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THE USE OF COCOA POD HUSK EXTRACT (*THEOBROMA CACAO L.*) AS AN EDIBLE COATING WITH THE ADDITION OF ALGINATE TO INCREASE THE SHELF LIFE OF TOMATOES (*SOLANUM LYCOPERSICUM* L.)

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ABSTRACT

This research aims to determine the effect of edible coating made from cocoa pod husk added with alginate-containing antimicrobials with different concentrations on the shelf life of tomatoes stored at 30º C and 4º C. Extraction of cocoa pod husk is carried out using the maceration method using acetone: water (7:3) solvent. *Maserat* underwent phytochemical screening. Edible coating made from cocoa pod husk extract with 10% concentration + 0% alginate; cocoa pod husk extract concentration 10% + alginate 1.5%; cocoa pod husk with 10% concentration + 2% alginate; and 10% concentration of cocoa pod husk extract + 2.5% alginate. Phytochemical test results show that cocoa pod husk extract contains phenolic compounds, flavonoids, alkaloids, and tannins. Edible coating cocoa pod husk extract 10% + 2% alginate had a significant effect on the weight loss of tomatoes, and cocoa pod husk extract 10% + 1.5% alginate had a significant effect on the pH of tomatoes in research on levels Vitamin C tomatoes are the best treatment for edible coating. Cocoa pod husk extract 10% + 2.5% alginate. The panelists' highest preference for tomatoes using edible coating was the treatment with cocoa pod husk extract + 2% alginate, storage temperature 30º C, and temperature 4º C with a rating of 4.0 (like). This research concludes that edible coatings based on cocoa pod husk extract with the addition of alginate can be used to package and extend the shelf life of tomatoes.

Keywords: Alginate, Edible Coating, Cocoa Pod Husks Extract, Tomato Fruit

INTRODUCTION

The edible coating is a thin layer made from materials that are safe for consumption as a barrier layer to improve the quality and shelf life of a food product (Duguma, 2022).

Edible coating consisting of natural biopolymers on the surface of food products (Ghorbani et al., 2021) and biodegradable are new approaches to reducing food spoilage (Ríos-De-benito et al., 2021).

This technology creates a barrier against external factors such as oxygen, humidity, light, etc., which can lead to increased quality and shelf life of food products (Alexandre et al., 2021).

Edible coatings developed with antimicrobials will play a role in reducing or inhibiting the growth of microbes that grow on food ingredients, as well as maintaining the integrity and preventing product damage during the shelf life (He & Wang, 2022).

Cocoa plants are rich in bioactive compounds (Wibisono et al., 2021). Cocoa has the potential to be a natural antimicrobial because it contains various secondary metabolites, such as phenolic compounds, namely flavonoids, which are known to have antifungal properties (Yuanita et al., 2020). Cocoa shells mainly consist of polysaccharides (cellulose and hemicellulose), which can be used as edible coating materials (Nisa et al., 2022)

Tomatoes are a commodity that is easily damaged after being harvested, which results in a short shelf life (Tolasa et al., 2021). Post-harvest losses on average in developing countries and developed countries are the primary source of waste (Debebe, 2022). There is a need for post-harvest handling so that it can increase the durability and quality of food during the storage period (Shehata et al., 2021).

Materials commonly used to coat food include plastic and wax. However, this material could be safer and environmentally friendly (Ciano et al., 2023). Cold storage is also insufficient to maintain the quality of fruit and vegetables at optimal levels during transportation and marketing, which often results in severe symptoms of cold injury (Rajapaksha et al., 2021).

For this reason, edible coating technology is a technology that is being considered as an approach or solution for increasing the shelf life and microbiological safety of fresh products (Ciano et al., 2023).

Alginate is included in the hydrocolloid group, potentially an edible coating on food products (Medina-Jaramillo et al., 2020a). Alginate is a constituent of cell walls in algae, which is often found in brown algae (Phaeophyta) (Alexandre et al., 2021). Alginate has the potential to form biopolymer components of films or coatings because alginate has a unique colloidal structure as a stabilizer, binder, suspender, film-former, gel-former, and emulsion stability (Beaumont et al., 2021; Chen et al., 2021; Lai et al., 2021; Rashid et al., 2020; Zhang et al., 2021). Alginate is considered safe for human consumption and biomedical applications. Alginate can inhibit bacterial growth by damaging bacterial cell walls, denaturing proteins, and damaging cell membranes, disrupting protein synthesis and inhibiting the work of enzymes (Ahmad Raus et al., 2021). It is necessary to research the edible coating of cocoa pod husk extract with antimicrobial active ingredients with the addition of alginate and its application on fruit in post-harvest handling of agricultural products. Edible coatings developed with antimicrobials will play a role in reducing or inhibiting the growth of microbes that grow on food ingredients, as well as maintaining the integrity and preventing product damage during the shelf life.

