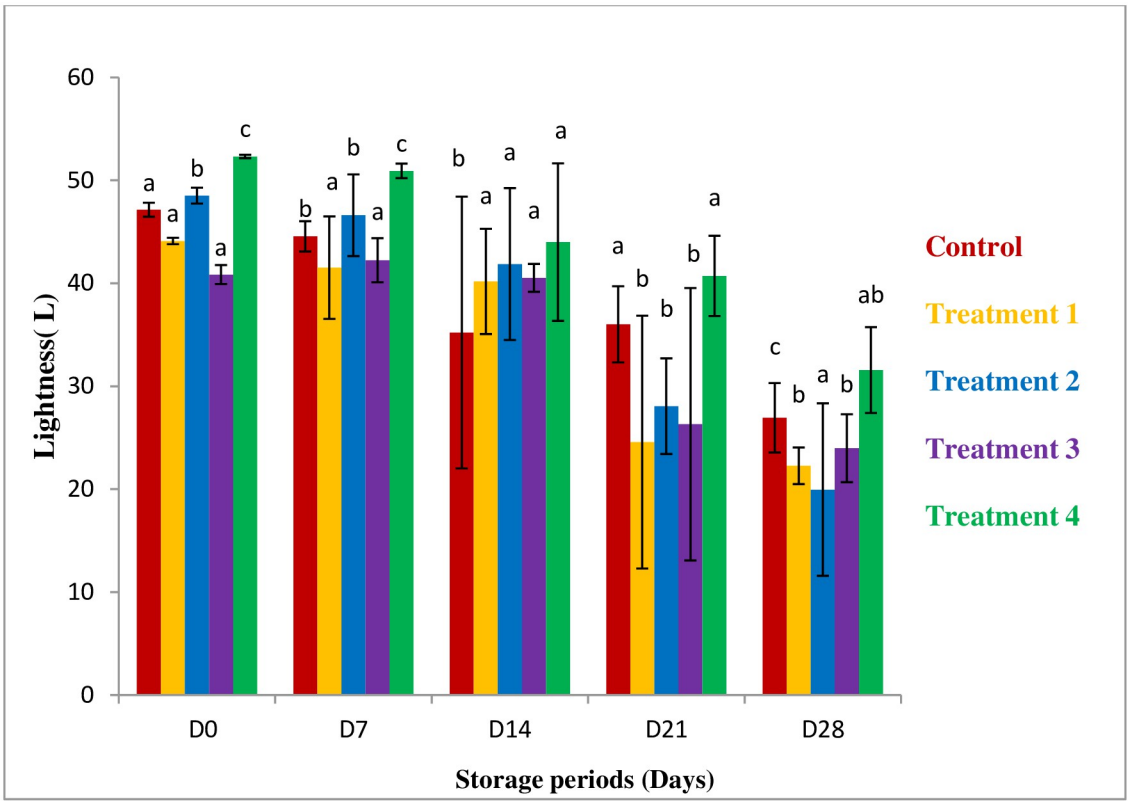

Fig 4. Effect of coating on lightness. *All values are express as mean ± SD. *Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

https://doi.org/10.1371/journal.pone.0293553.g004

Martinez–Romero *et al.*, (2006) also found that aloe vera gel has the power to lower weight loss which also influences the retarding of firmness [28]. The possible reason may be the use of a higher concentration of aloe vera in this study. The higher concentration of aloe vera retards the firm loss and improved quality [24, 28].

The color attribute of guava. The change in lightness, redness, and yellowness is shown in Fig 4 and Table 1. The value showed negative in the case of "a" because guava is generally green in color. When storage time was increased lightness of guava decreased (highest 47.15 to 26.94 in the controlled and 52.32 to 31.57 in the 100% aloe vera coated sample). But the coated sample has higher lightness than the uncoated sample. On day 28, the 100% aloe vera-coated sample had higher value than others. One of the possible reasons for the change in lightness is the coating material. It acts as a modified atmosphere packaging material which delays the degradation of color [29]. According to Baldwin *et al.*,1995 the edible coating was also demonstrated to delays color change, and weight loss in tropical fruit and improves appearance [7].

