

A mixture of Aloe Vera Gel and Sungkai Leaf Extract as Edible Coating to Increase Tomato Storage Life

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Abstract— Tomatoes are climacteric fruits, are well-known for containing lycopene is an antioxidant. The post-harvest shelf life of harvested tomatoes is only 4-5 days. This research aims to optimize previous methods such the use of plastic packaging and cold storage methods were found to be inefficient and produced waste, so it is necessary to renew them by using the edible coating method, a natural ingredient from *Aloe vera*. L gel, while sungkai leaf extract (*Peronema canescans*. Jack) shows the effectiveness of edible coating could potentially provide a protective barrier against external factors, helping to maintain the quality of tomatoes and waste reduction. Edible coating material from aloe vera gel added with sungkai leaf extract of various compositions (C, EC₁, EC₂, EC₃, EC₄, and EC₅) was prepared and applied to tomatoes. Fourier Transform Infrared (FTIR) testing was carried out to determine the functional groups in all edible coating materials. Physicochemical properties tests were carried out on tomatoes. The results obtained by EC₅ the lowest weight loss 11.14%, while EC₄ was the best edible coating material in percent decay 8.89%, total dissolved solids 1.00°Brix, total antioxidant 0.024 mg AA/g FW, and total phenolic 0.224 mg GAE/g FW for 15 days compared to aloe vera gel coating (EC₁), which only lasted for 9 days, and uncoated (C), which only lasted for 6 days.

Keywords: Edible coating, physicochemical properties, FTIR

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1. Introduction

Tomatoes (*Solanum lycopersicum*) are climacteric fruits, undergoes a climacteric the phase during its the ripening process, characterized by a significant increase in ethylene production and respiration rate. This phase is associated with various physiological and biochemical changes, including softening, color changes, and flavor development. Ethylene is a natural plant hormone that plays a crucial role in the ripening and decay processes. During the climacteric phase, ethylene acts as a signaling molecule that triggers the expression of genes involved in ripening [1]. Tomatoes are indeed a nutritious fruit that offers a variety of health benefits. Here's a breakdown of some key nutrients found in tomatoes: lycopene is responsible for the red color in tomatoes. It has been associated with various health benefits, including potential protection against certain types of cancers. Antioxidant such as vitamin C and beta-carotene, which help combat oxidative stress in the body. Besides lycopene, tomatoes also contain other carotenoids like beta-carotene, which is a precursor to vitamin A. Tomatoes contain natural sugars, such as fructose, which provide a sweet taste. Despite their sweetness, tomatoes are relatively low in calories and fat [2].

Many methods to overcome this problem have been used, including tomatoes stored in the refrigerator, modified atmosphere packaging (MAP), and the use of plastic packaging, which turns out to be less efficient. While refrigeration can slow down the ripening process and extend the shelf life of tomatoes, it might adversely affect their flavor and texture. Cold temperatures can cause changes in the cell structure, leading to a mealy or mushy texture. MAP involves adjusting the mix of gases inside the

packaging to slow down ripening and inhibit microbial growth. However, if not properly controlled, it can lead to issues such as fermentation, off-flavors, or the growth of spoilage microorganisms. The use of plastic packaging raises environmental concerns due to the generation of plastic waste. Improper disposal of plastic packaging can contribute to pollution and harm ecosystems. Sustainable and environmentally friendly packaging solutions, such as biodegradable materials, are being explored to address the environmental impact of traditional packaging methods. The edible coating method was carried out in order to optimize existing methods [3].

The use of edible coatings is indeed a promising method to optimize the storage and shelf life of fruits and vegetables, including tomatoes. Edible coatings, often made from natural ingredients, can provide a protective layer on the surface of the produce, helping to slow down the deterioration processes and extend freshness. This method has several advantages: Edible coatings are typically made from natural ingredients such as proteins, polysaccharides, lipids, and other food-grade materials. This makes them safe for consumption and addresses concerns related to chemical residues. Edible coatings can be effective in reducing moisture loss, gas exchange, and microbial contamination, thus slowing down the spoilage of tomatoes. They can also act as a barrier against external factors that contribute to decay. Using natural ingredients in edible coatings can be cost-effective compared to certain packaging methods. Minimized environmental impact: Unlike some traditional packaging methods that generate plastic waste, edible coatings can be designed to be biodegradable and environmentally friendly, minimizing the environmental impact. Edible coatings can help maintain the quality attributes of tomatoes, including color, texture, and flavor, by providing a protective barrier against factors that lead to deterioration. In summary, the use of edible coating made from natural ingredients represent a promising approach for enhancing the storage and quality of tomatoes, offering benefits such safety, efficiency, cost-effectiveness, and environmental sustainability [3]. By creating a semipermeable barrier, they help regulate moisture levels, control gas exchange, and reduce respiration rates, thus extending the shelf life of the fruit. Additionally, coatings can prevent microbial growth, reduce weight loss, and maintain fruit appearance [20].

