Effect of Dragon Fruit Skin Extract (Hylocereus costaricensis) on Bio-plastic Physical and Mechanical Properties of Cassava Starch and Polyvinyl Alcohol

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Abstract. This study aims to determine the effect of dragon fruit skin extract (Hylocereus costaricensis) to the bio-plastic characteristics of cassava starch and polyvinyl alcohol and to know the addition of the best dragon fruit skin extract (Hylocereus costaricensis). The treatment of this research is the addition of dragon fruit skin extract of 5%; 10%; 15%; 20%; and 25%. Observations on the resulting bio-plastic product are physical properties and mechanical properties. Physical properties test include thickness, density, water absorption and mechanical properties test including tensile strength test, percent elongation. The results showed that the difference of dragon fruit color extract concentration in bio-plastic has effect on thickness, density, water absorption, tensile strength, elongation percentage. The best treatment based on bio-plastic mechanical properties is on E treatment (addition of 20% dragon fruit skin extract).

Keywords: Bio-plastic, Color extract

1. Introduction

Plastics are produced primarily from petroleum which is the largest application of petroleum for fuel (Siracusa, Rocculi, Romani and Dalla, 2008; Shen, 2011) [1,2]. The manufacture of plastics that use oil as raw material causes environmental problems associated with waste, the use of non-renewable resources, and climate change (Shen, Haufe and Patel, 2009; Chadha, 2011). Bioplastics today are developing very rapidly as a solution to overcome the problem of non-degradable plastics. Bioplastics are a type of plastic that is used like conventional plastics such as polyethylene (PE) but is easy to decompose naturally by microorganisms (Firdaus, and Anshory, 2008) [3].

Bioplastics are a form of plastic derived from biological resources and biodegradable. Bioplastics can be used like conventional plastics, but will be destroyed by the activity of microorganisms into the end product of water and carbon dioxide gas after used up and discharged into the environment. Another advantage of bioplastics is that the raw materials used can be updated and the amount is abundant. Starch is one of the most widely used and promising ingredients in the bioplastics market due to biodegradability, availability, eco friendly and cheap (Sprajcar, Horvat and Krzan, 2013) [4].

Bioplastics can be developed by utilizing natural resources such as starch. Indonesia has a big potency to product bio-plastic which is made from huge starch resources (Fazira, Eliza 2014). Bioplastics are now widely used as packaging for various products. However there are two characteristics that influence the quality of bio-plastic namely mechanical and physical properties. The mechanical and physical properties are caused by additional material, such as plasticizers, stabilizers, dyes and antistatics. Putra (2017) [5] had carried out dye enhancer to study the mechanical properties of bio-plastic by added the dyes from leaf and fruit extracts of syzygium oleina.
Syzygium oleina is commonly used as ornamental plants that have periodical bloom unpredictable especially in red lead and fruit. Hence, it will be a difficult to used, its red leaf and fruit, as the dyes for bio-plastic ingredient. This study propose skin of dragon fruit (Hylocereus costaricensis) as the other ingredient for bio-plastic since this fruit is being cultivated in Indonesia, easy to find, has a similarity with syzygium oleina especially in anthocyanin pigment, and the more important the wasted of its skin. Therefore, anthocyanin pigment which is extracted from skin of dragon fruit was the main dyes to be studied, whether there is an effect anthocyanin pigment of its fruit on the physical and mechanical characteristics of bio-plastics.

2. Research Methods

2.1 Materials and Tools

Research material in the form of dragon fruit, cassava starch, PVA (polyvinyl alcohol), sorbitol, chitosan, water.

The equipment used are glass pyrex beaker, blender, thermometer, erlenmeyer, stirrer, scales, pyrex measuring cup, pyrex reaction tube, magnetic stirrer, hot plate, oven, 20 × 20cm glass mold, shear term, and drop pipette and Universal Testing Machine (UTM).

2.2 Research Design

The design used in this study is Explorative Method with 5 treatments and 3 replications. The treatment used was the addition of anthocyanin pigment extract of dragon fruit skin. The use of anthocyanin pigment extract of anthocyanin dragon fruit skin based on Putra's research (2017) [5] that the addition of dyes in bioplastics ranged from 5 to 25%.

2.3 Anthocyanin Pigment Extraction

Anthocyanin pigment extraction was carried out in several stages, namely, dragon fruit peel was sorted then continued with washing and draining. Weighed as much as 100 grams and then added a solvent (1: 1 = material: solvent). The solvent used is water. The next stage is maceration for 4 hours. Then blender and extract the color.

2.4 Bio-Plastic Film Making

Prepared 1 g starch and 3 g PVA. Dissolve 3 g PVA in distilled water according to the formulation into a beaker, and stirred with a magnetic stirrer while heated on a hot plate with a temperature of 80 °C until homogeneous. After homogeneous and added 1 g of starch while stirring again until gelatinized and add 1.5 g of sorbitol. Then added dragon fruit skin pigment extract. The alloys formed are allowed to stand for about 1 hour so that they are free of air bubbles and then printed on a glass plate with a size of 20 × 20 cm and dried in an oven at 45°C for 16 hours before leaving it to room temperature for 3 hours. After drying the film as a bio-plastic is released from the glass plate.