In the case of greenness, a lowering effect throughout the storage period was observed. The green color changed from light yellow to dark yellow. The controlled sample changed its color earliest because of its high respiration rate compared to the other coated samples. Previous studies also showed the same color changes over the period [30, 31].

With the change of time, the hue angles were increased (Table 1). This indicates the changing of green to yellow color. The reduction of greenness (-8.08 to -16.01) is nearly similar to Xing et al., 2011, who used a polysaccharide-based chitosan coating [32].

Table 1. Comparison of different color parameter (a, b and Hue values) for different samples of the product.

Treatment	Storage periods (Days)				
	D_0	D_7	D_{14}	D_{21}	D_{28}
a value					
T_0	-8.86±2.05^{a}	-25.9±14.1^{a}	-31.79±29.4^{c}	-27.12±7.70^{b}	-15.55±5.44^{b}
T_1	-6.64±2.05^{a}	-15.46±0.5^{ab}	-21.45±7.61^{a}	-12.03±5.49^{a}	-8.77±6.09^{b}
T_2	-8.98±2.14^{a}	-19.92±2.1^{ab}	-29.81±16.8^{ab}	-13.16±3.23^{a}	-13.99±0.65^{a}
T_3	-5.97±1.97^{a}	-21.56±8.64^{a}	-13.5±11.5^{ab}	-20.1±0.79^{ab}	-10.60±0.37^{b}
T_4	-8.08±2.12^{a}	-8.30±0.21^{a}	-25.14±9.5^{b}	-32.11±5.25^{b}	-16.1±0.81^{b}
b value					
T_0	32.65±0.40^{a}	10.16±0.76^{b}	14.85±1.15^{ab}	14.30±2.99^{b}	13.63±4.6^{b}
T_1	28.34±0.28^{b}	15.98±8.72^{b}	26.33±4.56^{a}	24.96±9.34^{a}	18.44±2.52^{a}
T_2	31.55±0.40^{a}	17.26±2.25^{c}	15.3±4.39^{ab}	15.805±0.86^{b}	17.94±7.21^{a}
T_3	27.91±1.19^{b}	32.46±1.26^{a}	24.12±12.2^{a}	20.04±6.39^{a}	17.33±0.62^{a}
T_4	31.64±0.27^{a}	19.45±0.17^{c}	17.06±1.13^{b}	18.36±4.54^{a}	17.74±0.94^{a}
Hue angle (h^0)					
T_0	-74.85±3.14^{a}	-23.87±10.2^{b}	-34.97±28.3^{a}	-28.83±11.7^{a}	-51.72±5.02^{c}
T_1	-74.64±0.71^{a}	-43.73±15.1^{bc}	-51.05±14.6^{ab}	-62.255±18^{b}	-64.72±18.1^{b}
T_2	-64.1±10.7^{ab}	-40.9±0.74^{bc}	-52.1±41.1^{b}	-49.08±7.5^{ab}	-50.66±10.3^{a}
T_3	-78.02±3.40^{b}	-57.12±9.61^{c}	-58±32.0^{ab}	-44.13±8.1^{ab}	-58.54±0.03^{ab}
T_4	-75.68±3.73^{a}	-66.88±0.73^{a}	-36.19±8.72^{a}	-29.56±2.11^{a}	-47.77±0.08^{a}

*All values are express as mean ± SD.

*Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

*T_0 = Control, T_1 = 25% Aloe vera, T_2 = 50% Aloe vera,T_3 = 75% Aloe vera, T_4 = 100% Aloe vera.

https://doi.org/10.1371/journal.pone.0293553.t001

Chemical properties

Proximate analyses. The chemical composition of guava and aloe vera is shown in Table 2. In the case of guava, the results showed 83.73% moisture, 12.6% carbohydrates, 1.7% ash, and 1.3% protein, which were similar to those reported by USDA (1982) [33]. They found 80.61% moisture, 0.7% ash, 1.28% acidity, 11% carbohydrates, and 19% TSS. The variation in the results may be due to different species, environmental conditions, and horticultural practices in guava production [34].