METHOD

1. Preparation sample

Sample of cocoa pod husk (*Theobroma cacao L.*) the one used is the Criollo variety, originating from Tobajo Hamlet, Bolubanggu Village, Dapurang District, Pasangkayu Regency, and West Sulawesi. The selection of cocoa pod husk samples is ripe skin, taken while it is still fresh and yellow. cocoa pod husk samples are then collected, wet sorted, washed with running water, and air dried. The sample is then cut into small pieces and then air-dried again. The cocoa pod husk (*T. cacao L.*), which has been cleaned, is then dried in an oven (Memmert) at a temperature of 60°C for 3x24 hours until it becomes hard, which indicates a low water content. Then, puree using a blender (Philips).

2. Sample extraction

Cocoa pod husk (*T. cacao L.*) extracted using the maceration method using acetone: water (7:3) in a ratio of (1:3) for dry samples. Samples ground using a sieve (Mesh) were weighed as much as 300 grams, put into each measuring cup, and soaked in 1000 ml of solvent. Soaking was carried out for 24 hours at 30^{o} C and repeated 3 times. The macerate obtained is filtered using a filter cloth and then concentrated using an evaporator until a thick extract is obtained (El-Ghaffar et al., 2016). After that, the yield percentage is calculated using the formula:

$$\text{Extract yield} = \frac{\text{Total weight of extract}}{\text{Total weight of simplicial powder}} \times 100\% \qquad \text{(Sasidharan et al., 2011)}$$

After calculating the yield percentage, the sample is stored in the refrigerator.

3. Fractionation

The extract is first tested by TLC (Thin Layer Chromatography). To get the best eluent. 0.5 gram of extract was dissolved in 10 ml of acetone solvent. Then, it is spotted on the TLC plate using a capillary tube. The plates are tested in various eluent ratios, which will be detected under UV light and then sprayed with 10% cerium sulfate. TLC results, the best eluent obtained was n-Hexane:

Ethyl Acetate. 3 grams of the extract was impregnated with 9 g G60H silica gel in a ratio of sample: silica gel (1:3). The sample was impregnated until it was homogeneous and had a sand-like texture (Choma & Grzelak, 2011)

The fractionation stage uses vacuum Liquid Column Chromatography (KCV) with Silica G 60 F254 silica gel as the stationary phase. Meanwhile, the eluent (mobile phase) uses an eluent with a gradient of increasing polarity (Step Gradient Polarity), the best eluent obtained from the first TLC results. Elution begins by withdrawing 100% non-polar eluent and then increasing the polarity level periodically. The resulting fractions were evaporated, and then TLC was tested again with the best eluent in the first TLC. Fraction results that have an R-value f adjacent to each other are combined to test their activity further (Sasidharan et al., 2011)

4. Antifungal Testing

a. Microbial Preparation *Fusarium oxysporum* as an Inoculant

F. oxysporum grown in petri dishes containing PDA media. After 7 days, the mushroom spores were harvested. The formulation had a spore density of $1x10^6$ conidia/ 1 L.

b. Antifungal testing

The test tested the antifungal activity of combined fractionated cocoa shell extract against *F. oxysporum*. Previously, the paper disk had been soaked in the fraction and positive control solution for 1 hour. The paper disk that has been soaked in the fraction and control is placed on the agar medium, and then the fungal culture is taken using a tube placed in the middle of the agar medium. Antifungal observations are seen from the inhibition zone formed. Observations were made during 3 days of incubation at 25˚C (Stracquadanio et al., 2020)

5. Compound Identification

The fraction results were tested using $FeCl_3$ reagent, Wagner, Mayer, Mg, and HCl to determine the class of secondary metabolite compounds obtained. A qualitative examination of cocoa pod husk extract's active ingredients was performed using standard procedures (Nahak & Sahu, n.d.) Compound classes can be identified based on Table 1 as follows:

Table 1. Identification of compound groups from phytochemical tests

No.	Reagent	Results	Description
1	Wagner	Formed reddish-brown precipitate	+ Alkaloid
2	Mayer	White precipitate is formed	+ Alkaloid
3	Mg + Hcl	A yellowish-brown discoloration occurs	+ Phenol

4	$FeCl_3$	Changes to brown color occur	+ Flavonoid
5	$FeCl_3$ 3%	Blackish-green deposits are formed	+ Tannin

6. Preparation of solution edible coating

Preparation of solution edible coating, namely 250 ml distilled water heated to a temperature of 80ºC, a thermometer is used to control the temperature, 10% concentration cocoa pod husk extract + 0% alginate, 10% concentration cocoa pod husk extract + 1.5% alginate, 10% concentration cocoa pod husk extract + 2.0% alginate, and 10% concentration of cocoa pod husk extract + 2.5% alginate, then the solution is added with 2.0% glycerol and $CaCl_2$ 2.0%, homogenized for 15 minutes at 65ºC. Keep stirring until homogeneous for 5 minutes at 80ºC until a solution forms the edible coating. All these activities are carried out aseptically (Medina-Jaramillo et al., 2020b).

