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# Preparation of Bioplastics from Pineapple Peel Nata and Rice Washing Water

Sani*, Amanah Nur Febrianti, Dwika Mahtris Nandani Putri, Dwi Hery Astuti

Chemical Engineering Study Program, Faculty of Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia

*Corresponding author:
E-mail:
sani.tk@upnjatim.ac.id

ABSTRACT

Bioplastics are plastics made from natural materials such as starch, seeds, and tubers, then added cellulose such as nata. Bioplastics are easily degraded by microorganisms or moisture. Pineapple peel is a part of pineapple fruit that has been underutilized so it ends up as waste. The high carbohydrate content in pineapple fruit skin can potentially be used as raw material for making nata, with the addition of rice washing water which contains carbohydrates, starch, vitamin B1, vitamin B6, and vitamin B3 which can be utilized by microorganisms as a medium for making nata. The resulting nata is used as raw material for making bioplastics because the cellulose content in nata is quite high. The results of the analysis of cellulose content in the nata produced amounted to 42.78%. This study aims to make bioplastics from pineapple peel nata and rice washing water that meet the Japanesse Industrial Standard (JIS). The method of making bioplastics used is the solution casting method. The variables used in making this bioplastic are 15 grams of nata, plus 3.5 grams of chitosan with 500 rpm stirring for 10 minutes at 70 °C with the addition of glycerol variations of 2; 2.5; 3; 3.5, and 4% and variations of CMC ingredients 4; 6; 8; 10 and 12%. From the results of the study, the best results of bioplastics, namely the tensile strength value of 0.51 MPa, elongation of 71.49%, water resistance of 55.61%, and biodegradation of 35.81%, were obtained in the addition of CMC 8% and glycerol added 3.5%. The results of the bioplastic SEM test obtained a very tight and fairly flat bioplastic structure. In addition, the FTIR test found that bioplastics have 5 peaks where the 5 peaks represent the forming functional groups of bioplastics such as O-H functional groups.

*Keywords: Bioplastic, nata, CMC, glycerol*

## Introduction

Pineapple fruit waste is part of the pineapple fruit such as pineapple skin that is wasted during the processing process. Generally, pineapple fruit waste in the industry is not utilized anymore and is disposed of as raw waste and left to accumulate. If left unchecked, this will pollute the environment. The carbohydrate and sugar content of pineapple fruit peel is quite high so it can be used as a substrate for the growth of nata-forming bacteria (Wardhana, 2009). In addition, nata can also be made from rice-washing water. Rice-washing water is waste that comes from the rice washing process. This waste is generally thrown away, while the content of carbohydrates, starch, protein, vitamin B1, vitamin B6, and vitamin B3 in rice washing water can be utilized by microorganisms as a medium for making nata (Syamsu et al., 2015). The resulting nata can be utilized for bioplastic materials because the cellulose content in nata is quite high. Plastic is the most widely used type of packaging because it is considered more practical and cheap. However, plastic can cause environmental pollution due to the nature of plastic that is difficult to decompose, causing plastic waste to continue to increase. To deal with this problem, people need to switch from using conventional plastics that are not easily decomposed to

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bioplastics that are easily decomposed. Bioplastics can be made from cellulose (nata), and starch (tubers and seeds) which are easily decomposed by weather such as sunlight and humidity, or decomposed by microorganisms (Nazir, 2020).

The process of making bioplastics requires supporting materials such as chitosan, glycerol, and CMC. Chitosan is a linear polysaccharide such as 1,4-N-acetylglucosamine made from chitin which is abundant in seafood waste and affordable (Mujtaba et al., 2019). The anti-bacterial properties, hydrophilicity, and biodegradability of chitosan are beneficial. Biodegradability is that it can be broken down by living microorganisms. The process of biodegradation into non-toxic is the function of chitosan. Hydrophilicity is a property of chitosan that can bind to water. Chitosan also has the properties of reactive components, binders, absorbents, stabilizers, film formers, and clarifiers (Selpiana et al., 2016). Glycerol is a simple glyceride compound, colorless, odorless, and viscous liquid. Glycerol has three hydroxyl groups that are hydrophilic and hygroscopic. Various types of lipids have glycerol as one of their components, such as triglycerides (Pratiwi & Sinaga, 2017). Glycerol is always used to modify the mechanical properties of bioplastics. Glycerol is often used for plasticizers in hydrophilic films (pectin, starch, gels, and modified starch) and bioplastics (Juliyarsi et al., 2011). Carboxymethyl cellulose (CMC) has an important and useful role as an emulsifier, suspender, and binder in the drug manufacturing process. And CMC is a derivative of cellulose. CMC is widely used in many industrial fields such as textiles, medicine, food, electrical elements, and papermaking. The addition of CMC to bioplastics affects water absorption, as a stabilizing agent and increases tensile strength. The higher the addition of CMC, the greater the tensile strength of the bioplastics produced (Ningsih et al., 2019).