On the other hand, in the case of aloe vera, the results showed 97.4% moisture, 1.3% ash, and 1.7% carbohydrates. Pierce (1983) and Rowe (1941) also found 98.5% moisture and 0.3% carbohydrates, which were nearly similar [35, 36].

Table 2. Proximate composition of guava and aloe vera.

Sample	Composition (%)						
	Moisture	Protein	Fat	Carbohydrate	Ash	TSS	pH
Guava	83.73±0.73	1.3±0.04	-	12.6±0.24	1.7±0.16	18.6±0.45	4.63±0.21
Aloe vera	97.4±0.52	-	-	1.7±0.07	1.3±0.08	1.2±0.36	4.76±0.16

*All values are express as mean ± SD.

*Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

https://doi.org/10.1371/journal.pone.0293553.t002

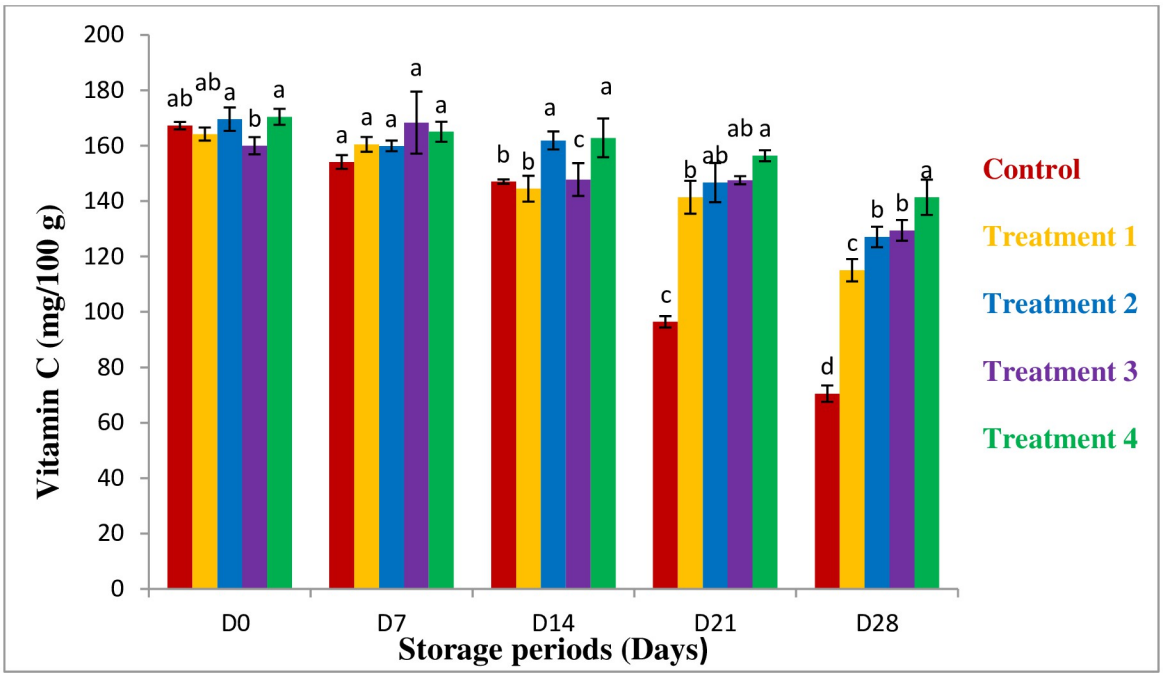

Fig 5. Vitamin C content of the coating samples. *All values are express as mean ± SD. *Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

https://doi.org/10.1371/journal.pone.0293553.g005

Vitamin C. Vitamin C is an important factor for guava. The change in vitamin C of guava is shown in Fig 5. In this study, the result shows vitamin C content of raw guava was 167.25 mg/100g which was similar to Vila *et al*., 2007 [37].