This research used aloe vera gel added to sungkai leaf extract. Glucomannan or pectic acid these compounds are known for their ability to inhibit damage. They can act as film-forming agents in edible coatings, creating a protective layer on the surface of tomatoes. Aloe vera is recognized for its antimicrobial and antioxidant properties. Incorporating aloe vera gel into edible coatings can help inhibit the growth of microorganisms and reduce oxidative processes, contributing to the preservation of tomatoes. Sungkai leaves contain various metabolite compounds such as phenolics, tannins, alkaloids, steroids, saponins, and flavonoids. These compounds can have antimicrobial, antioxidant, and other bioactive properties. With its ability to thrive in tropical climates at varying altitudes and its adaptability to different levels of rainfall, the Sungkai is indeed a versatile species.

The problem that arises from the use of natural ingredients is the solvent used during the extraction process. In general, the solvents usually used to extract are organic solvents such as methanol and ethanol, which not everyone can consume because they are alcohol. So in this research, the process of extracting natural edible coating ingredients was carried out by replacing organic solvents with water. Using water as a solvent has several advantages, making the process more accessible, environmentally friendly, and suitable for a broader range of applications. Water is a safe and universally accepted solvent. Unlike organic solvents such as methanol or ethanol, water is non-toxic and can be consumed by all age groups. This enhances the safety and acceptability of the edible coating materials.

Based on the explanation above, research was carried out on making edible coating materials using a mixture of aloe vera and sungkai leaf extract with variations in composition and characterization of the edible coating materials using FTIR, then applied to tomatoes. The physical and chemical properties of tomatoes that had been coated with edible coating material were tested, which included determining tomato weight loss using the gravimetric method and determining tomato rot before and after being coated. Determination of total dissolved solids using the refractometry method, determination of total antioxidant content, and determination of total phenolic content using the UV-Vis spectrophotometry method. Statistical data analysis was carried out using the one-way ANOVA method.

2. Material and Method

2.1 Tools and Material

The equipment used during the research was an ultraviolet-visible spectrophotometer (Genesys 10s UV-Vis Scanning), FTIR (Perkin Elmer), analytical balance (KERN), spatula, knife, blender, °Brix refractometer, porcelain cup, blender, and laboratory glassware (Pyrex).

The ingredients used are tomatoes, aloe vera plants, sungkai leaves, citric acid, oxalic acid (Merck), phenolphthalein, 1,10-phenanthroline chloride monohydrate (Sigma), FeCl₃.6H₂O (Merck), Folin-Ciocalteu reagent (Sigma), ascorbic acid (Merck), gallic acid (Merck), ethanol, CMC, glycerol, aluminum foil, Whatman filter paper, and distilled water.

3. Experimental Procedures

3.1 Reagent

Prepare the following: CMC 1%, ethanol 50%, glycerol 20%, acid citrate 10%, and total phenolics and antioxidants at the reagent determination rate.

3.2 Sampling

Tomatoes, aloe vera plants, and sungkai leaves served as the research's samples. Tomatoes were harvested from the Alahan Panjang plantation in Solok, West Sumatera at nearly identical sizes, weights, and stages of maturity. Fresh aloe vera was taken in the Pelana Indah complex, Pampangan, Lubeg, Padang, and fresh sungkai leaves were taken in the Jl. Air Paku, Sei Sapih, Sungai Sapih sub-district, Kuranji sub-district, Padang city, West Sumatra. The ripe, dark green leaves of the aloe vera plants were used to make the samples.

3.3 Edible Coating Material Preparation

Aloe vera is cleaned and then soaked in a 10% citric acid solution for half an hour. Using a knife, remove the green outer skin of the aloe vera, then puree the aloe vera with a blender.

3.4 Edible Coating Production by Mixing Aloe vera Gel and Sungkai Leaf Extract.

Tomatoes were collected at nearly identical weights, sizes, and levels of ripeness. After washing and drying, the tomatoes are submerged for approximately 30 seconds in the edible coating material solution (Table 1). Tomatoes with coatings are kept for a period of 15 days at room temperature (28°C–30°C). Physical and chemical characteristics are tested at 0, 3, 6, 9, and 15 days.

Table 1. Composition of Edible Coating Materials

No.	Edible Coating Code	Aloe Vera Gel	Water Extract of Sungkai Leaves (1%)	Ethanol Extract of Sungkai Leaves (1%)	Glycerol 20%	CMC 1%
		mL	mL	mL	mL	mL
1.	C	0	0	0	0	0
2.	EC ₁	45	0	0	2.5	2.5
3.	EC ₂	0	45	0	2.5	2.5
4.	EC ₃	0	0	45	2.5	2.5
5.	EC ₄	20	25	0	2.5	2.5
6.	EC ₅	20	0	25	2.5	2.5

Information:

C : Control

EC₁ : Aloe Vera Gel (45 mL) Edible Coating

- EC₂ : Water Extract of Sungkai Leaves (45 mL) Edible Coating
EC₃ : Ethanol Extract of Sungkai Leaves (45mL) Edible Coating
EC₄ : Aloe Vera Gel (20 mL) + Water Extract of Sungkai Leaves (25 mL) Edible Coating
EC₅ : Aloe Vera Gel (20 mL) + Ethanol Extract of Sungkai Leaves (25 mL) Edible Coating

3.5 FTIR Characterization

Following the preparation of the material, aloe vera gel coating, water extract of sungkai leaves, and ethanol extract of sungkai leaves (Table 1), the material coating is FTIR analyzed.

