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Smart Packaging Based on Pectin and Anthocyanin from Purple Sweet Potato Extract (Ipomoea batatas L) with the Addition of Lemongrass (Cymbopogon citratus) Essential Oil

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Abstract

Purple sweet potato (Ipomoea batatas L) is one of the tubers that contain anthocyanin compounds because it has natural dyes. Anthocyanins derived from purple sweet potatoes have properties sensitive to changes in pH, so purple sweet potatoes are the right choice to be used as an alternative to natural dyes. Changes in pH that occur in food spoilage are the reason for making and developing smart packaging films based on pectin and anthocyanins derived from purple sweet potato extract by adding lemongrass essential oil. This research aims to determine the effect of purple sweet potato extract anthocyanin levels and kitchen lemongrass essential oil levels on the physical and pH-sensitive properties of the resulting film and determine the performance of the film produced from pectin with the addition of purple sweet potato extract anthocyanins and kitchen lemongrass essential oil as packaging. smart to monitor the freshness of chicken fillet meat. There are three methods used in this research, namely purple sweet potato extraction, film making from pectin-anthocyanin-essential, and film application from pectin-anthocyanin-essential. The research phase was purple sweet potato extract with a concentration of 0%, 10%, 20%, and essential oil 0 mL, 0.5 mL. It added 1 mL of these to the pectin film solution. We are observing color changes, mechanical properties, pH-sensitive properties of films, and film biodegradability. Then, perform measurements of light transmittance and opacity, film thickness, water content, and water vapor permeability. After that, apply a film to detect the freshness level of chicken fillet meat. This research concludes that the anthocyanin content of purple sweet potato extract and essential oil of lemongrass has a significant effect on the physical properties of the pectin-anthocyanin-essential film

Keywords : Anthocyanin, Purple Sweet Potato Extract, Film, Lemongrass Essential Oil, Pectin

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INTRODUCTION

Biodegradable film is used to form smart packaging that can detect pH changes in food (Utama et al., 2018). According to Ulya et al. (2016), the film is a transparent material used to wrap various kinds of food ingredients with the function of extending storage life. The content of the film is a polymer material that has a high molecular weight. Generally, several materials are added to the film, which helps improve the structure and mechanical properties and provides active functions. Plasticizers are added to the film to increase the flexibility of the film. Some of the ingredients added to the film are chitosan, essential oils, and extracts from plants.

Pectin is an additive compound that functions as a gelling agent. Pectin is a fiber structure found in the middle lamella layer and main cell walls in plants. The substance formed in pectin is coarse to fine white, brownish, gray, or yellowish powder. There is a lot of pectin processing for the needs of the food, pharmaceutical, and medicine industries. In the food industry, pectin is used as an adhesive and stabilizer to prevent sediment formation. Meanwhile, in the pharmaceutical sector, pectin is used as a diarrhea medicine. Pectin is also commonly used to form gels and thickeners in making jelly, marmalade, and low-calorie foods (Rosida et al., 2018).

Anthocyanins are compounds that have amphoteric properties; that is, they can react well in acidic and basic conditions. Under acidic conditions, anthocyanins have a red color, and under alkaline conditions, anthocyanins change to purple and blue. As the name suggests, anthocyanins produce color in green plant leaves, flowers, and fruit and are used as natural coloring in food. Temperature, light, pH, and oxygen are factors that significantly influence the stability of anthocyanins. Purple, red, and blue anthocyanin pigments are unstable when temperature, light, pH, and oxygen change (Samber et al., 2013). The purple color of purple sweet potato is caused by the purple anthocyanin pigment it contains, which extends from the skin to the flesh of this purple sweet potato (Pokorny et al., 2001). Kristijarti and Arlene (2012) said that the anthocyanin levels in purple sweet potatoes are higher than in other types of tubers, with a value range of 14.68-210 mg/100g of raw material. Lemongrass essential oil is a compound that contains carbon and hydrogen or carbon, hydrogen and oxygen, which does not have aromatic properties. Lemongrass essential oil has a concentration of 0.2–0.4% fresh weight. Lemongrass essential oil has anti-fungal and bacterial properties (Poeloengan, 2009).