**Material and Methods**

***Preparation of Nata De Pina***

Rice washing water is filtered, take 1000 ml, and add 500 grams of pineapple peel. Then mashed and filtered. Filtrate was taken 1000 ml, sterilized heated at 100$^{o}$C for ± 15 minutes. After 10 minutes of heating, 10% sugar 0.5% urea, and acetic acid are added until pH 4. If foam forms, it is removed. The filtrate is closed and allowed to cool (temperature ± 30$^{o}$C). Prepare a container that has been sterilized. filtrate poured on the container and add aceto bacteria xylinum starter as much as 10%. The container is closed using baking paper and then pierced. Set aside and fermentation lasted for 10 days at room temperature.

Figure 1. Nata de Pina

***Preparation of bioplastics***

Making Solution 1: dissolve 3.5 grams of chitosan with 1% acetic acid as much as 50 ml.

Making Solution 2: heat 50 ml of distilled water at 100$^{o}$C add 4% CMC stir until completely dissolved.

Making Solution 3: grind 15 grams of nata by adding 100 ml of distilled water. put it in a beaker glass. Mix solution 1 and solution 2 into solution 3 in a glass beaker, and add glycerol with a concentration of 2% or according to the variables then heat to a temperature of 70$^{o}$C and stir at 500rpm for 10 minutes. Then the mixture is poured on the printing flattened and then dried at room temperature for 4 - 5 days. The results of bioplastic sheets were tested for tensile strength, elongation, water resistance, biodegradation, SEM, and FTIR. Making Solution 1: dissolve 3.5 grams of chitosan with 50 ml of 1% acetic acid.

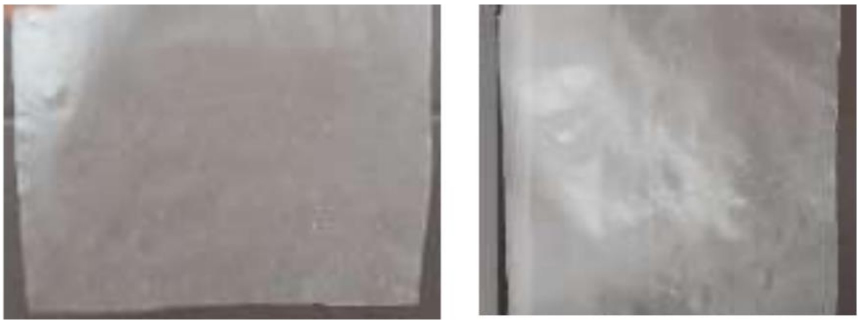

Figure 2. Bioplastik dari Nata De Pina

**Results and Discussion**

***Raw material analysis***

The results of the analysis of cellulose content in the Nutrition Laboratory of the Faculty of Public Health, Universitas Airlangga, on nata from the pineapple fruit peel and rice washing water, are 42.78%, this cellulose content is greater than the results of Fatimah's research (2020), namely the cellulose content in nata produced by 42.51%.

***Tensile strength test analysis of bioplastics***

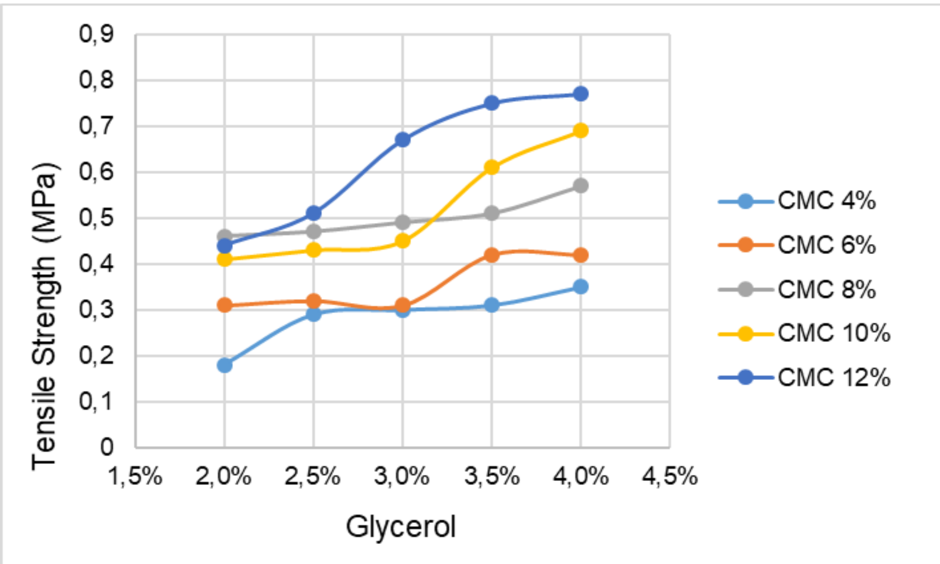


Figure 3. Relationship of bioplastic tensile strength analysis results (MPa) with various glycerol concentration additions and CMC concentration variations