3.6 Determination of Physical and Chemical Properties of Tomatoes Coated with Edible Coating Material

3.6.1 Determination of Tomatoes Weight Loss

Tomatoes from each treatment were weighed using a digital scales on storage days 0, 3, 6, 9, and 15 days. The difference between heavy-beginning tomatoes and the end is considered a difference in lost weight.

3.6.2 Determination of Tomatoes Decay

Visually monitor the physical symptoms on the surface of tomatoes and use a scale [4]. The scale of tomato decay can be determined as follows:

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

$$\% \text{ Decay} = 100 \times AB/CD \quad (1)$$

Where:

- A : total damage level value
B : number of samples at this level
C : number of samples at this level
D : number of samples at this level

3.7 Determination of total dissolved solids

A refractometer was used to measure the TDS in tomatoes, which were then reported as a percentage (°Brix). Each treatment's mashed tomato flesh was tested by setting it on the refractometer's glass prism after the device had been calibrated with distilled water beforehand. On the refractometer, the number at the intersection of the blue and white lines indicates the TDS value [5].

3.8 Determination of Total Antioxidants with Modified Phenanthroline Method

3.8.1 Preparation of a Series of Ascorbic Acid Standard Solution

1 mL of each standard solution of ascorbic acid (5, 10, 15, 20, and 25) mg/L was pipetted into a test tube, then added 2 mL of distilled water, 1 mL of 0.1% FeCl₃ solution, and 1 mL of 1.10 phenanthroline 0.1%. Next, let it sit for 20 minutes at room temperature, and the absorbance at a

wavelength of 510 nm was measured using a UV-Vis spectrophotometer, and a standard calibration curve for ascorbic acid was made [6].

3.8.2 Determination of Total Antioxidant Content

Pipette 1 mL of the sample extract into a vial, then add 2 mL of distilled water, 1 mL of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ 0.1%, and 1 mL of 1.10 orthophenanthroline 0.1%. Next, the solution was allowed to stand for 20 minutes, and the absorbance was measured using a UV-Vis spectrophotometer at a wavelength of 510 nm [7].

3.9 Determination of Total Phenolic with Folin-ciocalteau Reagent

3.9.1 Preparation of a Series of Gallic Acid Standard Solutions

The standard solution of gallic acid (40, 80, 120, 160, and 200) mg/L was pipetted 0.5 mL each into a test tube containing 4 mL of 2% Na_2CO_3 and 0.2 mL of Folin-Ciocalteau reagent, then the mixture was shaken, then left for 90 minutes, and the absorbance was measured at a wavelength of 750 nm with a UV-Vis spectrophotometer. Next, a standard calibration curve for gallic acid was created.

3.9.2 Determination of Total Phenolic

After pipetting 4 mL of 2% Na_2CO_3 solution into a test tube, 0.5 mL of sample extract and 0.2 mL of Folin-Ciocalteau reagent were added. The mixture was then shaken and allowed to sit at room temperature for 90 minutes. Next, a UV-Vis spectrophotometer was used to measure the absorption at a wavelength of 750 nm.

3.10 Statistical Analysis

Results data study processed in a way statistics with use analysis variant One Direction (one way ANOVA) using IBM SPSS *Statistics* 25.

4. Result and Discussion

4.1 Edible Coating Aloe Vera Gel Extract and Sungkai Leaf Extract

Figure 1 of the variations in the composition of edible coating materials based on data from Table 1 shows the consecutive results of aloe vera gel extract (EC_1), ethanol extract of sungkai leaves (EC_3), aloe vera gel extract with ethanol extract of sungkai leaves (EC_5), water extract of sungkai leaves (EC_2), and aloe vera gel with water extract of sungkai leaves (EC_4). The color differences in each edible coating material are attributed to the different mixtures added to each material.



Figure 1. Coating Materials with Various Compositions

Figure 1 show, the color differences observed in each edible coating material are a result of the mixtures added to them. Furthermore, it indicates that the mixture has the ability to attract different active substances at different levels, implying a potential correlation between the composition of the

coating material and its color. The composition of edible coating materials is added CMC and glycerol. CMC (Carboxymethyl Cellulose) Acts as a thickening agent and binder, helps in forming a layer on the surface, providing a protective barrier and enhancing the overall stability of the coating. Glycerol Used to increase flexibility, enhances the flexibility of the coating, making it more adaptable and less prone to cracking. Glycerol also contributes to the moisture retention properties of the coating. These ingredients, along with the extracts from aloe vera gel, sungkai leaves, and other components collectively contribute to the overall characteristics of the edible coatings. The combination of these elements can impact properties such as color, flexibility, thickness, and stability [8].