MATERIALS AND METHODS

1. Materials

   Purple sweet potato flour was purchased from CV. Lingkar Organik Yogyakarta, Indonesia. Pectin was purchased from CV. Taminaa Surabaya, Indonesia. Chicken fillet were purchased from local market in Yogyakarta, Indonesia. Aquadest, glycerol (99%) and ethanol (96%) were purchased from CV Progo Mulyo in Yogyakarta, Indonesia. Buffer solutions were purchased from CV Nitra Kimia in Yogyakarta, Indonesia. Lemongrass oil was purchased from CV Star Cosmetic in Surabaya, Indonesia.

2. Research Design

   This research aims to determine the effect of the anthocyanin content of purple sweet potato extract and the essential oil content of kitchen lemongrass on the physical and pH-sensitive properties of the film produced and to determine the performance of the film made from pectin with the addition of anthocyanin purple sweet potato extract and essential oil of kitchen lemongrass as packaging. Smart to monitor the freshness of chicken fillet meat. Add purple sweet potato extract with a concentration of 0%, 10%, 20%, and essential oil 0 mL, 0.5 mL, and 1 mL to the film solution. Observe color changes, mechanical properties, pH-sensitive properties of the film, and biodegradability. Then, measure light transmission and opacity, film thickness, water content, and water vapor permeability. After that, apply a film to detect the level of freshness of the chicken fillet.

2.1. Anthocyanin Extraction (Kristijarti and Arlene, 2012)

Put 150 grams of purple sweet potato flour into a beaker and add 96% ethanol with a ratio of 1:3. After that, move and leave the sample for 24 hours at room temperature in a bottle. Filter the sample, the result of which is a filtrate, then put it into a rotary vacuum evaporator until the filtrate becomes concentrated. Put the filtrate obtained (extract) into a sample bottle and store it in the freezer at 4-6°C.

2.2. Delevopment of Pectin-Antosainin-Essential Films (Nuansa, et.al, 2017)

Four grams of pectin were dissolved in 200 ml of distilled water with rapid stirring at a temperature of 70°C using a magnetic stirrer. Then glycerol was added to the solution with a ratio of 1:0.25. After 1 hour, the film solution was cooled to a temperature of 40°C. Then purple sweet potato extract was added with a concentration of 0%, 10%, 20%, and essential oil 0 mL, 0.5 mL, 1 mL and stirred until homogeneous. The homogenized solution was allowed to stand to remove air bubbles. After that, the solution was poured directly into an acrylic mold measuring 18 cm x 18 cm and dried at 50°C for 24 hours using an oven. The film was dried at room temperature for 30 minutes.

2.3. Analysis Procedure

a. pH-Sensitive Properties of Anthocyanins in Purple Potato Extract (Marco, et.al, 2011)

A total of 3 drops of purple sweet potato extract was mixed with 7 mL of distilled water and 3 mL of pH 2-13 buffer solution. Monitor the color changes and look for the maximum wavelength between 500-700 nm.

b. Characteristics of Pectin-Anthocyanin-Essential Films Color

UV-vis spectrophotometer model ISR-2200 (Shimadzu Corporation, Japan) was used to determine the color parameters (L, a and b) of film. The objective color of the film sample and the background used are measured to determine the level of clarity of the film. ΔE value can be calculated using the equation:

$$\Delta E = \sqrt{(\Delta L *)^2 + (\Delta a *)^2 + (\Delta b *)^2} \quad (1)$$

With :

ΔE = Total of colour difference

ΔL* = L* sampel – L* standar

Δa* = a* sampel – a* standar

Δb* = b* sampel – b* standar

c. Light Transmittance and Opacity

The film's light transmittance as well as film's opacity were evaluated based on the method by Qin et al. (2019). A piece of the film was scanned using UV-vis spectrophotometer model ISR-2200 (Shimadzu Corporation, Japan) between 200 to 700 nm. The opacity of the film was then calculated based on Eq. (2).

$$Opacity = \frac{A}{x} \quad (2)$$

With :

A = Film absorption at wave length 600 nm

x = Film thickness (mm)

d. Film Thickness
The thickness of each film was measured by using Thickness Gauge Tester YG 1410 YG 1410/No.: 16182 (Cina), each at randomly chosen points.

