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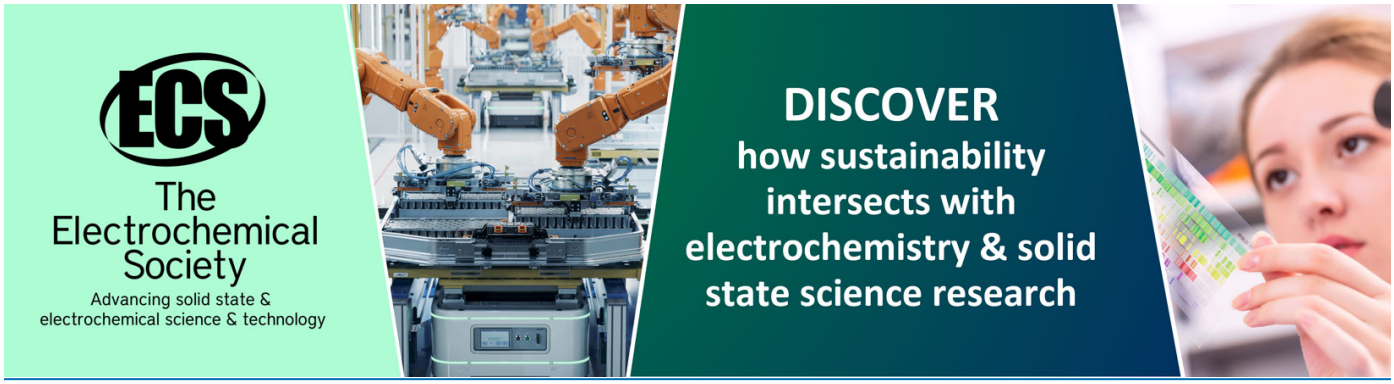

Utilization of Aloe vera gel and *Acalypha indica*. L leaf extract as edible coating to increase the shelf life of guava (*Psidium guajava*. L) fruit

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Abstract. The technology that is commonly used to control postharvest pathogen attacks is coating with synthetic chemicals, but this has an unfriendly impact on the environment and consumers. Coating with *A. vera* L gel and plant extracts is a natural way to extend shelf life and maintain postharvest quality. The research was focused on finding the composition of guava fruit coating with *A. vera*. L gel and *A. indica*. L leaf extract that provided physicochemical properties with optimal quality during storage. Parameters tested were weight loss, percent decay, moisture content, total dissolved solids and total titrated acid from guava fruit. The coating composition that gives the best guava fruit quality with a storage time of 15 days were 85% *A. vera* gel, 10% *A. indica*. L leaf extract, 0.025% Carboxy Methyl Cellulose (CMC) and 0.5% glycerol. The guava fruit coated with this composition had a weight loss of 11.19%, moisture content of 57.15%, a spoilage of 3.33%, a total dissolved solids of 7.67 °Brix and a total titrated acid of 1.90%. This value was better than uncoated fruit with weight loss of 30.48%, moisture content 28.42%, spoilage 14.44%, total dissolved solids 12.33 °Brix and total titrated acid 0.40%.

1. Introduction

Guava (*Psidium guajava* L.) is a productive and profitable crop grown commercially in sub-tropical and tropical areas. Guava is a perishable fruit known for its good taste, nutritional status and moderate price in the market. Guava fruit is an excellent source of vitamin C (228.3 mg/100 g), contains about 17% dry matter and 80% moisture along with sizable amounts of minerals such as phosphorus, calcium, iron as well as vitamins such as niacin, acid pantothenic acid, thiamin, riboflavin and vitamin A [1].

The quality of guava fruit is strongly influenced by the level of fruit ripeness and storage methods which will affect the taste, appearance, aroma and nutrition of the fruit. Guava with good quality will be obtained if the fruit is picked at a sufficient level of maturity. Guava fruit that is picked when it is not ripe will have an astringent taste, with firm flesh and low juice content. During ripening, the fruit undergoes significant changes in color and texture, indicating that physiological changes occur in it, including changes in carbohydrates, organic acids, proteins, amino acids and other components that can affect the taste of the fruit [2]. Furthermore, the storage period of fruit can be a problem in post-harvest activities because fruit is a perishable commodity. Guava fruit has a shelf life of 2-7 days. Therefore, good postharvest handling is needed in order to have a longer shelf life [3].