4.2 Edible Coating Material Function Group

Figure 2, which represents the Fourier Transform Infrared (FTIR) characterization of the edible coating materials.

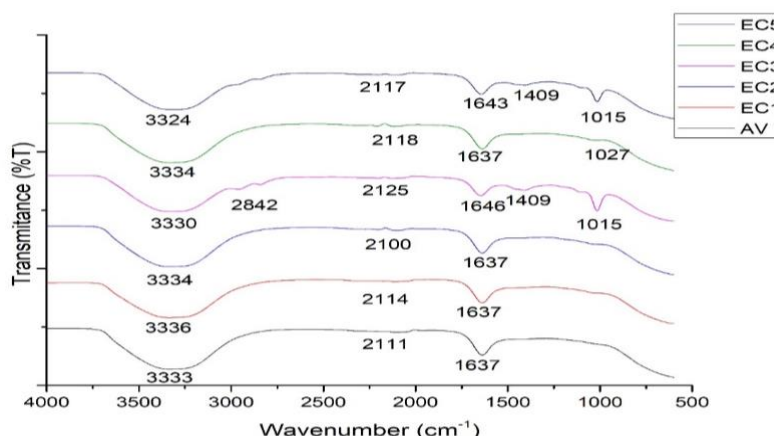


Figure 2. FTIR Spectra of Edible Coating Materials from Various Compositions

The FTIR analysis did not show the formation of new functional groups in the edible coating materials, but instead revealed similar patterns. This suggests that the metabolite compounds in the edible coating materials share similarities. The dominant functional group identified is O-H, which is characteristic of glucomannan, a polysaccharide compound found in the aloe vera component and Sungkai leaves also exhibit the O-H functional group, associated with phenolic compounds. The O-H functional group identified in aloe vera gel and sungkai leaves is noted for its antimicrobial and antioxidant properties. This functionality is considered beneficial for inhibiting post-harvest damage and preventing the transfer of CO₂ and O₂. The identified functional groups indicate that the edible coating materials, derived from aloe vera gel and sungkai leaves, have the potential to coat the surface of tomatoes effectively. The antimicrobial and antioxidant properties of these functional groups suggest that the coatings could contribute to maintaining the shelf life of tomatoes.

4.3 Tomatoes Weight Loss

The edible coating materials used have six types of edible coatings, each with a different composition: Control Treatment (C), aloe vera gel coating (EC₁), sungkai leaf water extract coating (EC₂), sungkai leaf ethanol extract coating (EC₃), aloe vera gel with water extract of sungkai leaves (EC₄) and aloe vera gel with ethanol extract of sungkai leaves (EC₅). The results highlight the effectiveness of edible coating, especially aloe vera gel with ethanol extract of sungkai leaves (EC₅), in minimizing weight loss in tomatoes during a 15 day storage period. Tomatoes treated with edible coating a smaller weight loss compared to those without any coating. EC₅, which involves the combination of sungkai leaf extract with aloe vera gel, demonstrated the highest effectiveness in reducing weight loss. EC₅ the lowest decrease in weight loss, measuring at 11.14% after 15 days of storage. The control treatment (C) showed the highest weight loss among all treatments, reaching 50.60% on day 15. Aloe vera gel coating (EC₁) a weight loss of 46.58% on day 15.

The addition of sungkai leaf extract combined with aloe vera gel, as seen in EC₅, was particularly effective in optimizing the edible coating material. This combination appears to enhance the coating's ability to maintain tomato weight and reduce loss during the storage period. These findings suggest that the specific combination of sungkai leaf extract and aloe vera gel in edible coatings has practical applications in preserving tomatoes by minimizing weight loss during storage.

Edible coating material is intended to act as a barrier on the surface of tomatoes. When functioning properly, it effectively reduces the permeation of high levels of O₂ into the tomatoes. This helps in suppressing the respiration process, preventing increased respiration and water loss in tomatoes. A well-formed layer from the coating treatment is effective in suppressing the respiration process. This layer contributes to reducing transpiration, preventing excessive water loss, and minimizing tomato weight loss [9]. The edible coating material acts as a barrier or protector on the surface of tomatoes. It plays a role in suppressing the ripening process, leading to a reduction in weight loss [10]. Water loss from tomatoes occurs as a result of reduced turgor pressure, and this reduction is caused by the transpiration process happening at the stem scars. In other words, as water evaporates through the stem scars during transpiration, it leads to a decrease in turgor pressure within the tomato cells, ultimately resulting in water loss. This process is a normal part of plant physiology and is essential for nutrient transport and temperature regulation within the plant [11]. Extended storage time may lead to wrinkles on the surface of tomatoes [12].

