

Preliminary Investigation of Bioplastics from Durian Seed Starch Recovery Using PEG 400 for Reducing Marine Debris

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ABSTRACT

Plastic is a source of pollution both on land and sea that can disrupt balance of the ecosystem. The characteristic of plastic as a material is difficult to decompose causing problems for environment. Various research needed to produce bioplastics that easily biodegradable in about 60 days. Biodegradable plastics are made from organic materials in the form of starch. Durian seed starch is one of the potential raw materials that can be used as bioplastics. Durian fruit is one of the typical fruits in Indonesia, at present seeds of durian had not been used as raw materials to produce object with economic values. It is necessary to combine the processing of durian seeds through a recovery approach in the form of processing into bioplastics. The aim of study is to analyze the effect of adding PEG 400 as a plasticizer plus calcium carbonate as a solidifier. Tests were carried out on swelling ability, acid and base resistance, tensile strength and biodegradation. The variation of the addition of PEG 400 is 4%; 30%; 50% and 70% were carried out to analyze the effect of different concentrations of plasticizers. None of the tensile test results met SNI 7188-11:2018 but all variations had biodegradation values according to SNI 7188-11:2018. Swelling test resulted from 4% and 30% are 1.2% and 2.1% respectively.

Keywords: bioplastics, durian, seed, PEG, intact.

INTRODUCTION

Non-biodegradable plastics (NBP) released to marine environment potentially harmfulness to inhabitants and cause damage. At present, around 7.8–8.2 million tons of plastics waste enter the oceans every year (Sari et al., 2021). NBP is the biggest part as source of marine debris. Indonesia has generated the amount of plastic waste is growing at unsustainable levels. The accumulation of plastic waste from waterways and coastlines is harming food system and human health. Fishing industry is under threat from increasing levels of marine debris. Plastic waste leaking into oceans could increase to

780,000 tonnes per year if no action is taken by Indonesia. Plastic is one of the valued materials with key role in economy, Indonesia generates around 6.8 million tonnes of plastic waste each year. It is growing by 5% annually. The projection showed growing of plastic waste flow into water bodies is growing by 30% between 2017 and 2025 (World Economic Forum, 2020).

Bioplastic is a potential alternative in accordance with environmental sustainability. Synthetic plastic produced by irreversible process causing an environmental burden, microorganisms have not taken apart to degrade petroleum-derived polymers. The energy consumption of bioplastic production is lower than petroleum

polymer, potentially to solve global warming problems (Gironi and Piemonte, 2011)

Due to environmental concerns, replacement conventional plastics with bioplastics became high priority. Plastic based on petroleum can be substituted by using bio-based polymers in order to minimize environmental risk. Green technology conducted using chemistry methodology are able to extract natural polymers, cellulose from vegetable waste. (Moura et al., 2017). Bioplastic can be molded from crop waste, plants, waste from processing fruit, among others, starch, proteins and cellulose are some of the examples as natural polymers materials (Moura et al., 2017; Jara et al., 2018)

Among the polymers, starch is abundant, harmless, low cost most and cheaper when comparing with protein, gelatin, poly lactic acid (PLA) and chitosan (Huntrakul et al., 2020-4; Muller et al., 2017; Montero et al., 2017; Chen et al., 2019). Starch is biodegradable and has favorable thermoplastic properties. Polysaccharides is plentiful macromolecules in fauna, is suitable raw material for bioplastics in the form of starch (Imre & Pukánszky, 2013).

At present, biodegradable plastics from starch have been examined by using banana pile starch, rice starch, corn starch (Shafqat et al., 2021; Zoungranan et al., 2020), potato starch (Beevi et al., 2020), cassava starch (Maulida et al., 2016; Wahyuningtiyas & Suryanto, 2017, Zoungranan et al., 2020; Huntrakul et al., 2020), jackfruit seed starch (Santana et al., 2018; Wahidin et al., 2021; Retnowati et al., 2015; Lubis et al., 2016), avocado seed starch (Ginting et al., 2018), durian seed starch (Wahidin et al., 2021; Retnowati et al., 2015; Ginting et al., 2016).

Starch has limitations in its application as bioplastics raw material such strength and stiffness usually large, low impact resistance and sensitivity to water. The limitations are generally overcome by plasticization as one of the modification approaches (Imre & Pukánszky, 2013). Plasticization usually use in modification of raw material to improve processability, to increase deformability through exchange intermolecular bonds to bonds between macromolecules and small molecular weight compound (Bibber et al., 1999). Plasticizer used to destroy crystalline structure of native starch in melt processing as gelatinization (Li & Huneault, 2011). The plasticizers widely used in bioplastics manufacturing such as glycerol, water, urea, sorbitol and formamide (Shafqat et al., 2021; Wilpiszewska & Spychaj, 2011).