e. Water Content (Darni and Utami, 2010)
In order to measure the moisture content, the film was dried at 105 °C until its weight remained constant. Equation (3) was then used to calculate the moisture content of the film:

$$\% \, Water\ content = \frac{W_0 - W_i}{W_0} \quad \text{...(3)}$$

With :
W_0 = initial weight of film (gram)
W_i = final weight of film (gram)

f. Water Vapor Permeability
With minor modifications, the gravimetric method of Ilyas et al. (2017) was used to determine the WVP of the film. Briefly, 30 g of dried silica gel were placed inside a test tube that was sealed with a film sample (10 cm x 10 cm). Afterwards, the test tube was kept in a desiccator filled with distilled water at room temperature. The tube was then weighed every 24 h for 7 days. The film's WVP was calculated using Equation (4).

$$WVP = \frac{\Delta W}{t \times A} \quad \text{...(4)}$$

Where :
WVP = Water Vapor Permeability
W = Increase in film weight (gram)
t = Time of analysis
A = Cross-sectional area of the test tube (m2)

g. Mechanical Properties
The mechanical characterization of the film sample was performed by measuring the tensile strength and elongation at break using Tenso Lab Machine. MESDAN LAB. S. p. a., Model Tenso. 300 type 168 E (Italy).

h. Analysis of the pH-Sensitive Properties of Pectin-Anthocyanin-Essential Films
The method by Wang et al. (2019) was used to measure the film's pH-sensitive property. A 2 cm x 2 cm film sample was submerged for one minute in various buffer solutions with pH values ranging from 2 to 13. Digital camera was then used to record the color changes of the film sample.

i. Application of Pectin-Anthocyanin-Essential Film to Detect the Freshness Level of Chicken Fillet Meat
Applying the pectin-anthocyanin-essential film to detect the freshness of chicken fillet meat by using the film sample as a cover on the top of a petri dish containing 30 grams of chicken fillet meat. Then, the petri dish was stored at room temperature 25 - 29°C for 48 hours. Color changes in the film samples were observed visually every 8 hours. 10 grams of chicken fillet homogenized in 100 mL of distilled water. The pH of the solution was measured every 8 hours using a digital pH meter.

j. Film Biodegradability
The method used for biodegradable Testing is the ASTM D5526-18 - a standard test for determining the anaerobic biodegradation of plastic materials under accelerated landfill conditions. Bury the film samples used with soil and leave

them until at least 70% of the film samples have decomposed by checking regularly.

RESULT AND DISCUSSION

1. Anthocyanin Extraction

   The yield of purple sweet potato extract obtained from this research was 15.78%. According to Wardaningrum et al. (2020), the yield of the resulting extract is good if the yield value exceeds 10%. Purple sweet potato extract is stored in a dark bottle to avoid sunlight because it can damage the anthocyanin content in purple sweet potato extract. To maintain the anthocyanin content, the extract is stored in a freezer at 4-6 °C.

2. Making Pectin-Anthocyanin-Essential Films

   Figure 1 (A) shows a film solution from a mixture of pectin, distilled water, and glycerol, where the solution is clear yellowish. Meanwhile, Figure 1 (B) shows the film solution by adding anthocyanin from purple sweet potato extract and purplish lemongrass essential oil

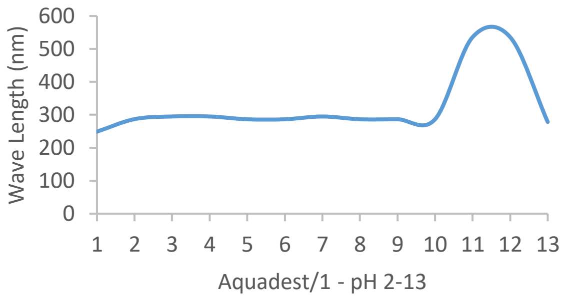
(A)

(B)

Figure 1 Solution of pectin (A), Solution of pectin-antosianin-essential oil (B)

3. pH-Sensitive Properties of Anthocyanins in Purple Potato Extract

   Figure 2 (A) shows the color change of purple sweet potato extract at a pH value of 2-13. Purple sweet potato extract at pH 2-3 is purple; at pH four, it is clear purplish; at pH 5-9, it is clear; at pH 10, it is clear bluish; at pH 11, it is blue; at pH 12, it is yellowish blue; and at pH 13 is yellow. Changes in the anthocyanin structure cause the change in anthocyanin color from purple sweet potato extract due to the pH value (Marco et al., 2011). Figure 2 (B) shows the results of the liquid wavelength obtained from a UV-Vis spectrophotometer from purple sweet potato extract in a pH 2-13 buffer solution.