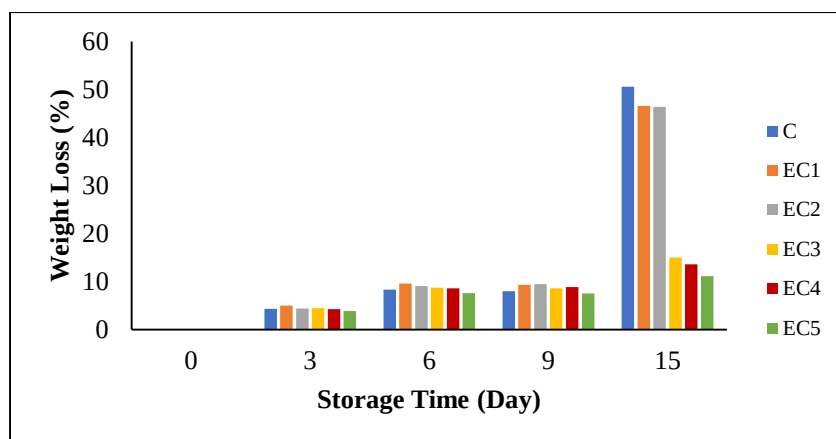


Figure 3. Effect of Edible Coating Materials on Reducing Weight Loss of Tomatoes During Storage Time

It appears from the results of the one-way ANOVA test that there was no significant effect of the edible coating material on reducing tomato weight loss during the storage time, as indicated by $P > 0.005$. Research results obtained from testing different coating processes on strawberries showed that strawberries coated with a composition of aloe vera gel and 50% sungkai leaf water extract showed superior performance in several parameters compared to uncoated strawberries. Strawberries coated with this composition can be stored 6 days longer than uncoated strawberries. This suggests that the coating has a positive impact on extending the shelf life of post-harvest strawberries. Over the storage period of 0 to 8 days, coated strawberries a decrease in fruit weight of 10.6%, indicating a reduction in weight loss compared to uncoated strawberries [13].

4.4 Tomatoes Decay

The edible coating materials used have six types of edible coatings, each with a different composition: Control Treatment (C), aloe vera gel coating (EC₁), sungkai leaf water extract coating (EC₂), sungkai leaf ethanol extract coating (EC₃), aloe vera gel with water extract of sungkai leaves (EC₄) and aloe vera gel with ethanol extract of sungkai leaves (EC₅). The results highlight the impact of edible coatings on tomato spoilage during storage. Rotting increases during storage for both tomatoes coated with edible coating materials and those without treatment. Tomatoes uncoated rot more quickly compared to those coated with edible coating materials. Aloe vera gel with water extract of sungkai

leaves (EC₄) demonstrated the smallest decay at 8.89%. This indicates that EC₄ was effective in slowing down the rotting process compared to other coating materials. The control (C), uncoted edible coating, the highest decay at 17%. In the control treatment (C), tomatoes an anomaly on the 6th day. The decay in the control involved tomatoes rotting, becoming soft, shriveling, changes in aroma, and fungus starting to grow on some parts. Tomatoes coated with the aloe vera gel layer (EC₁) decay at a rate of 13.89% on the 15th day, and tomatoes were unable to survive beyond 9 days before complete decay. Tomatoes that start to change color and reduce the respiration rate can be controlled by managing the composition of CO₂ and O₂ gases [14]. The addition of sungkai leaf extract combined with aloe vera gel is mentioned to optimize the edible coating material.

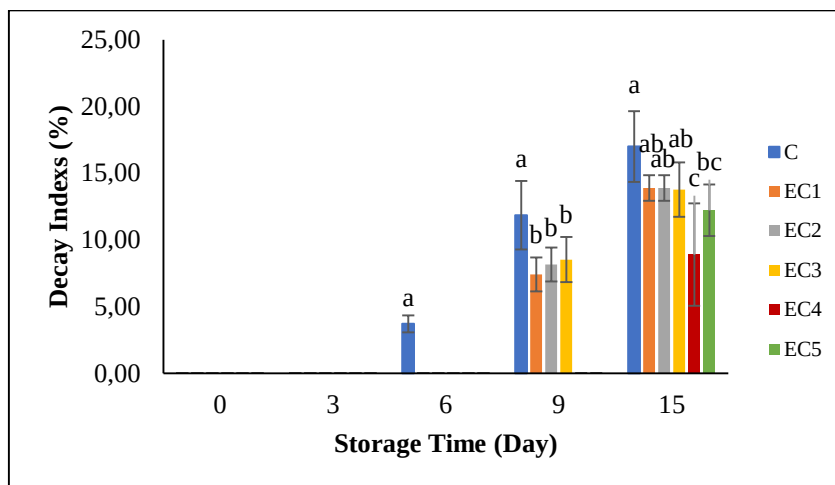


Figure 4. Effect of Edible Coating Materials on the Percent of Tomato Decay During Storage Time

Figure 4. show the edible coating material used to coat tomatoes acts as a barrier or protector on the surface of the tomatoes. This barrier serves to reduce the lack of air content and has the ability to suppress the control process [10]. Uncoated tomatoes are prone to fluctuations due to the high air content. The high air content can lead to elevated respiration processes in tomatoes [15]. Edible coating material provides protection to tomatoes from external influences, including microorganisms. Direct contact with O₂, which can be a cause of tomato rotting, is mitigated by the presence of the edible coating [16]. The application of edible coatings on tomatoes serves as a protective measure, creating a barrier that helps regulate air content, control respiration processes, and shield tomatoes from external factors that could lead to decay and rotting. The research underscore the importance of edible coatings in enhancing the shelf life and quality of tomatoes during storage.