Durian is one of the typical Indonesian fruits, is produced more than 1 million per year (Statistics Indonesia, 2020). At present, seed durian has not been managed optimally, disposed of as solid waste. Otherwise, seed durian has been reported have a high enough starch content around 42.1% (Baraheng & Karrila, 2019), can be considered as suitable raw material for bioplastics. Bioplastic research using durian seed starch reported by Wahidin et al., 2021 using glycerol as plasticizer, has resulted edible film which transparency is not required. Durian seed starch used as raw material and glycerol have been used explored resulting biodegradable time approximately 2–4 weeks (Rozikhin et al., 2020; Irhamni et al., 2014; Retnowati et al., 2015; Jannah et al., 2021). Other plasticizer, polyethylene glycol (PEG) has good solubility in water, stronger, thicker and can increase the value of strain on bioplastic. PEG has several advantages such as non-toxic, odorless, not irritating and not evaporating easily (Syamsu et al., 2007; Rohman, 2016). The usage of PEG400 as plasticizer have been explored with raw material of bioplastic from cassava starch (Syamsu et al., 2007); carrageenan waste (Maulana et al., 2021); palm fruit (Sitompul & Zubaedah, 2017); jackfruit seed starch (Anas et al., 2016, Santana et al., 2017). The previous research to explore PEG as plasticizer have been widely examine, but application in using durian seed starch has not been investigated so far. It would be a new addition to enrichment in bioplastics from durian seed starch. This research focused on the preparation of extraction starch from durian seed by addition PEG 400 as plasticizer and calcium carbonate. The aim of study is to investigate the quality of bioplastic from durian seed starch by considering the effect of PEG 400 addition. This research was also conducted to identify the potential application of seed durian starch resulting in a research database for designing and manufacturing biodegradable plastics through recovery of waste material.

MATERIALS AND METHODS

Materials

This research was conducted using waste from processing of durian from local community. Seed durian collected from home industry processing durian become juice, cake and snacks. Seed durian was peeled and washed before sliced

and mashed become slurry. Starch was extracted from durian seed slurry by decanting and drying. Molding made of glass with dimensions of 200×200 mm. PEG 400 as plasticizer was food grade otherwise calcium hydroxide, sodium hydroxide, sulphate acid and calcium carbonate were used analytical grade.

This experiment carried out in laboratory scale using slightly modified procedures as outlined below: (a) washed durian seeds (b) peeled the seed coat and sliced (c) soaked the slice seeds with $\text{Ca}(\text{OH})_2$ for about 3 hours (d) washed the seed until clean (e) soaked the slice seeds with $\text{Ca}(\text{OH})_2$ for about 3 hours again (f) washed until free from mucus (g) grinded the seeds in 1:10 ratio weight with water (h) precipitated starch that has mashed (i) disposed water, drying starch sediment during 3 days in sun (depending the weather) (j) refined dry starch completely and sieved mashed starch in 100 mesh (k) 5 g dry starch added by 0.2; 2.14; 5 and 11.67 ml PEG (according research variation 4%, 30%, 50%, and 70%, respectively) and 1.5 g calcium carbonate; (l) heated in 80 °C and stirred until thickened (m) molded in bioplastic molding, wait until dry.

Soil burial method used for biodegradability test conducted by burying bioplastics sample in dry soil during 15 days (Yaradodi et al., 2016; Marichelvam et al., 2019) observed the decreased of weight. Swelling test investigated water sorption capacity of bioplastic sample was soaked with deionized water at room temperature during 30 minutes. Swelling percentage was calculated based on difference between the weight sample bioplastic after and before soaking (Gonzalez and Igarzabal, 2013). Tensile strength test was conducted according to ASTM D638 for examining bioplastics sample mechanical properties (Jannah et al., 2021).

RESULTS AND DISCUSSION

Visualization of bioplastics

Figure 1 showed visualization of bioplastics manufacturing from starch durian, the color was slightly brown and smells like durian. Represent bioplastic with PEG addition variation was (a) 4%, (b) 30%, (c) 50% and (d) 70%. Figure 1a captured bioplastics could be removed from mold, was more intact form compared to bioplastics produced in other variations. The usage of PEG 4% producing bioplastics with physical properties are not rigid, not easily broken but not elastic. In the research variations using 30% PEG addition (Figure 1b), bioplastics produced were in the form of small part, not intact, not rigid and have no elasticity but still could be removed from mold. On the other hand, bioplastics manufacturing using 50% (Figure 1c) and 70% (Figure 1d) PEG addition could not be removed from mold, forming slurry as raw material before molding if picked up. Figure 1 captured physical condition of bioplastic manufacturing from durian seed with PEG addition. The higher concentration of PEG addition, weaker bioplastics physical condition, for further research needed to conduct in order to determine precise PEG addition concentration.