2.5 Testing Biodegradable Plastic Films

Observations made on this bioplastic film are in the form of thickness, density, water absorption, tensile strength, elongation analysis.

1. Thickness Measurement (ASTM 2005) [6]

The resulting smart packaging film was measured in thickness using a micrometer thickness gauge with an accuracy of 0.001 mm using a calipers. The thickness value is measured from the average of five measurements of the thickness of the smart packaging film.

2. Density

Density testing was carried out on a 5 × 5 cm test sample, the sample tested weighed and the dimensions measured were thicknesses at 5 different points. Calculation of density:
3. **Water Absorption (ASTM D570)**

The sample used is a 4x4 cm sheet. The previous sample was dried for 24 hours in an oven at 50°C, cooled in a desiccator and immediately weighed. Water absorption data was obtained by immersing the sample in water for 24 hours or more at 23°C. Then the sample is dried with a cloth and immediately weighed.

Percentage of water absorption can be calculated by equation:

\[
\text{Water Absorption (\%)} = \left(\frac{W - W_0}{W_0}\right) \times 100\%
\]

where:
- \(W_0\) = dry sample weight
- \(W\) = wet sample weight

4. **Tensile Strength (ASTM 2005) [6]**

The biodegradable plastic film to be analyzed is cut to a length of 50 mm and a width of 10 mm. After that, the specimen was clipped to a universal tensile test and pulled at a constant speed and a maximum load of 5 kgf. From the value obtained can be determined the amount of tensile strength by using the equation:

\[
\sigma = \frac{F_{\text{max}}}{A}
\]

where:
- \(\sigma\) = tensile strength (MPa)
- \(F_{\text{max}}\) = maximum voltage (N)
- \(A\) = area (mm²)

5. **Elongation (ASTM 2005)**

Elongation is measured by the equation:

\[
\%E = \frac{\Delta L}{L_0}
\]

where:
- \(\%E\) = elongation (%)
- \(\Delta L\) = length of specimen increase (mm)
- \(L_0\) = initial specimen length (mm)

3. **Result and Discussion**

3.1 **Thickness**

Thickness is one of the parameters to determine the characteristics of bioplastics that have been made. Thickness is an important parameter that influences the use of bioplastics in the formation of the product to be packaged. Bioplastic thickness will affect gas permeability. The thicker the bioplastic, the smaller the permeability of the gas and better protect the packaged product. Thickness can also affect the mechanical properties of other bioplastics, such as tensile strength and elongation. But in its use, the thickness of bioplastic must be adjusted to the product it packs (Kusumasmara, 2007) [7].

Bioplastic film thickness measurement results can be seen in Figure 1.
Figure 1. Thickness analysis results

From Figure 1. The results of bioplastic thickness measurements with dragon fruit skin dyes have a thickness ranging from 0.062 mm to 0.088 mm. Based on the results of these thickness measurements the addition of dyes from dragon fruit peel extract gives an effect on the thickness of bioplastics, that the higher the concentration of addition of dyes from extracts of dragon fruit skin color, the thicker the bioplastics produced.

It is suspected that the addition of coloring from dragon fruit peel extract in a certain amount will increase the total amount of solids in the solution so that the thickness of the bioplastic increases. This is consistent with the opinion of Nugroho et al., (2013) [8] which states that increasing the total of solids in solution results in more and more polymers that make up the bioplastic matrix. And also confirmed by Putra's research (2017) [5] that in his research the addition of leaf and fruit extracts syzygium oleina increased the thickness of the bioplastics produced.

3.2 Density

In general, the density is related to the physical properties of bioplastic films in terms of water absorption, gas and water permeability, thermal properties, and degree of crystallinity. The higher the density of bio-plastic, the greater the regularity of bio-plastic films. The density value of bioplastic films shows the ability of bioplastic films in protecting substances inside them from free air. Low density bioplastic films have a more open structure so that they are easily passed by small molecules. Bioplastic film density measurement results can be seen in Figure 2.

Figure 2. Density analysis results

From Figure 2 can be seen the results of the calculation of the density of bioplastics with dyes from dragon fruit peel extract has a density ranging from 0.202 g / cm3 to 0.144 g / cm3. Based on the results of this density measurement the addition of dyes from leaf extracts and fruit of red shoots gives
an effect on the density of bioplastics, that the higher the concentration of addition of dyes from extracts of dragon fruit peels, the smaller the density of bioplastics produced.

The results of this study are in line with Ratnasari's research (2014) [9] that in bioplastics increasing the concentration of limonene will reduce the weight of the type of bioplastics produced. And also confirmed by Putra's research (2017) [5] that in his research the addition of coloring extracts of leaves and fruit syzygium oleina reduced the density value of the bioplastics produced. This indicates that the addition of dyes of dragon fruit peel extract makes the biodegradable plastic order decrease because of the weaker polymer chain in the presence of dragon fruit peel extract. This facilitates the movement between molecules so that the order of biodegradable plastic decreases (Arrieta et al. 2013) [10].