The results of your one-way ANOVA analysis on the percent rotting of tomatoes provide insights into the influence of edible coating material during different periods of storage. On days 3 and 9, the one-way ANOVA analysis showed a significant value of $P < 0.005$. This suggests that there is a significant influence of the edible coating material on the percent rotting of tomatoes during these specific days of storage. On day 15, the one-way ANOVA analysis showed a significant value of $P > 0.005$. This indicates that there is no significant influence of the edible coating material on the percentage of decay during storage on the 15th day. The results suggest that the impact of the edible coating material on the percent rotting of tomatoes varies during different periods of storage. While there is a significant influence on days 3 and 9, this influence diminishes by day 15.

The results of research on guava fruit coated with aloe vera gel modified with the addition of anting-anting plant extract highlight the effect of different treatments on the physicochemical properties of guava during storage. T-9 treatment, which involves adding mostly *A. indica* extract without distilled water, is very effective. Inhibits fruit rot until the 15th day, with a decay rate of 3.33%. Fruit in the T-9 treatment remained green, firm, with slightly brown spots. Research shows that *A. indica* extract, especially in the T-9 treatment, can significantly inhibit guava fruit rot during storage, maintaining desirable characteristics such as green color and firmness [17].

4.5 Total Dissolved Solids of Coated Tomatoes

The results of the research showed that the effect of the edible coating material on the total soluble solids of tomatoes during storage time decreased the TDS value. The edible coating materials used have six types of edible coatings, each with a different composition: Control Treatment (C), aloe vera gel coating (EC₁), sungkai leaf water extract coating (EC₂), sungkai leaf ethanol extract coating (EC₃), aloe vera gel with water extract of sungkai leaves (EC₄) and aloe vera gel with ethanol extract of sungkai leaves (EC₅).

TDS content in the EC₁ treatment reached the lowest level at 0.100°Brix on the 15th day of storage. In contrast, the EC₄ treatment had the highest TDS content, measuring 1,000°Brix on the 15th day of storage. Tomatoes treated with edible coating materials, exhibited inhibition of the breakdown of carbohydrates. This inhibition prevented a significant increase in the TDS content. The level of ripeness of fruit, including tomatoes, is related to the total amount of dissolved solids (Dong et al., 2018). The variations in TDS content can provide insights into the ripeness and quality of the tomatoes during storage. These results emphasize the impact of edible coating on the TDS content of tomatoes during storage, showcasing how it can influence the ripeness and quality of the fruit

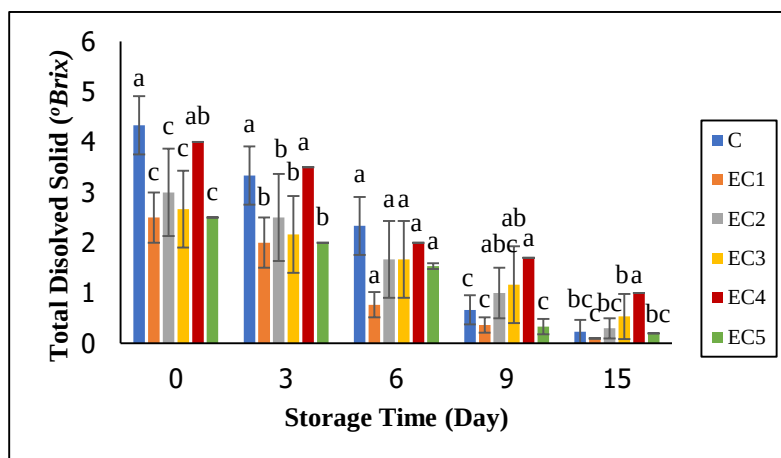


Figure 5. Effect of Edible Coating Materials on Total Dissolved Solids in Tomatoes During Storage Time

The results of your one-way ANOVA test and Duncan test provide information about the influence of edible coating materials on the total dissolved solids (TDS) of tomatoes during storage. The one-way ANOVA test showed significant values on the 0, 3, 9, and 15 days $P < 0.005$. This indicates a significant influence of the edible coating material on the total dissolved solids during storage time. On the 6th day, the significant value was $P > 0.005$. There was no significant effect of the edible coating material on total dissolved solids on the 6th day. Duncan test results for day 0 indicated that the control treatment (C) was significantly different from EC₁, EC₂, EC₃, and EC₄, but not significantly different from EC₅. On the 3rd day, C was significantly different from EC₁, EC₂, EC₃, and EC₅ but not significantly different from EC₄. On the 6th day, based on Duncan's test, there was no significant difference in all the edible coating ingredients. On day 9, Edible Coating C, EC₁, EC₄, and EC₅ materials were significantly different but not significantly different from EC₂ and EC₃. On day 15, C, EC₂, and EC₅ were not significantly different, while EC₁, EC₃, and EC₄ were significantly different. The results collectively suggest that the edible coating materials have a significant influence on TDS during various days of storage, except on the 6th day.