Biodegradation tests

Bioplastic biodegradability represented bioplastic can be degraded biologically easily with no environmental damage. Bioplastic investigation was buried in soil, had role as a nitrogen and carbon source for microorganism growth. Microorganism consumed bioplastic as its food and increase biomass (Natalie et al., 2008). Based on the result of bioplastic manufacturing, biodegradation test only conducted

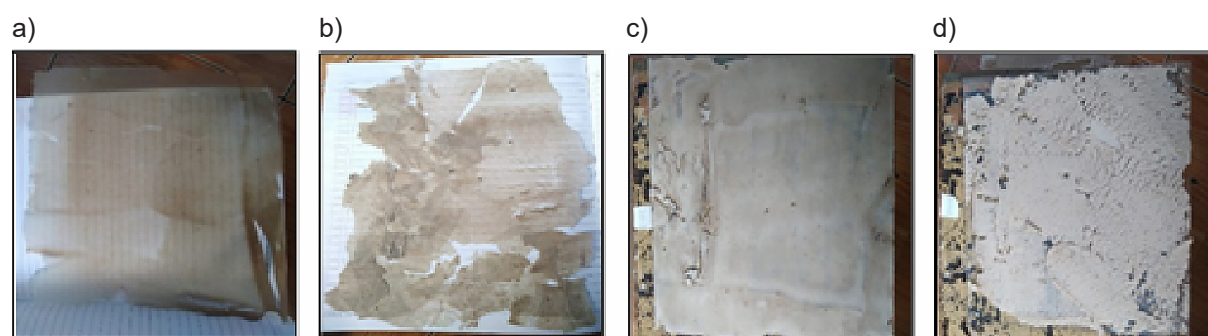


Figure 1. Visualization of bioplastics from durian starch with PEG addition: (a) 4%, (b) 30%, (c) 50% and (d) 70%

in two variations of PEG 400 addition (4% and 30%). The two other variations could not be removed from molding. The results of the biodegradation test reported that addition of 4% and 30% PEG was 42% and 40%, respectively.

Comparing with Indonesia standard regarding bioplastic in SNI 7188-11:2018, stated that percentable biodegradation value was less than 60% in a week, the result of bioplastics from durian starch was appropriate with bioplastic quality standard. PEG addition in durian seed starch will bind moisture in the air causing bioplastic easily adsorb water in soil. Swelling durian bioplastic becomes increase causing more easily broken into fragment as well as easily degraded by microorganism like fungi or bacteria in soil (Lu et al., 2009). The hydroxyl (O-H) contains in bioplastic made from starch-based, due to hydrolysis after absorbing water from compost and increased nature decomposition (Wahyuningtyas and Suryanto, 2018).

Swelling test

Swelling test conducted due to investigate swelling behavior of bioplastic was emerged in water. The observation could be conducted within two variation research 4% and 30% PEG addition. The result shown percentable swelling by calculated weight differences between after and before emerging in water. Bioplastic made from durian seed starch by 4% and 30% PEG addition resulting 1.2% and 2.1% respectively.

Tensile test

The examination of mechanical testing only conducted with bioplastic sample manufactured by 4% PEG addition. Tensile test could be carried out on intact bioplastic condition with size in accordance with test requirement conditions. The tensile strength value was achieved at 1.2 ± 0.2 MPa, was not appropriate with SNI standards (24.7–30.2 MPa) for plastic packaging.

Usage PEG as plasticizer with durian seed starch resulted various physical condition of bioplastic. Three of the research variation showed that bioplastic was not intact, two of them was able to remove from molding. The role of PEG had made fusion in production using chemical polymerization. Chemical polymerization can occur regardless of the raw materials origin, as opposed to natural fermentation that can only take place by the

utilization of renewable feedstock (Endres et al., 2017; Karamanlioglu et al., 2017; Kartika et al., 2018). Based on the investigation of this research, higher PEG concentration resulted more melted as slurry. The research variation using PEG addition 50% and 70% could be investigated more detailed. Saeful et al. (2018) reported an optimum bioplastics composition was investigated to be 5% (w/w) plasticizer. PEG as a commonly plasticizer, can act as a lubricant during processing (Seggiani et al., 2015). However plasticizer net effects of physical changes could be hard to predict, sometimes resulting low strength bioplastic (Hubbe et al., 2021). Future research needed to examine the compatibility of PEG with durian seed starch and its concentration to be added precisely.

CONCLUSIONS

In conclusion, the study showed that durian seed starch can be recovered as a promising bioplastic in the plastic advancement. PEG also can be utilized as plasticizer with calcium carbonate addition to manufacture biodegradable plastics. Furthermore, future research is needed to determine the precise concentration of PEG in order to develop intact plastic form environmentally friendly bioplastics due to its environmental benefits.

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