Samples of tomatoes were taken from plantations in Banca Hamlet, Bontongan Village, Baraka District, Enrekang Regency. The selection criteria for tomatoes to be sampled were that the color of the fruit was still green or yellowish green, had almost the same size, and had no damage.

7. Edible Coating on tomatoes

The selected tomatoes are then cleaned of dirt using running water and dried. Next, dip it in sterile distilled water and let it dry, then dissolve it in the solution edible coating for 5 minutes and drain. The method used to apply edible coating on tomatoes is the dipping method (dipping). Dyeing is done twice to get good results, then drained and air dried; do the same with all samples. The tomatoes that have been drained are then stored at room temperature (30ºC) and cold temperature (4ºC) for 21 days (Kumar et al., 2020). Research parameters include measuring weight loss, pH test, and Vitamin C content test.

a. Weight Loss

Weight loss measurements are carried out gravimetrically, namely comparing the difference in weight before storage and after storage. The weight loss measurement interval is once every 7 days. Weight loss during storage can be calculated using the following formula:

$$\text{Weight Loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100\%$$ (Eboibi et al., 2021)

b. Use pH

The pH acidity level of the sample can be measured using a pH meter. Before starting measurements, this tool is calibrated first using buffer standards 4 and 7, and then the electrode was rinsed with distilled water and dried until smooth using a mortar. Distilled water was added to a measuring flask to a volume of 100 ml, and then the electrode was dipped until it sank in the sample solution and left until a stable number was obtained as a measured pH value (Rab et al., n.d.).

c. Test Vitamin C Levels

Vitamin C levels were measured 4 times during the study (from the day of application of edible coating until day 21). Measure vitamin C levels before application of edible coating. This is done by crushing 10 grams of material with mortal, then putting it in a 100 ml measuring flask, diluting it to the tera mark by adding distilled water, which is used as a rinse for mortal, and then filtering. The resulting filtrate was put into an Erlenmeyer flask, 2-3 drops of 1% starch were added, then titrated with 0.01 N iodine solution until a stable color change appeared. Each ml of iodine is equivalent to 0.88 mg of ascorbic acid, so ascorbic acid can be calculated using the formula:

$$\text{Ascorbic acid} = \frac{\text{Volume iod } 0{,}01 \times 0{,}88 \text{ FB} \times 100}{\text{Grams Sample}}$$ (Rab et al.,2013)

Note: FP = Dilution factor

8. Organoleptic test

This test was carried out by 10 panelists consisting of 2 men and 3 students, 2 male lecturers, and 3 female lecturers from the Department of Biology and Chemistry who know the quality of tomatoes. The organoleptic test was carried out using the hedonic rating test. Each panelist gives an assessment based on their preferences. Test parameters include color, aroma, texture, and taste of tomatoes, carried out in 1 treatment once every 7 days for 21 days. The hedonic rating test uses a scale of 1-5. The assessment criteria include (1) do not like, (2) do not like, (3) Neutral, (4) like, and (5) like very much (Luh Suastuti & Kadek Eni Juniari, 2019)

Data analysis

The data obtained was analyzed through one-way analysis of variance (ANOVA) using SPSS version 26. Duncan's test compared means at the 95% confidence level. All experiments were triplicate.

RESULTS

1. Results of Extracting Cocoa Pod Skin

Extraction of cocoa pod husk samples (*T. cacao L.*) using the maceration method with acetone solvent: acetone: water (7:3) Characterization of the extract resulting from the extraction of cocoa pod husk (*T. cacao L.*) with the solvent acetone: water (7:3) has a blackish brown color with a thick consistency. The extract results obtained from the maceration process of 1200 g of sample, namely 350 g of cocoa pod husk extract, obtained a yield value of 29.16%.

2. Chemical Analysis

To determine the secondary metabolite compounds in cocoa pod husk, phytochemical screening was carried out as a qualitative test by adding reagents. The results of the phytochemical screening of cocoa pod husk (*T. cacao L.*) can be seen in Table 2.

Table 2. Phytochemical Screening Results of cocoa pod husk (*T. cacao L.*)

No	Compound Identification	Reaction	Color
1	Alkaloid	+	brownish yellow →There is a reddish brown precipitate
2	Saponin	-	Brown → Brown, no foam
3	Tannin	+	Dark yellow → Blackish green
4	Flavonoid	+	Greenish yellow → orange
5	Phenol	+	Dark yellow → Bluish black

The results of compound identification using phytochemical tests showed acetone extract: water (7:3) cocoa pod husk (*T. cacao L.*) contains secondary metabolites in the form of alkaloids, flavonoids, phenols, and tannins but does not contain saponin compounds.