The research results obtained from testing different coating compositions on strawberries showed that strawberries coated with a composition of aloe vera gel and 50% sungkai leaf water extract showed superior performance in several parameters compared to uncoated strawberries. The total soluble solids value in layered strawberries is 7.47° Brix which indicates a certain level of sweetness [13].

4.6 Total Antioxidants of Coated Tomatoes

The edible coating materials used have six types of edible coatings, each with a different composition: Control Treatment (C), aloe vera gel coating (EC₁), sungkai leaf water extract coating (EC₂), sungkai leaf ethanol extract coating (EC₃), aloe vera gel with water extract of sungkai leaves (EC₄) and aloe vera gel with ethanol extract of sungkai leaves (EC₅). The determination of total antioxidants was carried out using the MPM (Modified Phenanthroline Methode). The total antioxidant content decreased in each treatment during the storage time. Tomatoes in the EC₄ treatment tended to maintain a higher total antioxidant content of 0.024 mg AA/g FW. Total antioxidant levels in the EC₄ treatment to be able to reduce damage. This implies that the higher antioxidant content in EC₄ might contribute to mitigating damage or deterioration in tomatoes during storage. The EC₄ treatment, with its higher antioxidant content, appears to have a protective effect against oxidative damage.

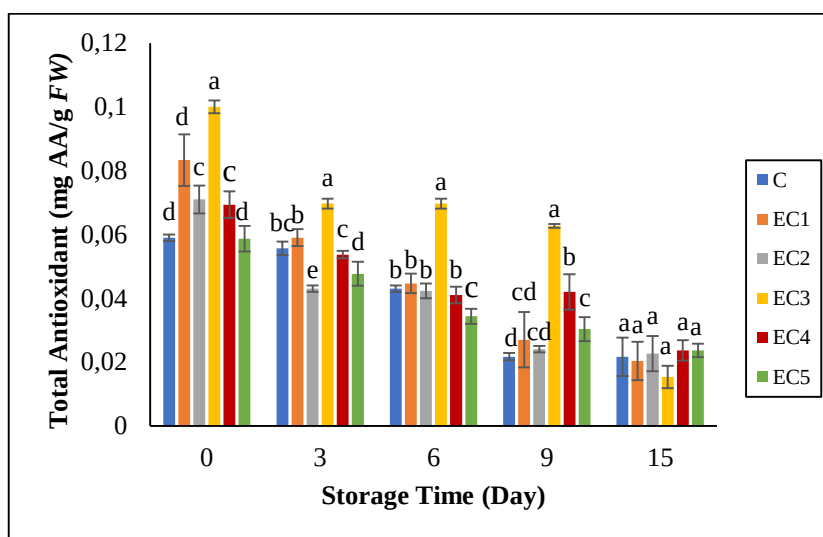


Figure 6. Effect of Edible Coating Materials on Total Antioxidant of Tomatoes During Storage Time

Aloe vera gel mixed with water extracts of sungkai leaves in EC₄ is suggested to have the ability to reduce the production of free radicals [19]. The composition of the edible coating material, specifically aloe vera gel with sungkai leaf extracts, play a crucial role in mitigating damage by reducing the production of free radicals. The results of your one-way ANOVA test and Duncan test provide important information about the influence of edible coating ingredients on antioxidant levels in tomatoes during storage. The one-way ANOVA test showed significant values on day 0, day 3, day 6, and day 9 ($P < 0.005$). This indicates a significant effect of edible coating ingredients on antioxidant levels over time during storage. On the 15 day, the significant value obtained was $P > 0.005$. There was no significant influence of the edible coating material on the percentage of antioxidant levels in tomatoes during storage time. The Duncan test on all edible coating materials at each significantly different time indicated variations in antioxidant levels, while on day 15, the Duncan test results showed that all edible coating materials were not significantly different.

The research results obtained from testing different coating compositions on strawberries showed that strawberries coated with a composition of aloe vera gel and 50% sungkai leaf water extract showed superior performance in several parameters compared to uncoated strawberries. The total antioxidant content in layered strawberries was measured at 0.28 mg AA/g FW, indicating potential health benefits and reduction of oxidative stress [13].