Coatings with synthetic chemicals have been used to control pathogens and extend fruit shelf life, but at the same time gave unfriendly effects on the environment and consumers. Prolonged use of

chemical fungicides on fresh produce has been the main reason for the development of resistant pathogenic strains and the increase in toxic residues on fruit surfaces. It is known that fungicides can negatively affect the nutritional properties of fresh produce. Indiscriminate use of chemical fungicides has been banned due to their high toxicological effect on human health and long degradation time.

Edible coating technology is a thin coating made of food (food grade) which aims to coat food and functions as a bacterial inhibitor so that the shelf life of food can be increased [4]. Aloe vera gel has been used as an edible coating [5]. This gel is tasteless, colorless and odorless. This natural product is a safe and environmentally friendly alternative. According to the researchers, this gel works through a combination of mechanics, forming a protective layer against oxygen and air humidity and inhibiting the action of micro-organisms [6].

Generally, coatings can be divided into proteins, lipids, and polysaccharides, alone or in combination. They act as moisture and oxygen barrier during processing, handling and storage. Coatings are not only slow down the spoilage of food but also increase its safety due to natural biocidal activity or incorporation of antimicrobial compounds. Aloe vera gel as an edible coating can play a good role in restraining the respiration rate and some physiological changes due to the ripening process of fruits and vegetables during storage[4]. Previous research was also reported that edible coating technique is able to extend the shelf life of strawberries [7].

A. indica is a wild growing plant that is often found on roadsides and is also known as a weed plant. Anting-anting plant (*Acalypha indica.* L) is one type of plant that is commonly used as medicine. Roots, stems and leaves contain saponins and tannins, stems also contain flavonoids and leaves contain essential oils. Phytochemical screening of Acalypha indica L. in methanol and ethanol extracts showed that the extracts contained phenolic, flavonoids, steroids, terpenoids and alkaloids compounds [8]. Several chemical compounds have been isolated from *A. indica*, including kaempferol glycosides, mauritianin, clitorin, nicotiflori, biorobin, tannins, pyranoquinolinone alkaloids flindersin [9]. *A. indica* methanol extract can inhibit effective antimicrobial principles due to the presence of phytochemical compounds such as alkaloids and tannins [10]. This study examined the effect of adding *A. indica* leaf extract to aloe vera gel as a coating material for guava fruit on the physical and chemical properties of the fruit during storage.

2. Material and Methods

2.1 Tools and materials used

The tools used are glassware commonly used in the laboratory, analytical balance (KERN), oven (Memmert), vacuum rotary evaporator, spatula, knife, tray, blender, brix refractometer, porcelain cup, blender, desiccator.

The ingredients used are guava fruit (*Psidium guajava* L.), aloe vera leaf (*Aloe vera*. L), *A. indica* leaf (*Acalypha indica*. L), citric acid, oxalic acid (Merck), NaOH (Merck). , ethanol 96% (Merck), carboxymethyl cellulose (Merck), glycerol (Intraco), aluminum foil, whatman filter paper and distilled water.

2.2 Trial procedure

2.2.1 Reagent manufacture. Prepared 0.1 N NaOH solution, 50% ethanol, 1% CMC, 20% glycerol, 10% citric acid.

2.2.2 Sampling. The samples used in this study were the leaves of the *A. indica* plant, aloe vera and guava fruit. Young and fresh *A. indica* leaves were taken from Padang. Aloe vera was obtained from a plantation in Apar Village, Padang Pariaman. The aloe vera sample taken was a mature aloe that was dark green in color. The guava fruit was obtained from the Ariza plantation in Korong Panggie-panggie, Nagari Limato Sungai Sariak, District VII Koto, Padang Pariaman, West Sumatra. The guava fruits were freshly harvested guava with almost the same size, weight and maturity.

