Bioplastic from Jackfruit Seeds and Rice

Retno A.S. Lestari¹,², Mega Kasmiyatun¹,², Kevin Dermawan¹, Alfia N. Aini¹, Nur Riyati¹, Finka R. Putri¹

¹Chemical Engineering Department, University of 17 Agustus 1945 Semarang, Central Java, Indonesia
²Study Center of Environmental and Alternative Energy, University of 17 Agustus 1945 Semarang, Central Java, Indonesia

retnotengaran@gmail.com

Abstract. This study tried to explore characterization of biodegradable plastic from jackfruit seeds and rice waste. Jackfruit seeds and rice waste contain starch, so it can be used for plastic material with addition of several additives such as polyvinyl alcohol (PVA), glycerol, chitosan and sorbitol. Starch is one of polysaccharides that be used as raw material for biofilms. Polyvinyl alcohol is the most important plastic in making water-soluble films. It was ability to form films, emulsifiers, and its adhesive properties. Polyvinyl alcohol has high tensile strength, good flexibility, and good oxygen barrier. Sorbitol and glycerol are also an additive in the manufacture of biodegradable plastics from starch, which is a plasticizer that increase elasticity. Chitosan have effects to bioplastic, such as biodegradable, hydrophilicity, and anti bacterial. This research aims to determine the effect of addition of PVA, glycerol, chitosan and sorbitol to optimum characteristics of bioplastic. The parameters to be examined bioplastic include thickness, moisture content, tensile strength, and % elongation. Increasing of glycerol added to the plastic material effect to decrease of tensile strength of bioplastic and elongation, lower water resistance and more easily degraded. Increasing of chitosan added to the plastic material effect to higher tensile strength, lower elongation, higher resistance to water and lower degradation. Increasing of PVA added to the plastic material effect to increasing of the tensile strength of the bioplastic and decreasing of elongation of bioplastic, but the increasing of sorbitol effect to decreasing of tensile strength and increasing of elongation of bioplastic.

1. Introduction
Plastic is packaging that relatively strong, lightweight, and has a low price. This packaging has a role in holding and protecting food [1]. The packaging used by manufacturers to package their products is polymers of petroleum. Most of these products are used for packaging of disposable products. Waste of this packaging is largely discharged into the environment, thus affecting water quality and the environment [2]. The use of plastic materials has caused negative impacts on the environment, landscape, and human health [3,4]. For this reason, it is necessary to find a solution to overcome this problem, by using packaging materials that can decompose quickly.
Substitution of plastic materials with biodegradable plastic produced from natural polymers as the main material is an alternative to reduce the impact of environmental damage [5]. Reducing environmental impacts by using biodegradable polymers in the food industry is an alternative to removing packaging from petroleum [6,7]. Reducing environmental impacts by using biodegradable polymers in the food industry is an alternative solution [8]. This material can be used to reduce and resolve environmental pollution. Natural polymers using natural ingredients such as starch, chitosan, cellulose, proteins, and enzymes obtained from nature [9]. The degradation time of packaging which produced from starch material was shorter than other polymeric materials such as poly (lactic acid) (PLA) or poly (butylene adipate-co-terephthalate) (PBAT) [10]. The faster time to degradation of packaging at the landfill effect to reduce of the volume of waste to be compacted. A reduction in degradation time, a significant reduction in waste volume will certainly be very beneficial for the environment.

However, biodegradable polymers have lower physical properties, strength, and process capability compared to polymers from petroleum [11]. To overcome the disadvantages of applying natural polymer-based materials that can be degraded, various methods such as a mixture of natural polymers and polymers derived from petroleum, the addition of functional plasticizers, and the use of chemical agents have been tried to increase tensile strength, extension properties, waterproof properties and the application [12].

2. Methods
2.1. Materials
Waste of rice and jackfruit seeds as a bioplastic base material were obtained from restaurants and traditional markets. The plasticiser such as acetic acid, chitosan, glycerol, poly vinyl alcohol (PVA), sorbitol were obtained from Chemical store in Semarang, Central Java, Indonesia.

2.2. The Equipment of Research
The equipment of research include: beaker glass, blenders, porcelain cups, stirring rods, electric heater, thermometers, filter cloths, ovens, incubators, molds, basins, porcelain spoons, plastic spoons bioplastic molding tools from glass sheets.