4.7 Total Phenolic of Coated Tomatoes

The edible coating materials used have six types of edible coatings, each with a different composition: Control Treatment (C), aloe vera gel coating (EC₁), sungkai leaf water extract coating (EC₂), sungkai leaf ethanol extract coating (EC₃), aloe vera gel with water extract of sungkai leaves

(EC₄) and aloe vera gel with ethanol extract of sungkai leaves (EC₅). The results of research regarding the determination of total phenolic content in tomatoes using the Folin-Ciocalteu method provide an overview of changes in phenolic levels during storage. The research showed that the total phenolic content decreased in each treatment during the storage time. Among the treatments, tomatoes in the EC₄ treatment had the highest total phenolic content, measuring 0.224 mg GAE/g FW on the 15 day of storage. The decrease in total phenolic content observed in all treatments during storage may be influenced by various factors such as oxidation, enzymatic reactions, or other physiological changes. The higher total phenolic content in EC₄ on the 15 day suggests that the specific composition of the edible coating material in EC₄ may have a protective effect on preserving phenolic compounds in tomatoes during storage.

Higher phenolic levels are associated with increased resistance to pathogens in plants, including tomatoes. Tomatoes coated with aloe vera gel with water extract of sungkai leaves as an edible coating were mentioned to retain phenol during storage. Retaining phenolic compounds in tomatoes can contribute to the overall quality and shelf life of the produce, as phenols play a role in defense mechanisms against microbial threats. Tomatoes coated with EC₄ treatment having the highest total phenolic content on the 15 day of storage. Understanding the relationship between phenolic levels and the ability to inhibit pathogens is crucial in the development of strategies, such as edible coatings, to enhance the resistance of tomatoes to microbial threats.

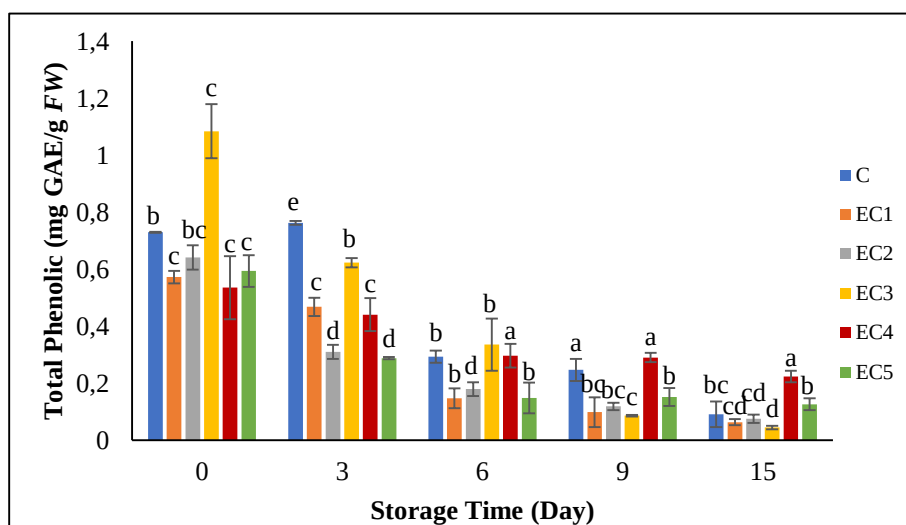


Figure 7. Effect of Edible Coating Materials on Total Phenolic Content of Tomatoes During Storage Time

The results of the one-way ANOVA test and the subsequent Duncan test provide important insights into the influence of edible coating ingredients on total phenolic content in tomatoes during storage. The one-way ANOVA test showed significant values on day 0, day 3, day 6, day 9, and day 15 ($P < 0.005$). This indicates a significant influence of edible coating ingredients on total phenolic content during storage time. On day 0, all edible coating materials were significantly different, except for EC₂. On day 3 and day 6, all edible coating materials were significantly different from each other. On day 9, the control (C) was significantly different from EC₃ and EC₄, but not significantly different from EC₁, EC₂, and EC₄. On day 15, C, EC₁, and EC₂ were not significantly different from each other. However, EC₃, EC₄, and EC₅ were significantly different from each other. The results collectively suggest that edible coating ingredients have a significant impact on the total phenolic content in tomatoes during various storage times. Specific differences between treatments were observed at different time points, emphasizing the nuanced effects of different edible coating materials on phenolic content.

5. Conclusion

Based on the research that has been carried out, FTIR spectra showed that the dominant functional group O-H were found in all edible coating. The physicochemical properties of tomatoes coated with these edible coating materials show better efficiency compared to tomatoes uncoated (C) or only with a layer of aloe vera gel (EC₁) during 15 days of storage. Among the tested edible coating materials, the aloe vera gel layer with ethanol extract of sungkai leaves (EC₅) resulted in the lowest weight loss of tomatoes during storage. For other chemical properties, the aloe vera gel layer with water extract of sungkai leaves (EC₄) was identified as a good edible coating material exhibited benefits such as a weight loss of approximately 8.89 %, total soluble solids of 1.00°Brix, total antioxidant content of 0.024 mg AA/g FW, and total phenolic content of 0.224 mg GAE/g FW over 15 days of storage. It seems that you are stating a conclusion. Based on research results, it suggests that the edible coating material EC₄, which was tested, has a positive impact on maintaining the shelf life and quality of tomatoes during storage. This could be significant for consumers looking for ways to enhance the preservation of tomatoes.

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