During the storage period, the vitamin C content of guava is decreased in all samples. The loss of vitamin C in the control sample is 96.75mg/100g and in the coated sample were 49.46, 42.55, 30.55, and 29.05mg/100g respectively. The result shows that vitamin C loss was higher in the fresh sample than in the coated sample. Vitamin C loss may occur because of phenol oxidase and ascorbic acid oxidase [38]. Also, the presence of light, heat, and oxygen can reduce the vitamin C content [39]. On the other hand modified packaging (aloe vera coating) creates an aerobic condition on the guava surface which influenced the lower oxidation rate in the guava surface [40].

This study concluded that the loss of vitamin C in the aloe vera coated sample is lower than the control. The higher concentration of aloe vera has the higher the efficiency of preservation. In this study, 100% coating concentration shows a higher result which is similar to Serrano *et al*., 2006 [41].

Total phenol content. Total phenol is also an important factor for the maturity index. Table 3 shows the changes in total phenol throughout the storage periods. The result showed that the total phenol content of guava in the fresh sample was 265.3–271.1 mg GAE per 100 g. This result is similar to Thaipong *et al*., 2006, and Hagen *et al*., 2007 who reported that it could be 170–344 mg GAE per 100g [42, 43].

During the storage periods, total phenol content was reduced to between 265.3 and133.85 for control and between 271.1 and219.6 mg GAE per 100g for the 100% aloe vera coated sample. The loss in the control sample was 131.45 and in the coated sample were 83.3, 72.9, 54.8, and 51.5 mg GAE per 100g respectively. The change may be due to many factors such

Table 3. Effect of coating on total phenol content of guava (mg GAE per 100 g).

Treatment	Storage periods (Day)				
	D_0	D_7	D_{14}	D_{21}	D_{28}
T_0	265.3±0.56^{ab}	255.6±4.66^{d}	193.6±1.83^{d}	172.7±5.79^{c}	133.85±6.29^{d}
T_1	256.45±2.61^{c}	242.7±4.10^{b}	211.65±1.34^{c}	196.75±3.60^{b}	173.15±5.30^{c}
T_2	263.25±2.62^{b}	251.85±4.59^{ab}	230.55±2.61^{b}	239.25±9.12^{a}	190.35±3.46^{b}
T_3	249.2±3.39^{d}	242.05±4.45^{b}	225±5.09^{b}	212.65±8.83^{b}	194.4±2.82^{b}
T_4	271.1±1.83^{a}	256.95±2.33^{d}	245.3±1.97^{a}	230.4±3.26^{a}	219.6±2.40^{a}

*All values are express as mean ± SD.

*Mean followed by different superscript letters in each raw are significantly different ($p<0.05$).

*T_0 = Control, T_1 = 25% Aloe vera, T_2 = 50% Aloe vera,T_3 = 75% Aloe vera, T_4 = 100% Aloe vera.

https://doi.org/10.1371/journal.pone.0293553.t003

as variety, species, ripening, and environmental conditions [44]. According to Taylor (1993), the lowering in total phenol content can reduce the astringency during the storage period [45]. More monomeric components can convert to polymeric components; these also cause the reduction of total phenol [46, 47]. This study shows that the loss of total phenol is reduced by the application of aloe vera coating which is also proven by Serrano *et al*., 2006 [41].

Storage studies of guava. Organoleptic properties of all the samples of guava were observed during storage periods at refrigeration temperature (4˚C), based on color, flavor, texture, and visual fungal growth. This was recorded at every 7 days intervals up to 35 days. The data are shown in Table 4. In the case of the control sample, there was no change in the properties for up to 7 days. On day 14 the color started to change from dark green to green and slight fungal growth was seen. On day 21 it was changed its all property and organoleptically unaccepted for consume because excessive fungal growth.