(A) (B)

Figure 2. Changes in color of purple sweet potato extract at pH 2-13 (A), wavelength of aquadest and purple sweet potato extract solution at pH 2-13 (B)

At pH 2-10, the maximum absorbance of anthocyanins from purple sweet potato extract appears at wavelengths of 200 - 300 nm. This is proven in Figure 2 (A), with almost the same color range of pH 2-10. There was an increase in the absorbance intensity of purple sweet potato extract at pH 10-12 with a wavelength from 286.5 nm to 536 nm. It can be seen in Figure 2 (A) that the color produced at pH 10-12 is blue. The maximum absorbance of purple sweet potato extract drops again at pH 12-13 with a wavelength value of 278.5 nm, and the color changes to yellow.

4. Characteristics of Pectin-Anthocyanin-Essential Films

a. Color

In Figure 3, it can be seen that the pectin film (A1) is colorless. In contrast, the essential pectin-anthocyanin film (A2 and A3) is yellowish, the pectin-anthocyanin film (A4) is grayish, the important pectin-anthocyanin film (A5 and A6) is grayish, anthocyanin pectin films (A7) are brownish, and essential pectin-anthocyanin films (A8 and A9) are brownish. From Figure 3, it can be seen that the greater the concentration of anthocyanin added (A4-A5-A6; A7-A8-A9), the color of the resulting film tends to be brownish. However, all films are transparent. Meanwhile, the addition of lemongrass essential oil causes the color of the resulting film to become yellowish (A1-A2) because the essential oil used is yellow. Anthocyanin film, with the addition of essential oils, causes the film color to become darker.

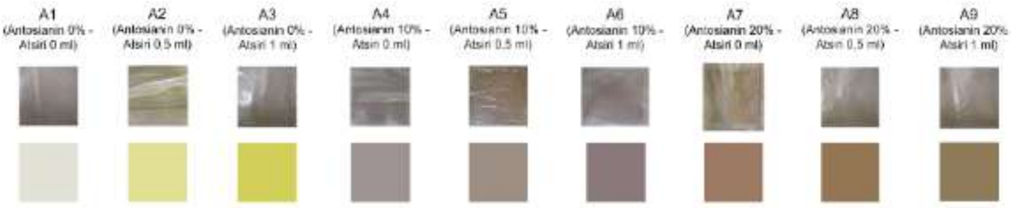


Figure 3. The color of pectin-antosianin-essential oil film

b. Light Transmittance and Opacity

Table 1 shows the color parameters of all films. It can be seen that the pectin-anthocyanin films (A4 and A7) show an increase in the values of a, b, and dE*ab but experience a decrease in the L value as the anthocyanin increases. The L value of all the films obtained is close to 100, indicating a light-colored film. In addition, the dE*ab value of the pectin-anthocyanin film increased with increasing anthocyanin content. This shows that the color of the film becomes more colorful. These results show that the anthocyanin level dramatically influences the color of the pectin-anthocyanin film.

Table 1. Parameter L, a, b dan dE*ab film pectin-antosianin-atsiri

Sample	Variation	L	a	b	dE*ab
A1	Extract 0%-Atsiri 0 ml	100,06	-0,21	1,04	1,85
A2	Extract 0%-Atsiri 0,5 ml	99,99	-0,22	0,98	1,88
A3	Extract 0%-Atsiri 1 ml	99,95	-0,14	1,20	2,02
A4	Extract10%-Atsiri 0 ml	99,33	0,30	1,27	2,59
A5	Extract 10%-Atsiri 0,5 ml	99,48	-0,18	1,96	2,84
A6	Extract 10%-Atsiri 1 ml	99,85	-0,17	2,02	2,61
A7	Extract 20%-Atsiri 0 ml	99,49	-0,11	1,70	2,67
A8	Extract 20%-Atsiri 0,5 ml	99,44	0,12	2,12	2,98
A9	Extract 20%-Atsiri 1 ml	99,09	-0,69	4,42	5,05