3. Thin Layer Chromatography (TLC)

Before carrying out fractionation, TLC (Thin Layer Chromatography) is first carried out to determine the best eluent that can be used as the mobile phase in the fractionation stage. Methanol, Acetone, Ethyl Acetate, and n-hexane eluents were used in various ratios.

Based on the results of Thin Layer Chromatography, two separate stains were obtained in the test using the eluent n-Hexane: Ethyl Acetate, which showed the separation of compounds in the extract. This shows that n-Hexane: Ethyl Acetate can be used as an eluent or mobile phase in the next stage, namely fractionation.

4. Fractionation

Fractionation is carried out using the method VLCC (Vacuum Liquid Column Chromatography). The eluent uses an eluent by increasing its polarity level (Step Gradient Polarity). From this fractionation stage, 11 fraction results were obtained. The resulting fractions were evaporated and then carried out further TLC. The eluent used is the same as the fractionation process. From this TLC process, you will get the stains that form. Calculated R-value f each. R-value f from each faction, which will later become a reference for the combined fraction. Which can be seen in Table 3.

Table 3. R-value from the results of Thin Layer Chromatography of Cocoa Pod Husk Extract Fractions

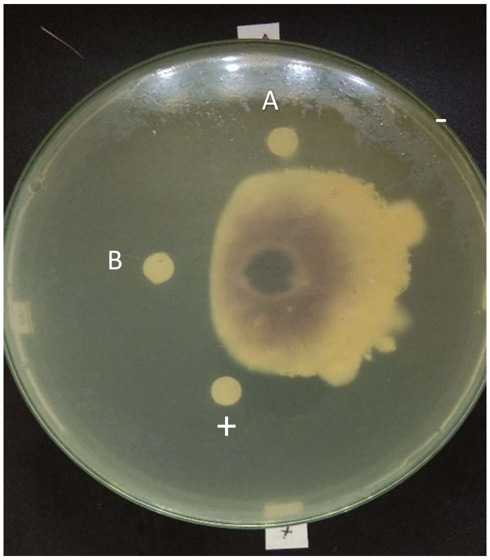
No	Fraction Results	R*f* Score
1	Fraction 1	0.89
2	Fraction 2	0.89
3	Fraction 3	0.89
4	Fraction 4	0.89
5	Fraction 5	0.89
6	Fraction 6	0.89
7	Fraction 7	0.89
8	Fraction 8	0.89
9	Fraction 9	0.33
10	Fraction 10	0.39
11	Fraction 11	0.37

From Table 3, the R value can be seen f each fraction. We get 2 combined fractions, namely Fraction A, a combination of fractions 1 to 8 because it has an R-value f the same, and Fraction B is a combination of fractions 9, 10, and 11, which has an almost close R-value f.

5. Antifungal Activity Assay

The resulting combined fractions were then tested for antifungals using culture *F. oxysporum*. The antifungal activity of the fraction was indicated by the presence of an inhibition zone formed compared to the positive control, which used Benomil. Benomyl, a systemic fungicide, was registered to control various fungal diseases that affect fruits, nuts, vegetables, turf, and field crops. Its fungicidal properties are suggested based on its ability to inhibit microtubule assembly. In contrast, the negative control was not given any treatment. The two combined fractions showed antifungal activity, as indicated by an inhibition zone. In the positive control, an inhibition zone of 0.59 mm was formed, and no inhibition zone was formed in the negative control. Meanwhile, for fraction A, an inhibition zone of 0.51 mm was formed, and for fraction B it was 1.20 mm. This shows that there is excellent antifungal activity in fraction B.

Information:



Description:

A: Combined fraction A

B: Combined fraction B

+: Positive control

-: Negative control

Figure 1. Antifungal Activity Test Results from Combined Fraction Resuslts

6. Phytochemical Test

The combined fraction, which has antifungal activity, will then be phytochemicals tested to determine the content of secondary metabolite compounds owned. The results of the phytochemical fraction test can be seen in Table 4 below:

Table 4. Phytochemical Test Results from Combined Fractions

No	Combined Fractions	Alkaloid	Flavonoid	phenol	tannin
1	Fractions A	-	-	+	-
2	Fractions B	-	+	+	-

The results of the phytochemical screening showed that fraction A was positive for containing phenol, while fraction B was positive for containing flavonoids and phenol.

7. Edible coating on tomatoes

Observe the quality of tomatoes treated with edible coating with the addition of alginate for 21 days by observing weight loss, pH test, and Vitamin C levels.

a. Weight Loss

Based on the research results, it was found that the percentage of weight loss of tomatoes during storage for 21 days at a temperature of 30^{o} C and 4^{o} C. The statistical test used is One Way Anova, and to find out which treatment can best reduce the percent weight loss of tomatoes, it is necessary to carry out further tests using further tests Duncan Multiple Range (DMRT) with a confidence interval of 95% or 0.05. The average results from further tests can be seen in Table 5.