In the case of the coated sample, there was no change up to 21 days except for a little of softness. At day 28, 25% and 50% aloe vera coated samples were unaccepted because they changed their properties. On the other hand, 75% and 100% coated samples had better quality than the other samples and were organoleptically acceptable for up to 28 days. But all samples were spoiled on day 35. Kendall and Sofos (2007) found that if the sample is processed properly and stored in a cool dry place it will retain good quality for up to several months [48].

Conclusion

This study was conducted to introduce a novel processing technique, edible coating by aloe vera gel on guava with the objectives to document the physico-chemical properties and find the suitable concentration of coating during storage periods. The analyzed proximate composition of guava and aloe vera gel was 83.73% moisture, 1.3% protein, 12.6% carbohydrate, 1.7% ash, and 97.4% moisture, 1.2% ash, and 0.7% carbohydrate respectively. The weight loss and soft texture were found to be lower in the coated samples. The vitamin C content of guava was higher (141.4mg) in the coated samples than in the fresh guava (70.5mg) on the 28th day of the storage period. The color change (yellowness) was also lower in the coated sample and had a better appearance and acceptance. The total phenol content loss was also controlled by the application of coating material. Therefore it is concluded that the application of aloe vera coating can increase the shelf life of guava. Also, the higher concentration of coating material has a

Table 4. Sensory studies of coated guava.

Storage period	Sample	Color	Flavor	Texture	Visual fungal growth	Remarks
Day 0	T_0	Dark Green	Good	Hard	No growth	Good
	T_1	Dark Green	Good	Hard	No growth	Good
	T_2	Dark Green	Good	Hard	No growth	Good
	T_3	Dark Green	Good	Hard	No growth	Good
	T_4	Dark Green	Good	Hard	No growth	Good
Day 7	T_0	Dark Green	Good	Hard	No growth	Good
	T_1	Dark Green	Good	Hard	No growth	Good
	T_2	Dark Green	Good	Hard	No growth	Good
	T_3	Dark Green	Good	Hard	No growth	Good
	T_4	Dark Green	Good	Hard	No growth	Good
Day 14	T_0	Green	Good	Semi Soft	Slightly growth	Good
	T_1	Dark Green	Good	Semi Soft	No growth	Good
	T_2	Dark Green	Good	Semi Soft	No growth	Good
	T_3	Dark Green	Good	Semi Soft	No growth	Good
	T_4	Dark Green	Good	Semi Soft	No growth	Good
Day 21	T_0	Slight yellowish	Off flavor	Soft	Highly growth	Spoiled
	T_1	Green	Good	Semi Soft	No growth	Good
	T_2	Green	Good	Semi Soft	No growth	Good
	T_3	Green	Good	Semi Soft	No growth	Good
	T_4	Green	Good	Semi Soft	No growth	Good
Day 28	T_0	Fully yellowish	Off flavor	No texture	Excessive growth	Spoiled
	T_1	Slight yellowish	Off flavor	Soft	Excessive growth	Spoiled
	T_2	Slight yellowish	Off flavor	Soft	Excessive growth	Slightly Spoiled
	T_3	Slight yellowish	Off flavor	Semi Soft	Medium growth	Slightly spoiled
	T_4	Slight yellowish	Off flavor	Semi Soft	Medium growth	Slightly spoiled
Day 35	T_0	Black	Off flavor	No texture	Excessive growth	Spoiled
	T_1	Full yellow	Off flavor	No texture	Excessive growth	Spoiled
	T_2	Full yellow	Off flavor	Semi Soft	Excessive growth	Spoiled
	T_3	Full yellow	Off flavor	Semi Soft	Medium growth	Spoiled
	T_4	Full yellow	Off flavor	Semi Soft	Medium growth	Spoiled

*T_0 = Control, T_1 = 25% Aloe vera, T_2 = 50% Aloe vera, T_3 = 75% Aloe vera, T_4 = 100% Aloe vera.

https://doi.org/10.1371/journal.pone.0293553.t004

higher quality. Among all the treatments 100% aloe vera coating was best. As it increased the shelf life and lowered the loss of nutritional and quality parameter, it can be used as a natural preservation technique.