Table 2. Opacity Value of Pectin-Antosianin-Essential Oil Film

Sample	X (mm)	A (%)	Opacity
Plastik wrapping	0,088	0,0055	0,06
A1	0,077	0,0059	0,08
A2	0,2095	0,0244	0,12
A3	0,0975	0,1586	1,63
A4	0,138	0,4051	2,94
A5	0,152	0,0637	0,42
A6	0,1265	0,4911	3,88
A7	0,1335	0,1953	1,46
A8	0,2075	0,1285	0,62
A9	0,2305	0,1111	0,48

Opacity shows the transparency of the film. The opacity results on the film can be seen in Table 2. From this table, it can be seen that the opacity value of the film with the addition of anthocyanin from purple sweet potato extract (A5 and A8) has increased. This shows that adding anthocyanin from purple sweet potato extract can reduce the transparency of the film. The opacity value of pectin-essential films (A2 and A3) increased compared to pectin films (A1) with kitchen lemongrass essential oil. This proves that, like the addition of anthocyanin, the addition of lemongrass essential oil can also reduce the transparency of the film.

c. Film Thickness

Thickness is an important factor that influences the opacity, water vapor permeability, and tensile strength of films for packaging. As shown in Table 3, the film thickness values of the samples that have been made vary. It can be seen from these values that there is no significant difference in values with the addition of anthocyanins from purple sweet potato extract and kitchen lemongrass essential oil. Table 3 shows that the average value of the film thickness produced ranges from 0.07 – 0.23 mm. According to Skurtys et al. (2009), the resulting film qualifies as packaging material if it has a thickness of <0.250 mm. In this research, the thickness of the film produced meets the standards for film thickness so that the ability to protect the packaged material is better and the shelf life is longer.

Table 3. The Thickness of Pectin-Antosianin-Essential Oil Film

No	Sample	Thickness (mm)
1	Plastic wrapping	±0,088
2	A1	±0,077
3	A2	±0,2095
4	A3	±0,0975
5	A4	±0,138
6	A5	±0,152
7	A6	±0,1265
8	A7	±0,1335
9	A8	±0,2075
10	A9	±0,2305

d. Water Content

It was found that adding anthocyanin and lemongrass essential oil could affect the water content (%). The water content value in samples with added anthocyanins (A4-A5-A6; A7-A8-A9) was higher when compared to samples without added anthocyanins. The water content value in the sample with kitchen lemongrass essential oil decreased because it is a hydrophobic compound that cannot dissolve in water so that it can maintain the film structure. The water content in samples A1-A9 can be seen in Table 4.

Table 4. Water Content of Pectin-Antosianin-Essential Oil Film

Sample	% Water Content
A1	±20,588
A2	±19,643
A3	±16,667
A4	±21,354
A5	±20,833
A6	±19,853
A7	±33,333
A8	±28,750
A9	±25,000

e. Mechanical Properties

In film samples A1, A2, and A3, there was an increase in tensile strength values. This is because essential oil compounds that dissolve in water will strengthen the intermolecular bonds of the film, making the tensile strength of the film stronger. The elongation value with the addition of high anthocyanin concentrations from purple sweet potato extract and kitchen lemongrass essential oil caused a decrease in the anthocyanin-essential film compared to the film without anthocyanin and essential oil. The higher the essential oil concentration added, the more the elongation value will decrease (Nuansa et al., 2016). According to Amalia et al. (2016), adding anthocyanin from purple sweet potato extract causes a decrease in the tensile strength and elongation values, making the resulting film less elastic and easy to tear. The higher the concentration of anthocyanin added from natural dyes, the more compounds cannot be bound by the polymer, resulting in changes in the structure of the polymer network that are more heterogeneous. Based on our research results, the highest tensile strength (N) and elongation (%) values are in sample A5, with values of 14.225 N and 38.400%. The tensile strength value of this sample is still far from the SNI range for plastic mechanical properties. Darni and Utami (2010) said that the tensile strength value of plastic is between 24.7-302 MPa. Meanwhile, its elongation meets SNI for plastic mechanical properties, namely between 21-220%.