Table 5. Average Weight Loss at Temperature 30° C and Temperature 4° C after 21 days

No.	Treatment	Average Weight Loss Test (cm)	
		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	9.40[a]	7.00[b]
2	Cocoa pod husk extract 10% + Alginate 1.5%	8.07[a]	5.98[b]
3	Cocoa pod husk extract 10% + Alginate 2.0%	7.12[a]	2.61[a]
4	Cocoa pod husk extract 10% + Alginate 2.5%	6.76[a]	3.23[a]

Note: a, b = similar letter notation means there is no significant difference at the Mann-Whitney test level which has a value of 5%.

Adding alginate to the solution edible coating applied to tomatoes at a temperature of 30° C does not affect weight loss in tomatoes. Results of analysis of variance in tomato fruit shrinkage at a temperature of 30° C with 0% alginate concentration treatment had the highest average value, 9.40, and 2.5% alginate concentration treatment had the lowest average value, namely 6.76.

Percentage of weight loss of tomatoes at temperature 4° C shows that tomato fruit weight loss had a significant effect on the alginate treatment with concentrations of 2.0% and 2.5% on the alginate treatment with alginate concentrations of 0% and 1.5%. Meanwhile, the 2% concentration alginate treatment was not significantly different from the 2.5% concentration alginate treatment. The 0% concentration alginate treatment was not significantly different from the 1.5% alginate treatment.

b. pH Test

The percentage from the research results was obtained from the pH test parameters on tomatoes during storage for 21 days at a temperature of 30° C and 4° C. The statistical test used is One Way Anova, then proceeded with further testing Duncan Multiple Range (DMRT) to show that the alginate addition treatment affects the degree of acidity (pH) of tomato fruit with a confidence interval of 95% or 0.05. The average results of the test can be seen in Table 6.

Table 6. Average pH Test at Temperature 30° C and Temperature 4° C after 21 days

No.	Treatment	Average pH Test

		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	5.20^{c}	4.60^{c}
2	Cocoa pod husk extract 10% + Alginate 1.5%	4.50^{b}	4.30^{bc}
3	Cocoa pod husk extract 10% + Alginate 2.0%	4.42^{ab}	4.17^{ab}
4	Cocoa pod husk extract 10% + Alginate 2.5%	4.02^{a}	3.80^{a}

Description: a, b = similar letter notation means there is no significant difference at the Mann-Whitney test level with a value of 5%.

Based on the results of observations obtained in the pH test at a temperature of 30° C with alginate concentration treatments of 0% (control), 1.5%, 2.0%, and 2.5%. The 0% concentration alginate treatment had a significant effect on the 1.5%, 2.0%, and 2.5% concentration alginate treatments, and the 1.5% concentration alginate treatment had a significant effect on the 2.5% concentration alginate treatment. Meanwhile, the 1.5% concentration alginate treatment was not significantly different from the 2% concentration alginate treatment, and the 2.0% concentration alginate treatment was not significantly different from the 2.5% concentration alginate treatment.

Results of temperature observations 4° C in the pH test with alginate concentration treatments of 0% (control), 1.5%, 2.0%, and 2.5%. The 0% concentration alginate treatment had a significant effect on the 2.0% and 2.5% concentration alginate treatments, and the 1.5% concentration alginate treatment had a significant effect on the 2.5% concentration alginate treatment. Meanwhile, the 0% concentration alginate treatment was not significantly different from the 1.5% concentration alginate treatment, the 1.5% concentration alginate treatment was not significantly different from the 0% and 2.0% concentration alginate treatments, and the 2.5% concentration alginate treatment was not significantly different from the 2.0 concentration alginate treatment. %.

c. Vitamin C levels

The results of research observations showed that the percentage of test parameters for vitamin C levels in tomatoes with application edible coating using the essential ingredients of cocoa pod shells with the addition of alginate except for the control treatment, which was stored for 21 days at 30° C and 4° C. The statistical test used is One Way Anova and uses further tests, Duncan Multiple Range (DMRT), with a confidence interval of 95% or 0.05. The average results of the test can be seen in Table 7.

Table 7. Average Vitamin C Levels at Temperatures 30° C and Temperature 4° C after 21 days

No.	Treatment	Average Vitamin C Levels

		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	7.65[a]	6.30[a]
2	Cocoa pod husk extract 10% + Alginate 1.5%	7.80[a]	7.15[a]
3	Cocoa pod husk extract 10% + Alginate 2.0%	6.80[a]	6.15[a]
4	Cocoa pod husk extract 10% + Alginate 2.5%	8.72[a]	8.50[a]

Note: a, b = similar letter notation means there is no significant difference at the Mann-Whitney test level which has a value of 5%.