Supporting information

S1 File.
(DOCX)

S2 File.
(DOCX)

S1 Fig.
(JPG)

Acknowledgments

This study was the completion of the thesis of the Masters of Science laboratory works.

Author Contributions

Conceptualization: Debashis Kumar Dutta Roy.

Methodology: Tanny Saha.

Project administration: Md. Asaduzzaman.

Resources: Tanny Saha.

Supervision: Md. Asaduzzaman.

Writing – original draft: Debashis Kumar Dutta Roy.

Writing – review & editing: Md. Asaduzzaman, Tanny Saha, Mst. Nazma Khatun.

References

1. Bose, T.K. Fruits of India, Tropical and Subtropical.1st edn, Naya Proksash, Calcata– 6 India. 2011, 278.
2. Feskanich D, Ziegler RG, Michaud DS, Giovannucci EL, Speizer FE, Willett WC, et al. Prospective study of fruit and vegetable consumption and risk of lung cancer among men and women. Journal of the National Cancer Institute. 2000 Nov 15; 92(22):1812–23. https://doi.org/10.1093/jnci/92.22.1812 PMID: 11078758
3. Campbell CA. Handling of Florida-grown and imported tropical fruits and vegetables. Hort Science. 1994 Sep 1; 29(9):975–8.
4. Silva JM, Correia LC, Moura NP, Maciel MI, Villar HP. Use of ionising radiation technology as a method of postharvest conservation of guava. International Journal of Postharvest Technology and Innovation. 2011 Jan 1; 2(2):168–79.
5. Lima MA, Durigan JF, SOUZA B, Donadon JR. Post-harvest conservation of guavas using calcium and gibberellic acid together with different plastic films. Revista Brasileira de Armazenamento. 2003; 28:31–40.
6. Singh SP, Pal RK. Controlled atmosphere storage of guava (Psidium guajava L.) fruit. Postharvest Biology and technology. 2008 Mar 1; 47(3):296–306.
7. Baldwin EA, Nisperos-Carriedo MO, Baker RA. Use of edible coatings to preserve quality of lightly (and slightly) processed products. Critical Reviews in Food Science & Nutrition. 1995 Nov 1; 35(6):509–24. https://doi.org/10.1080/10408399509527713 PMID: 8777016
8. Díaz-Pérez JC, Mejía A, Bautista S, Zavaleta R, Villanueva R, Gómez RL. Response of sapote mamey [Pouteria sapota (Jacq.) HE Moore & Stearn] fruit to hot water treatments. Postharvest Biology and Technology. 2001 May 1; 22(2):159–67.
9. Park HJ. Development of advanced edible coatings for fruits. Trends in food science & technology. 1999 Aug 1; 10(8):254–60.
10. Vargas M, Pastor C, Chiralt A, McClements DJ, Gonzalez-Martinez C. Recent advances in edible coatings for fresh and minimally processed fruits. Critical reviews in food science and nutrition. 2008 May 28; 48(6):496–511. https://doi.org/10.1080/10408390701537344 PMID: 18568856
11. Brody AL. Nano and food packaging technologies converge. Food Technology (Chicago). 2006; 60 (3):92–4.
12. Martínez-Romero D, Castillo S, Guillén F, Díaz-Mula HM, Zapata PJ, Valero D, et al. Aloe vera gel coating maintains quality and safety of ready-to-eat pomegranate arils. Postharvest Biology and Technology. 2013 Dec 1; 86:107–12.
13. Ahmed MJ, Singh Z, Khan AS. Postharvest Aloe vera gel-coating modulates fruit ripening and quality of 'Arctic Snow' nectarine kept in ambient and cold storage. International journal of food science & technology. 2009 May; 44(5):1024–33.
14. Capasso F, Borrelli F, Capasso R, Carlo GD, Izzo AA, Pinto L, et al. Aloe and its therapeutic use. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 1998; 12(S1):S124–7.