Rice waste from restaurants were cleaned from other leftovers and then mashed using a blender until the texture like powder. The powder of rice waste and plasticizer materials and solvent were mixing in beaker glass by stirrer and heated at 50-60 °C for 30 minute. Furthermore, the mixing of materials bioplastic was mold on sheet glass molding. While jackfruit seeds obtained from the traditional market at Semarang, Central Java, Indonesia were removed from the skin of the arrows and then washed. Furthermore, the jackfruit seeds which have been cut thinly crushed using a blender until smooth and the texture like powder

3. Results and discussion
3.1. Tensile Strength Test
Based on the results of the tensile strength test of plastic made from rice waste with the addition of chitosan and glycerol obtained the results shown in Figure 2. Figure 2 shows that the greater of the glycerol added to the plastic material, the plastic yield has a lower tensile strength, this is because glycerol functions as a plasticizer that can reduce intermolecular strength, so that the more amount of glycerol added causes the plastic tensile strength descend.
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Figure 2. Effect of Glycerol to tensile strength of bioplastic from Rice Waste

While the effect of chitosan addition on tensile strength of bioplastic can be seen in Figure 3, which appears when chitosan is added 30%, tensile strength of bioplastic is still low or close to zero, when chitosan increases to 50% and 55%, tensile strength of bioplastic reaches up to 31.8 MPa. But when the chitosan increases to 60 percent, the tensile strength of bioplastics reduced to 3.33 MPa. The increased tensile strength of bioplastics when the percentage of chitosan increased due to the increase of hydrogen bonds in the plastic when the percentage of chitosan ascend. Increased hydrogen bonding in the plastic causes the plastic film be stronger and harder to break (Katili, 2013).

Figure 3. Effect of Chitosan to tensile strength of bioplastic from Rice Waste

For bioplastic made from jackfruit seeds with sorbitol plasticizer and the addition of poly vinyl alcohol (PVA), the effect of adding these ingredients to jackfruit seeds get the results of bioplastic with a strong tensile strength as follows (Figure 4). In Figure 4 shows the lowest tensile strength is obtained from the addition of PVA as much as 0 gr and 0 ml of sorbitol that is tensile strength of 0 MPa, while the highest tensile strength is obtained from the addition of PVA as much as 3 gr and 2 ml of sorbitol which is 2.2 MPa. The effect of the addition of PVA on the tensile strength value shows the greater the PVA, so the higher tensile strength possessed by bioplastics too. This is because PVA can form film forming from bioplastics, and strengthen hydrogen bonds formed among bioplastic polymer chains. While the effect of the addition of sorbitol volume on Tensile Strength value shows that the more volume of sorbitol, the tensile strength value is lower. This is caused by the addition of the volume of sorbitol which will reduce the tensile strength between polymers during water evaporation which results in decreased resistance to mechanical treatment of plastics. According to Lieberman and Gilbert (1973), plasticizers can change the physical characteristic of plastics by reducing cohesion and mechanical resistance of polymer chains.
3.2. Elongation Test

Based on the elongation test results on plastics made from rice waste with the addition of chitosan and glycerol, the results obtained as in Figure 5 and Figure 6. Based on Figure 5, it appears the greater of glycerol added to the plastic material, get the yield of plastics which has higher elongation, it’s caused by glycerol functions as a plasticizer which increasing the flexibility of the plastic. Besides the addition of glycerol can impoverish hydrogen bonds, so the distance among the biopolymer molecules becomes tenuous. The state of strain among biopolymer molecules increase the flexibility of plastic samples.

As shown in Figure 6, it appears the greater the% of chitosan added to plastic manufacturing materials, take the bioplastics which have a lower elongation percentage. This is because the addition of chitosan as an additive will close the distance among the stretching biopolymer molecules. The decrease in the distance among degradable plastic biopolymer molecules caused by the saturation point being exceeded so that the excess plasticizing molecules are in a separate phase outside of the polymer phase and will decrease intermolecular forces between chains (Laila, 2014).
In Figure 7, it shows the lowest % of elongation value is obtained from the addition of 0 gr PVA and 0 ml of sorbitol with the value of % elongation is 0%, while for the highest % of elongation value obtained from the addition of 1 gr PVA and 6 ml sorbitol with % elongation of 6.8%.

The effect of adding PVA to the % elongation value appears the more PVA added, the lower of the % elongation produced. This is because PVA can reduce the plasticity or flexibility of the plastic due to the strengthening of the hydrogen bonds in the formed polymer. While the effect of increasing the volume of sorbitol on the % elongation value shows the more volume of sorbitol, the % elongation is the higher. This is caused by the addition of the volume of sorbitol causing a decrease in intermolecular forces, as a result the level of mobility among molecular chains increase and results in OH groups will form intermolecular bonds with polymer chains reduce.

The interaction between PVA and Sorbitol was seen in the value of tensile strength and the % elongation. In outline, increasing the amount of PVA that is more, can increase the value of tensile strength but reduce the value of the % elongation, conversely increasing the amount of sorbitol can increase the value of the % elongation and reduce the value of tensile strength of bioplastics.

3.3. Bioplastic Resistance to Water -Test

Based on Figure 8, it appears that the higher levels of glycerol added to the bioplastic mixture get the results of bioplastics which have lower water absorption. This is due to the increase in the amount of glycerol in bioplastics so that more hydroxyl groups of glycerol in bioplastics in order to increase the absorption of water by bioplastics. Glycerol as a plasticizer will increase the flexibility of the plastic. With the increase in glycerol, will create free volume in bioplastics, so that it will increase the gap in bioplastics to be occupied by water molecules.
The effect of the addition of chitosan to the resistance of bioplastics to water can be seen from Figure 9, which illustrates that the greater chitosan added to bioplastics causes the resistance of bioplastics to water also increases.