2.2.3 A. indica leaf preparation. Fresh *A. indica* leaves that have been collected were subjected to wet sorting to separate the plants from dirt or other foreign materials such as soil, gravel, and grass. Then washed with running water, then chopped and air-dried. After drying the sample was ground to obtain a powder

2.2.4 A. indica leaf extraction. A. indica leaves weighed as much as 200 g and put into a reagent bottle. Then about 1000 mL of 50% ethanol was added and then macerated for 3 days while stirring. After that, filtered using a Buchner filter. The filtrate from the results is filtered and then put into a clean reagent bottle. Then evaporated at 40°C to get the extract.

2.2.5 Preparation of aloe vera gel. Aloe vera were washed and then soaked in 10% citric acid for 30 minutes. After that, aloe vera were peeled and mashed with a blender. Then it were filtered to get a clear and good aloe vera extract. The final concentration of the aloe vera gel layer were 100%.

2.2.6 Making edible coating of aloe vera gel and A. indica leaf extract. Edible coating was prepared from aloe vera gel and *A. indica* leaf extract with the composition as shown in Table 1.

Table 1. Edible Coating Composition

Treatment	Aloe Vera Gel	Leaf Extract *A. indica*s	CMC 1%	Glyserol 20%	Water Distillation
	(mL)	(mL)	(mL)	(mL)	(mL)
T-0	0	0	0	0	2000
T-1	1000	0	50	50	900
T-2	900	100	50	50	900
T-3	800	200	50	50	900
T-4	1500	0	50	50	400
T-5	1400	100	50	50	400
T-6	1300	200	50	50	400
T-7	1900	0	50	50	0
T-8	1800	100	50	50	0
T-9	1700	200	50	50	0

2.2.7 Guava fruit surface preparation. The guava fruits were sorted then washed using running water and dried. The guava fruit used was 180 pieces (10 treatments, 6 pieces for each treatment, for 3 repetitions).

2.2.8 Coating of Guava Fruit with Edible Coating. The guava fruit was dipped in a solution with a composition as shown in Table 1 for 15 minutes, then air-dried for 30 minutes. The coated fruit was stored at room temperature. Measurement of the physicochemical properties of guava was carried out at intervals of 3 days, on days 0, 3, 6, 9, 12, and 15 after coating.

2.2.9 Determination of Physicochemical Properties of Guava Fruit

a. Determination of Fruit Weight Loss

The fruit from each treatment was weighed using a digital scale on the first day and at the end of each storage interval (0, 3, 6, 9, 12 and 15 days of storage). The difference between the initial and final fruit weight (after 15 days storage) was considered as the total weight loss.

b. Determination of Water Content of Guava Fruit

The porcelain dish was dried in an oven at 105°C for 30 minutes, then cooled in a desiccator for 15 minutes and weighed. A total of ±10 grams of the sample was weighed into a cup whose weight was known. The samples were then dried in an oven at a temperature of 105°C for 3 hours. The cup was cooled in a desiccator for 15 minutes and weighed. Drying and weighing were repeated for 1 hour until a constant weight was obtained. Determination of water content was repeated 3 times.

c. Determination of Guava Fruit Spoilage

The rate of spoilage was evaluated by observing the physical manifestation on the surface of the fruit visually using a scale:

0 = no signs of decay,
1 = 1-10% decay,
2 = 11–25% decay,,
3 = 26–40% decay,
4 = 40–50% decay,
5 = 50% decay.