15. Hamman JH, Viljoen AM. Use of Aloe vera for increasing the bioavailability of poorly absorbable drugs. SA patent application. 2008; 1542:2008.

16. Chen SH, Lin KY, Chang CC, Fang CL, Lin CP. Aloe-emodin-induced apoptosis in human gastric carcinoma cells. Food and chemical toxicology. 2007 Nov 1; 45(11):2296–303. https://doi.org/10.1016/j.fct.2007.06.005 PMID: 17637488

17. Miranda M, Maureira H, Rodríguez K, Vega-Gálvez A. Influence of temperature on the drying kinetics, physicochemical properties, and antioxidant capacity of Aloe Vera (Aloe Barbadensis Miller) gel. Journal of Food Engineering. 2009 Mar 1; 91(2):297–304.

18. Dixie, G., Imam, S.A. and Hussain, M.J., Medicinal plant marketing in Bangladesh. South Asia Enterprise Development Facility (SEDF) and Inter-Cooperation (IC), Bangladesh, 2003. 35.

19. Navarro D, Díaz-Mula HM, Guillén F, Zapata PJ, Castillo S, Serrano M, et al. Reduction of nectarine decay caused by Rhizopus stolonifer, Botrytis cinerea and Penicillium digitatum with Aloe vera gel alone or with the addition of thymol. International journal of food microbiology. 2011 Dec 2; 151(2):241–6. https://doi.org/10.1016/j.ijfoodmicro.2011.09.009 PMID: 21974979

20. AOAC (1998). Official Methods of Analysis of AOAC International (14th ed.). Washington, DC, USA: Association of Official Analytical Chemistry. Methods, 950.46, 938.08, 960.39, 955.04.

21. Lin JY, Tang CY. Determination of total phenolic and flavonoid contents in selected fruits and vegetables, as well as their stimulatory effects on mouse splenocyte proliferation. Food chemistry. 2007 Jan 1; 101(1):140–7.

22. Keditsu SE, Smith ST, Gomez J. Effect on ethanol vapor treatments on light rown apple. Postharvest Biology and Technology. 2003; 18:268–78.

23. Dorria MA, Safinaz ME, El-Mallah MH. Jojoba oil as a novel coating for exported Valencia orange fruit. Am-Euras. J. Agric. Environ. Sci. 2007; 2(2):173–81.

24. Nasution Z, Ye JN, Hamzah Y. Characteristics of fresh-cut guava coated with aloe vera gel as affected by different additives. Agriculture and Natural Resources. 2015 Feb 28; 49(1):111–21.

25. Vazquez-Ochoa RI, Colinas-Leon MT. Changes in guavas of three maturity stages in response to temperature and relative humidity. Hort Science. 1990 Jan 1; 25(1):86–7.

26. Azzolini M, Jacomino AP, Bron IU, Kluge RA, Schiavinato MA. Ripening of "Pedro Sato" guava: study on its climacteric or non-climacteric nature. Brazilian Journal of Plant Physiology. 2005; 17:299–306.

27. Brown BI, Wills RB. Post-harvest changes in guava fruit of different maturity. Scientia Horticulturae. 1983 Apr 1; 19(3–4):237–43.

28. Martínez-Romero D, Alburquerque N, Valverde JM, Guillén F, Castillo S, Valero D, et al. Postharvest sweet cherry quality and safety maintenance by Aloe vera treatment: a new edible coating. Postharvest Biology and Technology. 2006 Jan 1; 39(1):93–100.

29. Ergun M. and Satici F. Use of Aloe vera gel as bio preservatives for 'Granny Smith' and 'Red Chief' apples. The Journal of Animal and Plant Science, 2012, 22:363–368.

30. Siqueira AD, da Costa JM, Afonso MR, Clemente E. Pigments of guava paluma cultivar stored under environmental conditions. African Journal of Food Science. 2011 Jun; 5(6):320–3.