The research results obtained variations in vitamin C levels with treatment at a temperature of 30° C. It is known that the levels of vitamin C in tomatoes are not significantly different when treated with alginate concentrations of 0%, 1.5%, 2.0%, and 2.5%. Differences in using alginate to the solution edible coating applied to tomatoes do not affect vitamin C levels in tomatoes. Results of analysis of variance in vitamin C levels of tomatoes at a temperature of 30° C had the highest average value, namely 8.72 mg in the 2.5% alginate concentration treatment, and the lowest average value, namely 6.80 mg in the 2.0% alginate concentration treatment.

Treatment at temperature 4° C can be obtained from variations in vitamin C levels. It is known that the levels of vitamin C in tomatoes are not significantly different when treated with alginate concentrations of 0%, 1.5%, 2.0%, and 2.5%. Differences in using alginate to the solution edible coating applied to tomatoes do not affect vitamin C levels in tomatoes. Results of analysis of variance in vitamin C levels of tomatoes at temperature 4° C had the highest average value, namely 8.50 mg in the 2.5% alginate concentration treatment, and the lowest average value, namely 6.15 mg in the 2.0% alginate concentration treatment.

8. Organoleptic Test

The results of organoleptic tests on the color, aroma, texture, and taste of tomatoes were carried out with four treatments which resulted in an average preference for tomatoes during storage for 21 days at a temperature of 30° C and 4° C using an organoleptic test based on the panelists' liking scores on a scale of 1 to 5, namely: 1 (do not like it), 2 (do not like it), 3 (normal), 4 (like it), 5 (like it very much).

a. Color

Treating tomatoes with applications of edible coating and the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% at a storage temperature of 30° C for organoleptic tests, it shows that of the four treatments, the alginate concentration used obtained an average value of 3.6 to 4.1. The 0% alginate concentration treatment is 3.6 (close to like), the 1.5% alginate concentration treatment is 4.1 (close to very like), the 2.0% alginate concentration treatment is 4.0 (like), the 2.5% alginate concentration treatment is 4.0 (like). The average results of the test can be seen in Table 8.

Table 8. Average organoleptic test results based on Color category at Temperature 30^o C and Temperature 4^o C after 21 days of treatment

No.	Treatment	Average organoleptic test results based on Color category	
		Temperature 30^{o}C	Temperature 4^{o}C
1	Cocoa pod husk extract 10% + Alginate 0%	3.6	3.1
2	Cocoa pod husk extract 10% + Alginate 1.5%	4.1	3.8
3	Cocoa pod husk extract 10% + Alginate 2.0%	4.0	3.4
4	Cocoa pod husk extract 10% + Alginate 2.5%	4.0	3.3

Storing tomatoes at a temperature 4^o C in Table 8 shows that the organoleptic test results are related to the application treatment of edible coating with the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5%. Data were obtained with an average value of 3.1 to 3.8. The 0% alginate concentration treatment is 3.1 (usual), the 1.5% alginate concentration treatment is 3.8 (close to like), the 2.0% alginate concentration treatment is 3.4 (close to like), the 2.5% alginate concentration treatment is 3.3 (close to like).

b. Aroma

Treatment of tomatoes for the aroma category with applications of edible coating and the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% at a storage temperature of 30^o C. Shows that of the four alginate concentration treatments used, an average value of 3.6 to 4 was obtained. The 0% alginate concentration treatment was 3.7 (close to like), the 1.5% alginate concentration treatment was 3.8 (close to like), the 2% alginate concentration treatment was 3.8 (close to like), the 2% alginate concentration treatment was 3.8 (close to like), 2.5% alginate concentration treatment is 4.0 (like). The average results of the organoleptic test for the aroma category can be seen in Table 9.

Table 9. Average organoleptic test results based on Aroma category at Temperature 30^o C and Temperature 4^o C after 21 days of treatment

No.	Treatment	Average organoleptic test results based on Aroma category

		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	3.7	3.4
2	Cocoa pod husk extract 10% + Alginate 1.5%	3.8	3.4
3	Cocoa pod husk extract 10% + Alginate 2.0%	3.8	3.6
4	Cocoa pod husk extract 10% + Alginate 2.5%	4.0	3.5

Organoleptic test results are based on Table 9, regarding the application treatment edible coating with the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% to tomatoes stored at temperature 4° C gets an average grade of 3.4 to 3.6. The 0% alginate concentration treatment is 3.4 (close to like), the 1.5% alginate concentration treatment is 3.4 (close to like), the 2.0% alginate concentration treatment is 3.6 (close to like), the 2.5% alginate concentration treatment is 3.5 (close to like).

c. Texture

Treatment of tomatoes for the texture category with applications of edible coating and the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% at a storage temperature of 30° C. Shows that from the four treatments the alginate concentration used obtained an average value of 3.8 to 4.1. The 0% alginate concentration treatment is 3.8 (close to like), the 1.5% alginate concentration treatment is 3.9 (close to like), the 2.0% alginate concentration treatment is 4.1 (like), the 2.5% alginate concentration treatment is 3.9 (close to like). The average results of the organoleptic tests for the texture category can be seen in Table 10.