Decay formula (%) = 100 × AB/CD, where A is the total value of the level of damage, B is the number of fruits at this level, C is the number of fruits in the treatment and D is the highest level of damage

d. Determination of Total Dissolved Solids of Guava Fruit

Total Dissolved Solids was measured using a refractometer and expressed as a percentage (°Brix). Prior to measurement, the refractometer was standardized with distilled water and adjusted to a reading of 0°Brix. The flesh of the guava fruit were mashed using a blender then placed on a refractometer glass prism and the recorded. TDS value was indicated by the numbers obtained at the blue and white line boundaries.

e. Determination of Total Acid Titrated (TAT) of Guava Fruit

1. Making Guava Fruit Extract

10 g of treated fruit flesh was weighed then added with distilled water and mashed using a blender. The sample was transferred to a 100 mL volumetric flask and distilled water were added to the mark. Then the sample was homogenized and filtered using whatman paper.

f. NaOH standardization

A total of 0.6300 grams of oxalic acid was weighed and then put into a 100 mL volumetric flask and diluted to the limit mark, the concentration of oxalic acid was 0.05 M. Then 25 mL was pipetted into a 250 mL Erlenmeyer, added 2 drops of phenolphthalein indicator and then titrated with NaOH solution until a pink color is formed. Then the normality of NaOH was calculated.

Determination of Total Acid Titrated Guava

25 mL of guava extract was taken and titrated using 0.1004 N NaOH with phenolphthalein as an indicator.

2.2.10Statistic analysis. The research data were statistically processed using SPSS 23 One-Way Analysis of Variance (ANOVA), then continued with the Duncan Multiple Range Test.

3. Results and Discussion

Physicochemical properties of guava fruit coated with coating composition and storage time. The effect of coating guava fruit with a mixture of aloe vera gel and *A. indica* leaf extract on physicochemical properties such as reduction in fruit weight, moisture content, fruit spoilage, total dissolved solids and total titrated acid has been carried out, the results are as shown below.

3.1 Guava Fruit Weight Loss

The guava fruit weight were decreased with the length of storage time. The increase in weight loss occurred in all these treatments due to the transpiration process or the release of water in the form of steam through the skin surface that occurred during the storage period. Figure 1. shows an increase in the weight loss of guava fruit treated for 15 days of storage. Guava treated with T-9 with the mixture of 85% of *A. vera,* 10% of *A. indica* extract was the least weight loss (11.19%) compared to T-7 treatment coated with 95% of *A. vera* gel (16.15%) and control was the highest weight loss (30.48%) during storage. The greater concentration of *A. indica* extract added to the aloe vera coating, the smaller of guava fruit weight loss occured during storage. This related to the ability of the *A. indica*s to formed a

gel. The higher concentration of *A. indica*s added, the coating of aloe vera gel formed would be more sticky to cover the layer of guava fruit skin. Aloe vera coating would inhibit the release of water in fruit so the weight loss value would be smaller. Statistical result of the weight loss of guava fruit is shown in Table 2.

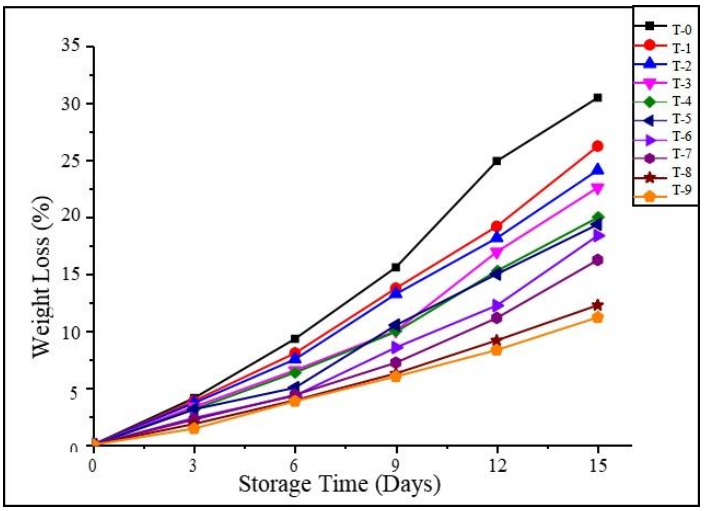

Figure 1. Effect of coating and storage time on weight loss of guava fruit

Based on Table 2, the significant value of decreasing guava fruit weight with all treatments were 0.641, this value indicated that there were no significant effect of each treatment on fruit weight loss during storage time. The results of previous studies have proven that aloe vera was very effective in acting as a coating [11].