31. González IA, Osorio C, Meléndez-Martínez AJ, González-Miret ML, Heredia FJ. Application of tristimulus colorimetry to evaluate colour changes during the ripening of Colombian guava (Psidium guajava L.) varieties with different carotenoid pattern. International journal of food science & technology. 2011 Apr; 46(4):840–8.

32. Xing Y, Li X, Xu Q, Yun J, Lu Y, Tang Y. Effects of chitosan coating enriched with cinnamon oil on qualitative properties of sweet pepper (Capsicum annuum L.). Food chemistry. 2011 Feb 15; 124(4):1443–50.

33. United States Department Of Agriculture Human Nutrition Information Service., (1982). Agriculture handbook no. 8–9.

34. Yusof S, Mohamed S, Bakar AA. Effect of fruit maturity on the quality and acceptability of guava puree. Food chemistry. 1988 Jan 1; 30(1):45–58.

35. Pierce RF. Comparison between the nutritional contents of the aloe gel from conventionally and hydroponically grown plants. Erde international. 1983; 1:37–8.

36. Parks LM, Rowe TD. A phytochemical study of Aloe vera leaf. Journal of the American Pharmaceutical Association. 1941 Oct; 30(10):262–6.

37. Vila MT, Lima LC, Vilas Boas EV, Doll Hojo ET, Rodrigues LJ, Paula NR. Chemical and biochemical caracterization of guavas stored under refrigeration and modified atmosphere. Ciência e Agrotecnologia. 2007; 31:1435–42.

38. Yaman Ö, Bayoındırlı L. Effects of an edible coating and cold storage on shelf-life and quality of cherries. LWT-Food science and Technology. 2002 Mar 1; 35(2):146–50.

39. Davey MW, Montagu MV, Inze D, Sanmartin M, Kanellis A, Smirnoff N, et al. Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing. Journal of the Science of Food and Agriculture. 2000 May 15; 80(7):825–60.

40. Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest biology and technology. 2000 Nov 1; 20(3):207–20.

41. Robles-Sánchez RM, Rojas-Graü MA, Odriozola-Serrano I, González-Aguilar G, Martin-Belloso O. Influence of alginate-based edible coating as carrier of antibrowning agents on bioactive compounds and antioxidant activity in fresh-cut Kent mangoes. LWT-Food Science and Technology. 2013 Jan 1; 50 (1):240–6.

42. Hagen SF, Borge GI, Bengtsson GB, Bilger W, Berge A, Haffner K, Solhaug KA. Phenolic contents and other health and sensory related properties of apple fruit (Malus domestica Borkh., cv. Aroma): Effect of postharvest UV-B irradiation. Postharvest Biology and Technology. 2007 Jul 1; 45(1):1–0.

43. Thaipong K, Boonprakob U, Crosby K, Cisneros-Zevallos L, Byrne DH. Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. Journal of food composition and analysis. 2006 Sep 1; 19(6–7):669–75.

44. Iqbal S, Bhanger MI. Effect of season and production location on antioxidant activity of Moringa oleifera leaves grown in Pakistan. Journal of food Composition and Analysis. 2006 Sep 1; 19(6–7):544–51.

45. Seymour GB, Taylor JE, Tucker GA, editors. Biochemistry of fruit ripening. Springer Science & Business Media; 2012 Dec 6.163–165.

46. Iversen CK. Black currant nectar: effect of processing and storage on anthocyanin and ascorbic acid content. Journal of Food Science. 1999 Jan; 64(1):37–41.

47. Ochoa MR, Kesseler AG, Vullioud MB, Lozano JE. Physical and chemical characteristics of raspberry pulp: storage effect on composition and color. LWT-Food Science and Technology. 1999 May 1; 32 (3):149–53.

48. Kendall, P. and Sofos, J. (2007). Leathers and Jerkies, Food and Nutrition Series, Fact Sheet no. 9.311,Colorado State University Extension, U.S.