Table 10. Average Organoleptic Texture at Temperature 30° C and Temperature 4° C after 21 days of treatment

No.	Treatment	Average Organoleptic Texture	
		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	3.8	3.6
2	Cocoa pod husk extract 10% + Alginate 1.5%	3.9	3.8
3	Cocoa pod husk extract 10% + Alginate 2.0%	4.1	4.1
4	Cocoa pod husk extract 10% + Alginate 2.5%	3.9	3.8

Table 10 shows that the organoleptic test results for the application treatment edible coating with the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% to tomatoes stored at temperature 4° C obtained data with an average value of 3.6 to 4.1. The 0% alginate concentration treatment is 3.6 (close to like), the 1.5% alginate concentration treatment is 3.8 (close to like), the 2.0% alginate concentration treatment is 4.1 (like), the 2.5% alginate concentration treatment is 3.8 (close to like).

d. Taste

Treatment of tomatoes for the taste category with applications edible coating and the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% at a storage temperature of 30° C obtained an average value of 3.2 to 3.6: 0% alginate concentration treatment, namely 3.6 (close to like), 1.5% alginate concentration treatment, namely 3.3 (close to like), 2.0% alginate concentration treatment, namely 3.5 (close to like), 2.5% alginate concentration treatment namely 3.2 (close to like). The average results of the organoleptic test for the taste category can be seen in Table 11.

Table 11. Average Organoleptic Taste at Temperature 30° C and Temperature 4° C after 21 days of treatment

No.	Treatment	Average Organoleptic Taste	
		Temperature 30°C	Temperature 4°C
1	Cocoa pod husk extract 10% + Alginate 0%	3.2	3.6
2	Cocoa pod husk extract 10% + Alginate 1.5%	3.3	3.9
3	Cocoa pod husk extract 10% + Alginate 2.0%	3.6	3.6
4	Cocoa pod husk extract 10% + Alginate 2.5%	3.5	3.9

Treating tomatoes with applications of edible coating and the addition of alginate concentrations of 0%, 1.5%, 2.0%, and 2.5% at storage temperature 4° C shows that from the four treatments, the alginate concentration used obtained an average value of 3.6 to 3.9. The 0% alginate concentration treatment is 3.6 (close to like), the 1.5% alginate concentration treatment is 3.9 (close to like), the 2.0% alginate concentration treatment is 3.6 (close to like), the 2.5% alginate concentration treatment is 3.9 (close to like).

DISCUSSION

The results of the Thin Layer Chromatography test showed that the extract was acetone: water (7:3) from Cocoa pod husk (*T. cocoa L.*) contains phenolic compounds and flavonoids.

In the antifungal test, the formation of an inhibition zone indicated antifungal activity compared to the positive control. The two combined fractions form an inhibition zone. This shows that both fractions have antifungal activity. The screening results showed that Fraction A contained phenol, while Fraction B contained flavonoids and phenol. This indicates that the compounds that function as antimicrobials in cocoa extract are phenolic and flavonoid compounds (Takó et al., 2020). This follows the statement that flavonoids are phenolic compounds produced as plant defense. Phenolic compounds have an antimicrobial function in plants. Flavonoids are secondary metabolites found in plants (Abdul Qahir et al., 2021; Arruda et al., 2021; Hussain et al., 2019; Mokhtar et al., 2021). These compounds can be used as antimicrobial, antifungal, anti-virus, anti-cancer, and anti-tumor (Kapustinskii et al., 2020; M. Liu et al., 2020; Takó et al., 2020; Tutunchi et al., 2020).

Judging from the largest inhibitory diameter of the fungus, fraction B, which contains phenols and flavonoids, means that the combination of phenolic and flavonoid compounds has greater inhibitory power against fungi. Flavonoids themselves are phenolic compounds that are water soluble and contain hydroxyl (-OH) functional groups, making them easier to enter cells and form complexes with cell membrane proteins (Golonko et al., 2023). Phenolic compounds interact with cell membrane proteins through an adsorption process involving hydrogen bonds by binding to the hydrophobic part of the cell membrane (X. Liu et al., 2020). The protein-phenolic compound complex is formed with weak bonds, so it will immediately undergo decomposition, followed by penetration of the phenolic compound into the cell membrane, which causes precipitation and denaturation of cell membrane proteins (Makarewicz et al., 2021). Damage to the cell membrane causes changes in the permeability of the membrane, resulting in lysis of the fungal cell membrane (Simonetti et al., 2020).