Table 2. Analysis of ANOVA weight loss of guava fruit during storage

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	437.623	9	48.625	0.774	0.641
Within Groups	3142.978	50	62.86		
Total	3580.601	59			

3.2 Water Content of Guava Fruit

The results showed that the water content of guava fruit decreased with increasing storage time as shown in Figure 2.

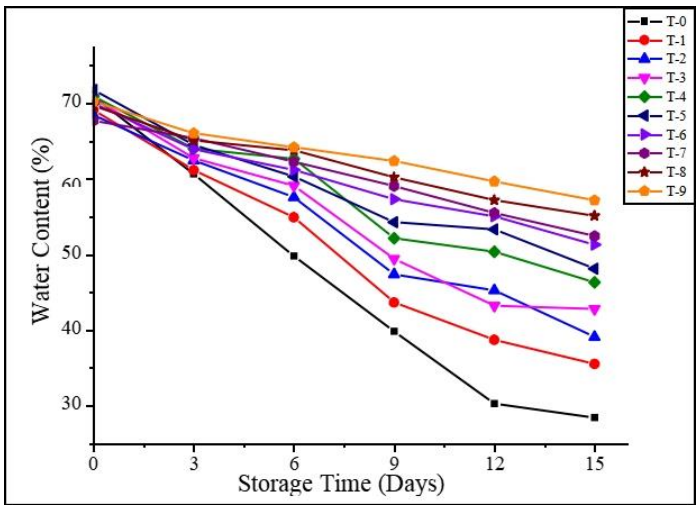

Figure 2. Effect of coating and storage time on water content of guava fruit

On the 15th days of storage, water content values were 57.15% of T9, 52.45% of T7 and 28.42% of control. Moisture content was correlated with weight loss. Therefore, it can be assumed that although coating with aloe vera gel could retain moisture content in the fruit, the treatments with the addition of *A. indica* extract were more efficient in maintaining the moisture content in guava fruit. Statistical result of the moisture content is shown in Table 3.

Table 3. ANOVA analysis of guava fruit water content during storage

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1514.7	9	168.3	1.659	0.124
Within Groups	5072.19	50	101.444		
Total	6586.89	59			

There was no significant effect of each treatment on water content during storage time (sig. 0.124). Water is easily lost through the skin through transpiration and weight loss occurs due to respiration Carbon atoms are lost from the fruit in each cycle in the form of CO_2. This is in accordance with a previous study that the reduction in weight and moisture content could be maintained by coating with *A.vera* gel as a semipermeable barrier to oxygen, carbon dioxide and moisture. It reduced respiration, water loss, and oxidation reactions [12].

3.3 Guava Fruit Spoilage

The decay of guava fruit increased with the length of storage time. However, the coating of aloe vera gel and *A. indica* extract could slow down the occurrence of spoilage in guava fruit during the storange period. Figure 3. showed that the T-9 treatment, which was treated with the addition of the most *A. indica* extract without the addition of distilled water, could inhibit fruit spoilage up to day-15 (3.33%) with the condition were green in color, hard and with slightly brown stains, compared to the T-7 treatment with the condition of the fruit that was yellowish, soft, and had wrinkles (5.56%). The control group had the most severe decay (14.44%) with the condition of the fruit was very soft and brown in color.