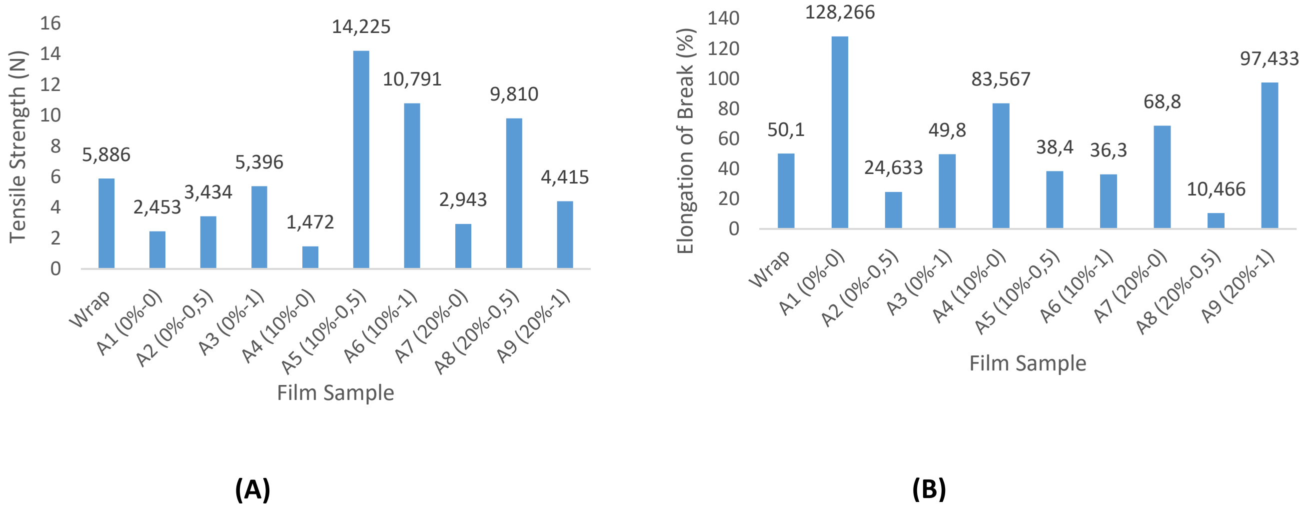


Figure 4. Tensile Stregth (A) and Elongation of Break (B)

f. pH-Sensitive Properties of Pectin-Anthocyanin-Essential Films

Figure 5 shows the color changes in the film with the addition of anthocyanin from purple sweet potato extract and lemongrass essential oil with a buffer solution of pH 2-13. Adding a buffer solution at an acidic pH causes the film color to change to purplish, while at an alkaline pH, the film color changes to yellowish. This is because the anthocyanin content in purple sweet potato extract provides a color pigment that can change color with certain pH conditions to be used as a pH indicator

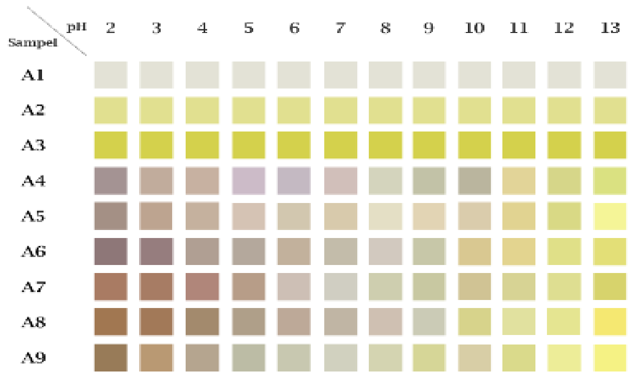


Figure 5. Color change of pectin-anthocyanin-volatile film

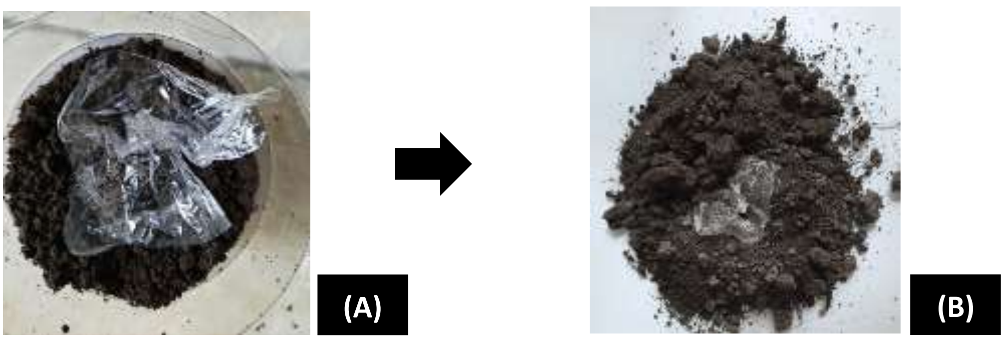
g. Application of Pectin-Anthocyanin-Essential Film to Detect the Freshness Level of Chicken Fillet Meat