Phenolic compounds work by denaturing cell proteins and cell membranes, resulting in changes in cell permeability, which can result in inhibited cell growth or death of fungal cells so that they are fungistatic and fungicidal, depending on the concentration. Phenol can also shrink cell walls so that it can lyse fungal cell walls (El-Hefny et al., 2020).

Cocoa pod husk extract contains polyphenols, which can prevent oxidation disease and neutralize free radicals that are around. Furthermore, by adding alginate with a concentration of 2%, you get a solution with a good concentration. The layer formed on the skin of the tomato fruit is perfect so that it can hold the water content that enters the surrounding air, can improve the texture of the fruit skin, and can reduce dehydration so that weight loss can be prevented.

Cocoa pod husk extract treatment with adding 1.5% alginate is the best treatment because it has a stable pH, where the pH range for tomatoes is between 4.0 and 4.5. This shows that the role of alginate inedible coating is able to cover the pores of tomatoes perfectly, thus maintaining osmotic pressure in the fruit, inhibit the growth of microorganisms, and slow down the rate of chemical and enzymatic reactions (Ahmad Raus et al., 2021).

The level of ripeness of the fruit influences vitamin C levels. Unripe tomatoes contain higher levels of vitamin C than more ripe fruit (Tolasa et al., 2021). The quality of tomatoes in 100 g is 21 mg of vitamin C. It is suspected that the coating with an additional alginate concentration of 2.5% produces a perfect layer covering the entire surface of the fruit skin. There is also an antioxidant role in cocoa shell extract as a base for the solution, which can inhibit the oxidation process that occurs so that it can suppress the ripening of tomatoes (Nguyen et al., 2022).

Organoleptic testing is a method of testing that uses human senses as the primary tool for measuring product acceptability. In assessing food ingredients, the characteristics that determine whether a product is accepted are its sensory properties. The senses used in assessing sensory properties are sight, touch, smell, and taste (Luh et al. Juniari, 2019).

Organoleptic tests are carried out by someone called a panelist. In this study, the parameters used were the panelists' hedonic scale preference level for the color, aroma, texture, and taste of tomatoes (Eboibi et al., 2021)

Based on research on tomato color sensory tests, the average panelist assessment ranged from 4.1 (like) to 3.1 (quite like). The color the panelists liked most from the organoleptic test results was the treatment with adding 1.5% alginate concentration, namely a value of 4.1 (liked). This is thought to be because the appearance of the tomato fruit has a bright red color and has a shiny effect, compared to the treatment without adding alginate, where ripening is faster so that the fruit has brown spots and is slightly wrinkled. The phenol content in cocoa pod husk extract can prevent the growth of fungi that cause brown spots on the surface of the fruit (Hussain et al., 2019). The addition of alginate also does not produce much edible coating, which is perfectly formed on tomatoes.

Based on research on the sensory test of tomato aroma, the average panelist assessment ranged from 4 (like) to 3.4 (close to like). The panelists' favorite level of tomato aroma was the alginate treatment with a concentration of 2.5% at a storage temperature of 30^{o} C with a value of 4 (like). This is because the aroma of the fruit is maintained and does not produce a strange smell even though there is a coating layer. Cocoa pod husk extract, as an antioxidant, can maintain the quality of tomatoes with the addition of alginate so that the aroma is maintained and does not cause an unpleasant aroma due to microorganism contamination.

Based on the research results on the sensory test of tomato fruit texture, the average panelist assessment ranged from 4.1 (like) to 3.6 (close to like). The panelists' highest liking rating for tomatoes using edible coating is in the alginate treatment with a concentration of 2.0% at a storage temperature of 30^{o} C and storage temperature of 4^{o} C, with a value of 4.1 (like). This is because the panelists liked tomatoes that were still hard and dense. These results showed that the addition of a 2.0% concentration of alginate was able to maintain the level of fruit hardness or inhibit the fruit softening process due to respiration and transpiration. Cocoa pod husk extract as an antioxidant will minimize the respiration process in tomatoes so that the quality and shelf life are longer.

CONCLUSION

Tomato fruit is always susceptible to spoilage and oxidation by microbes. The results of this study show that edible coatings from cocoa pod husk extract with the addition of alginate-containing antimicrobials can adequately resist oxidation, moisture loss, and reduction in hardness, and drastic color changes in samples relative to controls. According to microbial analysis, cocoa pod husk extract can inhibit fungal growth. In addition, the coating containing cocoa pod skin did not have a detrimental effect on the organoleptic tests of tomato fruit samples. In conclusion, coatings based on cocoa skin extract with the addition of alginate, which contains antifungal, can be used to package and extend the shelf life of tomatoes.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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