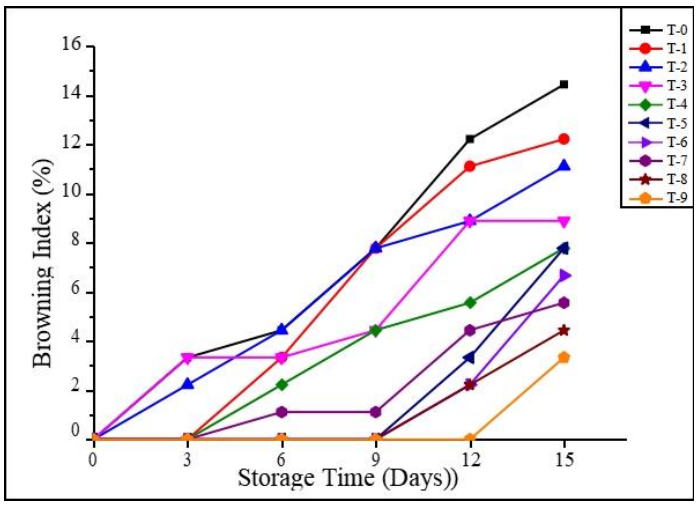

Figure 3. Effect of coating and storage time on guava fruit spoilage

Statistical result in Table 4. shows that the significant value of guava fruit decay of all treatments were <0.05, indicated a significant effect of each treatment on the decay process during storage time. Then it followed by Duncan's test.

Table 4. ANOVA analysis of guava fruit spoilage during storage

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	284.588	9	31.621	2.466	0.021
Within Groups	641.215	50	12.824		
Total	925.803	59			

Based on the Duncan test in Table 5, three different subsets were obtained, indicating that the values obtained were significantly different. The T-9 and T-0 treatments had significantly different values from the other treatments. These results were confirmed by previous studies, that coating with aloe vera gel can reduce the microbial population in papaya fruit [12]. *A. indica* extract contains alkaloids, flavonoids, steroids, saponins, tannins, and quinones that also have function as antimicrobials [9]. Texture changes in the T-0 treatment were more noticeable than in the treated fruit, which may be related to microbial attack. Microorganisms can break down cells pushing tissue away resulting in softening and dehydration.

Table 5. Post hoc tests of guava fruit spoilage

Treatment	Avarage of spoilage
T-0	7.0350^{c}
T-1	5.7400^{bc}
T-2	5.7400^{bc}
T-3	4.8133^{abc}
T-4	3.3333^{abc}
T-5	2.0367^{bc}
T-6	1.8517^{bc}
T-7	1.4817^{bc}
T-8	1.1100^{bc}
T-9	0.5550^{a}

Note: The same letter indicates the value is not significantly different ($p<0.05$)

3.4 Total Dissolved Solids of Guava Fruit

Total dissolved solids were higher in ripe fruit and increased with the length of storage. This increased were greater if respiration is a very fast in fruit. Total dissolved solids increased with increasing maturity of the fruit, this occured due to the increased concentration of dissolved compounds in the fruit, especially sugar during the fruit ripening process.

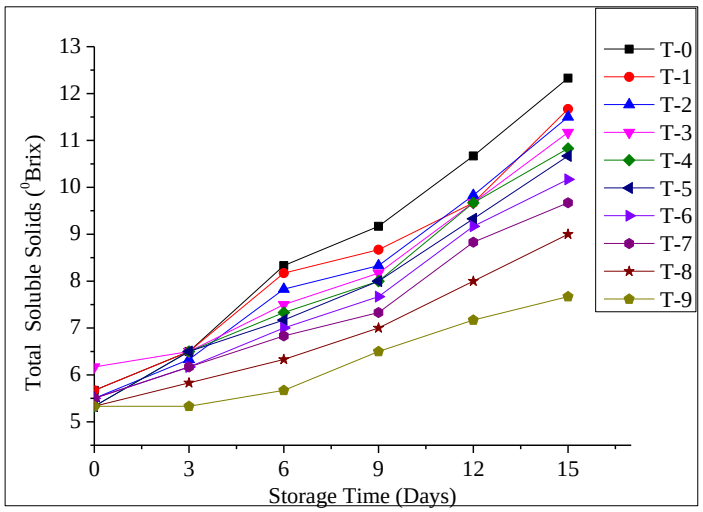

Figure 4. Effect of coating and storage time on total dissolve solids of guava fruit (^{0}Brix)

Figure 4. shows that the total dissolve solids of guava fruit that treated by T-9 had the smallest value compared to other treatments. This is due to the coating with *A. indica* leaf extract and *A. vera* gel protected the surface fruit which inhibited the formation of sugar . The higher concentration of *A. indica* extract added into *A. vera* as edible coating, the lower total dissolved solids of guava fruit.