For bioplastic made from jackfruit seeds, the effect of the addition of sorbitol and PVA to the bioplastic water content can be seen in Figure 10. In Figure 10, it can be seen that the lowest water content in bioplastic is obtained from the addition of PVA of 0 gr and sorbitol 0 ml that is water content of 0.3%, while the highest water content is obtained from the addition of PVA of 3 grams and 6 ml of sorbitol, which water content is 2.39%. From this appears the more amount of PVA is added, the more water is absorbed by bioplastic particles because PVA can bind water and make a film forming on bioplastics and inhibit the evaporation of water from bioplastics. Besides increasing the amount of sorbitol as a plasticizer essence which is increasing also increases the volume of water contained in bioplastics because sorbitol has a function as a humectant that can bind water and also has hydrophilic characteristic so that during the drying process, water is hard to evaporate. Bioplastics with low water level will get quality better because the less water level is obtained, the bioplastics will be more difficult to be damaged by microbes. This bioplastic water level shows the resistance of bioplastic in absorbing water, thus the more water level also shows the low resistance of bioplastic in absorbing water. Thus it can be said that the more the amount of PVA, so, the resistance of bioplastic in absorbing water will be lower because PVA can bind water and make a film forming on bioplastics and inhibit the evaporation of water from bioplastics. Likewise, the increase of the amount of sorbitol added to the bioplastic mixture from jackfruit seeds also decrease the resistance of bioplastics in absorbing water. Because sorbitol has a function as a humectant that can bind water and also has hydrophilic characteristic so that during the drying process, water is hard to evaporate.
3.4. Bioplastic FT-IR Characteristics Test

The characteristics of FTIR on bioplastic from rice waste based on FTIR images (Figure 11) generated several wave peaks in each vulnerable region. In region I (range from 4000 - 2,500) there are peaks with wave numbers 3448.72 cm$^{-1}$ and 2924.09 cm$^{-1}$. The peak corresponds to the absorption caused by C-H bonds (alkane compounds type), O-H (phenol compound types (hydrogen bond alcohol)) and N-H (amine compound types (amines)). In region II (range from 2,500 - 2,000) there is a peak with a wave number of 2368.59 cm$^{-1}$. The peak corresponds to the absorption caused by the triple bonds C=C (type of alkyne compound) bond. In region III (range from 2,000 - 1,500) there is a peak with wave number 1635.64 cm$^{-1}$. The peak is in accordance with the absorption caused by the C = O bond (type of aldehyde compound, ketone, carboxylic acid, ester) and C=C (type of alkene compound). In region IV (stretches of space of 1,500 - 400), there are many peaks with wave numbers from 1095.57 cm$^{-1}$ to 354.90 cm$^{-1}$. The peak corresponds to absorption caused by C-O bonds (type of alcohol compound, carboxylic acid, ester). Biodegradable plastic from the rice waste and chitosan with glycerol as plasticizer, and acetic acid as a catalyst, has a functional cluster that is a combination of specific functional groups that have constituent components such as CH, OH, NH, C≡C, C = O, and C=C, and also have amide and ester functional groups in biodegradable plastic film samples, so that plastic from the rice waste can be degraded and can be said to be green-plastic.

3.5. Bioplastic Degradation Test

Bioplastic degradation test is done by Soil burial test which is planting biodegradable plastics in the soil for 14 days, the results obtained as in Figure 12. Figure 12 shows the higher glycerol levels added to the bioplastic material, the bioplastic is obtained with the greater percentage of degradation. This is due to the higher levels of glycerol in bioplastics causing high absorption of water by bioplastics, because glycerol is hydrophilic in order to accelerate the rate of water absorption which making easier
for bacteria to decompose plastic samples further. and/or tables must be included in the results of the research. Article must be a research results. Therefore, figures and/or tables must be included in the results of the research. Article must be a research results. Therefore, figures and/or tables must be included in the results of the research.

Figure 12. %Biodegradation of Bioplastic from Rice Waste

4. Conclusion
1. Biomass derived from rice and jackfruit seeds waste can be made into bioplastics.
2. The greater glycerol added to the plastic material, giving bioplastic results which have lower tensile strength, higher elongation, lower water resistance and degraded more easily.
3. The greater chitosan added to the plastic material, giving bioplastic results which have higher tensile strength, lower elongation, higher water resistance and lower degradation.
4. The addition of the amount of PVA affects in tensile value raising but reduces the produced % elongation of the bioplastics and the resistance of bioplastic in absorbing water.
5. The addition of the amount of sorbitol increases % elongation, but decreases the tensile strength value of the bioplastics produced, and decreases the resistance of bioplastic in absorbing water.
6. The result of bioplastic products meet SNI standards, with a tensile strength of 49.87 MPa obtained in the addition of 10% glycerol of the weight of rice waste and 50% of the weight of rice waste. This bioplastic has 32.18% degradation percentage in 14 days.

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