3.3 Water Absorption

This test is carried out to determine the occurrence of bonding in the polymer and the level regularity of the bond in the polymer which is determined by the percentage addition of polymer weight after experiencing swelling. The process of diffusion of solvent molecules into the polymer will produce a bulging gel. The properties of bioplastic resistance to water are determined by swelling test, which is the percentage of bioplastic film swelling by the presence of water (Al Ummah, 2013) [11]. The results of the measurement of the water absorption capacity of bioplastic with dyes from leaf extracts and fruit from red shoots can be seen in Fig 3.

![Water absorption analysis results](image)

**Figure 3.** Water absorption analysis results

In Figure 3, it can be seen that the calculation of bio-plastic and dye absorption of water from leaf extracts of red shoots has a water absorption capacity of 34.22% to 80.18%. Based on the results of measurements of water absorption, the addition of dyes from dragon fruit peel extract gives an effect on the absorption capacity of bio-plastic, that the higher the concentration of addition of dyes from extracts of dragon fruit peels, the greater the water absorption capacity of the bio-plastics produced.

The thickness of edible films is also directly proportional to the water absorption capacity, the thicker the product, the greater the absorption of water (Setiani, et al., 2013) [12]. Then in this study cassava starch was also added, where cassava starch contains more amylopectin which has many branches. This branching causes the inter-chain bond in amylopectin to break easily. With the more amorphous nature of amylopectin, there is a lot of empty space so that the mass density between chains in the starch is not too large and the absorption of the water is large enough so that the water resistance is low.

3.4 Tensile Strength

Testing the plastic mechanical properties related to the plastic application in everyday life. This test aims to see the effect of the pigment component and sorbitol concentration on the mechanical
properties of plastic produced. Generally plastic will experience a decrease in mechanical properties when added starch. Testing of mechanical properties includes analysis of the value of tensile strength and elongation value in accordance with ASTM D-638.

According to Stevens (2007) [13], tensile strength is a measure of the amount of load or force that can be held before a sample is broken or broken. Tensile strength is measured by pulling the polymer in a uniform dimension. The results of the tensile strength of bioplastic films can be seen in Figure 4.

From Figure 4, it can be seen that the calculation of the bioplastics tensile strength with dye from dragon fruit peel has a tensile strength ranging from 8.30Mpa to 9.8Mpa. Based on the results of this tensile strength measurement the addition of dyes from dragon fruit peel extract gives an effect on bioplastic tensile strength, that the higher the concentration of addition of dyes from extracts of dragon fruit peels, the greater the tensile strength of the produced bioplastics.

This result is directly proportional to the thickness value that is produced, namely the thickness of the bioplastic which increases so as to increase the value of its tensile strength. This is because there will be more and more hydrogen interactions found in bioplastics so that the bonds between chains will be stronger and harder to break because they require a lot of energy to break the bond Coniwanti, et. al., 2014 [14]. The results of the study by Setiani, et al., (2013) [12], also showed that the more chitosan added, the tensile strength values tended to increase.

### 3.5 Elongation

Elongation is the change in the length of the sample produced by a certain stretch of specimen length due to the force applied. The extension of the break determines the elasticity of a plastic. The higher the extension value is broken, the plastic becomes more elastic so that the material can be stretched more flexible. Plastics with a low breaking length will be fragile Shah, A. et. al., (2008) [15]. The results of the measurement of the extension of the break can be seen in Figure 5.

![Figure 4. Tensile strength analysis results](image)

![Figure 5. Elongation analysis result](image)
From Figure 5, it can be seen from the results of the calculation of percent bioplastic display with dyes from dragon fruit peel extract has a percent elongation ranging from 35.24% to 3.55%. Based on the measurement results of this percentage increase, the addition of dyes from dragon fruit peel extract gives an effect on the percentage of bioplastic elongation, that the higher the concentration of addition of dyes from dragon fruit peel extract, the lower the percent value of bioplastic elongation produced.

But the measurement results of the percentage of elongation are inversely proportional to the tensile strength. The more extracts of dragon fruit skin color added to the bioplastic film, the elongation will decrease but the tensile strength will increase. This decrease in elasticity is caused by the decreasing intermolecular bond distance, because the saturation point has been exceeded so that excessive plastic molecules are in a separate phase outside the polymer phase and will reduce the intermolecular force between the chains, causing the chain movement to be freer so that flexibility increases (more elastic). Coniwanti, et. al., 2014 [14].

4. Conclusion

Based on the results of the study it can be concluded that the addition of extracts of dragon fruit skin color (Hylocereus costaricensis) affects the physical and mechanical characteristics of the produced bio-plastics. The best physical and mechanical characteristics based on tensile strength values were in treatment E with the addition of 25% extract of dragon fruit skin color with a value of 0.088 mm thickness, density 0.144 g / cm3, water absorption capacity of 80.18%, tensile strength of 9.85Mpa and elongation 3.55%.

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