Table 6. Analysis of ANOVA TPT of guava fruit during storage

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	29.677	9	3.297	0.914	0.521
Within Groups	180.319	50	3.606		
Total	209.996	59			

Table 6. shows that there is no significant effect of each treatment on TPT of guava during storage (sig. 0.521).

3.5 Total Acid Titrated of Guava Fruit

Figure 5. shows that TAT of guava fruits decreased during storage for all treatment. Coating guava fruits with a large concentration of extract T-9 contined TAT 1.90% greater than coating guava fruit with a small extract concentration T-7 (1.50%) and control (0.40%) at a storage time of 15 days. This shows that the coating with *A vera* gel and *A. indica* leaf extract were able to restrain the respiration rate and maintained the total acid in the guava during storage.

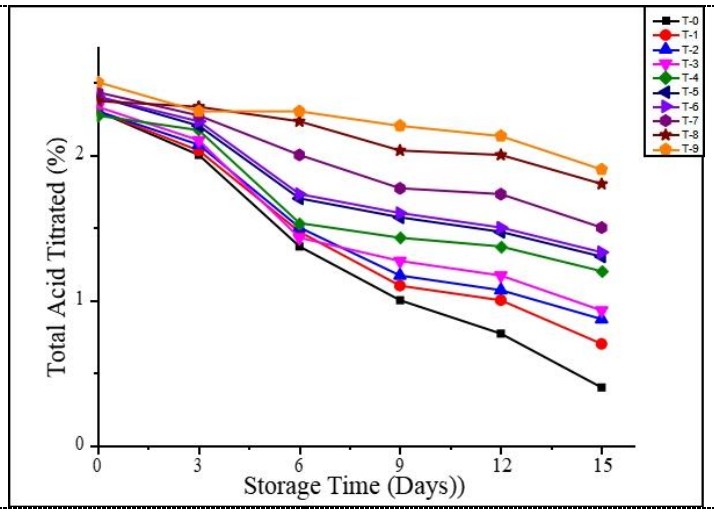

Figure 5. Effect of coating and storage time on total titrated acid of guava fruit

Table 7. ANOVA analysis of guava fruit during storage

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4.903	9	0.545	2.326	0.028
Within Groups	11.708	50	0.234		
Total	16.61	59			

Table 7 indicated a significant effect (Sig. 0.028) of each treatment on TAT of guava during storage, then continued with Duncan test in Table 8.

Table 8. shows that the T-9 and T-2 treatments had significantly different values from the other treatments. The change in TAT in guava fruit is related to the process of decomposition of organic acid molecules into water and CO_2 in the fruit. Evaporation of water can be prevented by coating. In addition, the decrease of TAT cause by organic acids are used by fruit for the respiration process. The results of previous studies using blueberry leaf extract added to the chitosan layer could also maintain the total titrated acid in blueberries during storage [13].

Table 8. Duncan's test of guava fruit TAT in each treatment

Treatment	TAT Average Score
T-0	1.3067^{a}
T-1	1.4333^{a}
T-2	1.4967^{b}
T-3	1.5383^{ab}
T-4	1.6617^{abc}
T-5	1.7733^{abc}
T-6	1.7983^{abc}
T-7	1.9500^{abc}
T-8	2.1267^{bc}
T-9	2.2217^{c}

Note: The same letter indicates the value is not significantly different ($p<0.05$)

4. Conclusion

It can be concluded that the use of *A. indica* leaf extract and *A. vera* gel as a coating material can maintaine the physical and chemical properties of guava fruit during storage. Guava fruit coated with *A.*

vera gel and *A. indica* extract with a composition of 85 % *A vera* gel, 10 % *A. indica* leaf extract, 0.025% Carboxy Methyl Cellulose (CMC) and 0.5% glycerol (T-9) could maintain fruit quality for 15 days of storage. *A vera* gel and *A. indica* extract can be used as a natural fruit coating material to maintain the quality and shelf life of postharvest guava fruit.

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