Meat rots very quickly due to microbial contamination. Microbial contamination of meat can cause changes in the pH value. Considering the pH-sensitive nature of pectin-anthocyanin-volatile films, such film samples can be used as meat freshness monitors. Figure 6 shows the color change when the film is applied to chicken fillet meat. Fresh chicken fillet meat has a pH of 6.8, and there is a change in the pH value as its shelf life increases. When the first film test was carried out, there was no change in color on the film, but during subsequent tests, the film's color began to change as the pH value increased from alkaline to yellowish green. It can be seen in Figure 6 that the film samples with the addition of lemongrass essential oil increased in pH value less than those without the addition of kitchen lemongrass essential oil. This is because the ingredients contained in lemongrass essential oil have antimicrobial properties, so they can inhibit microbial growth and extend the product's storage life.

Figure 6 Color changes in the pectin-anthocyanin-volatile film to detect the level of freshness of chicken fillet meat

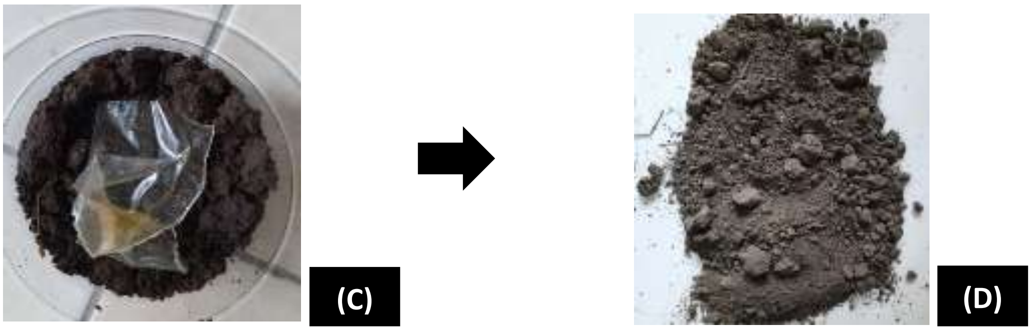
h. Film Biodegradability

The film containing natural ingredients, namely pectin with the addition of glycerol, can experience degradation of around 75% for 28 days. This follows the biodegradability criteria for plastic materials based on the ASTM D5526-18 standard. The standard states that a minimum of 70% of plastic material must biodegrade within 30 days or the duration of the procedure to be said to be biodegradable. This degradation process can occur due to chemical degradation through a molecular oxidation process to obtain a film with a low molecular weight and also occurs due to attack by microorganisms. In this research, films with pectin and glycerol have properties that can be decomposed or degraded more easily by soil compared to plastic made from synthetic materials.



Day – 0

Day – 30



Day – 0 Day – 30

Figure 7 Degradation of plastic wrapping, day-0 (A), day-30 (B), pectin-anthocyanin-atsiri day-0 (C), day-30 (D)

CONCLUSION

Anthocyanin levels from purple sweet potato extract and lemongrass essential oil greatly influence the physical properties of the pectin-anthocyanin-essential film. The anthocyanins contained in purple sweet potato extract affect the color of the film to become purplish. At the same time, the essential oil of kitchen lemongrass influences the color of the film to become yellowish. Purple sweet potato extract and lemongrass essential oil can increase the opacity value. The addition of anthocyanin from purple sweet potato extract and kitchen lemongrass essential oil does not have a significant effect on film thickness. The pectin-anthocyanin-essential oil film can be degraded, making it environmentally friendly (biodegradable). The pectin-anthocyanin-essential film can monitor the freshness of chicken fillet meat because it can change color at a certain pH. With the addition of lemongrass essential oil, which has antimicrobial properties, it can extend the shelf life of food. For further research related to intelligent packaging, polysaccharides, plasticizers, anthocyanin, and essential oil materials other than those used in this research for making edible films can be further developed and researched.

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