The results of the bioplastic tensile strength analysis described in Figure 3 state that the greater the addition of glycerol concentration, the greater the tensile strength value of bioplastics until the addition of 3.5% glycerol concentration, but between the addition of 3.5 - 4% glycerol concentration, the increase in the tensile strength value of bioplastics is less significant. Likewise, the greater the CMC added, the value of bioplastic tensile strength will increase. The addition of glycerol according to theory causes the tensile strength value of bioplastics to decrease because the addition of glycerol can reduce the intermolecular strength of bioplastics between polymer chains and increase the flexibility of bioplastics. The addition of CMC causes the number of polymers that make up the bioplastic matrix to be thicker and the force needed to break the bioplastics is also greater so that the tensile strength value is also greater. In this study, the addition of glycerol and CMC simultaneously made bioplastics have greater flexibility and tensile strength. This is by research conducted by Ningsih et al. (2019) which states that the tensile strength value of bioplastics tends to increase along with the increase in CMC concentration. The highest tensile strength value of bioplastics is 0.77 Mpa, this result is obtained by adding 12% CMC and adding 4% glycerol. According to the Japanese Industrial Standard (JIS 2- 1707) the tensile strength value of bioplastics is at least 0.3923 MPa.

***Elongation analysis of bioplastics***

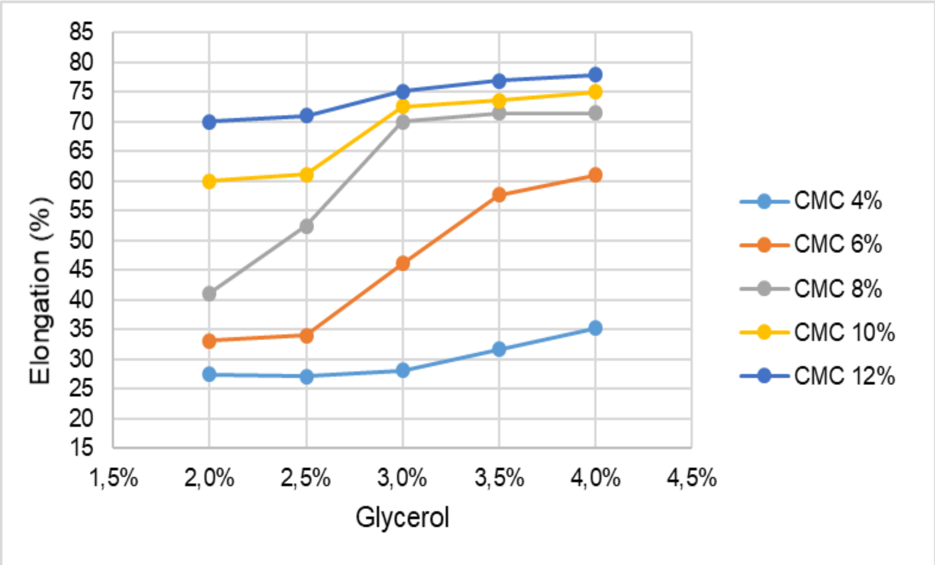


Figure 4. Relationship of bioplastic elongation analysis results (%) with various additions of glycerol concentration and CMC concentration variations

Figure 4 shows that the addition of glycerol increases the elongation value of bioplastics. The addition of glycerol will increase the molecular mobility of the polymer chain due to the branching bond so that the bioplastic is more elastic and the elongation at break tends to increase. In addition, the elongation value tends to increase along with the addition of CMC concentration. The use of CMC in larger amounts will increase the ability to bind water better so that the gel matrix can increase the percent elongation of bioplastics. This is by the results of Ningsih et al. 's research (2019) which states that the increase in elongation value is due to CMC having a high gel strength. This is also reinforced by Purnavita et al.'s research (2020) which states that the addition of glycerol tends to increase the elongation of bioplastics, due to the nature of glycerol as a plasticizer, which increases the flexibility of bioplastics.

Based on the results obtained, the highest elongation value is 77.96%, this result is obtained from the addition of 12% CMC concentration and 4% glycerol. According to the Japanese Industrial Standard (JIS 2-1707) the elongation value of bioplastics is at least 70%.

### *Water resistance analysis of bioplastics*

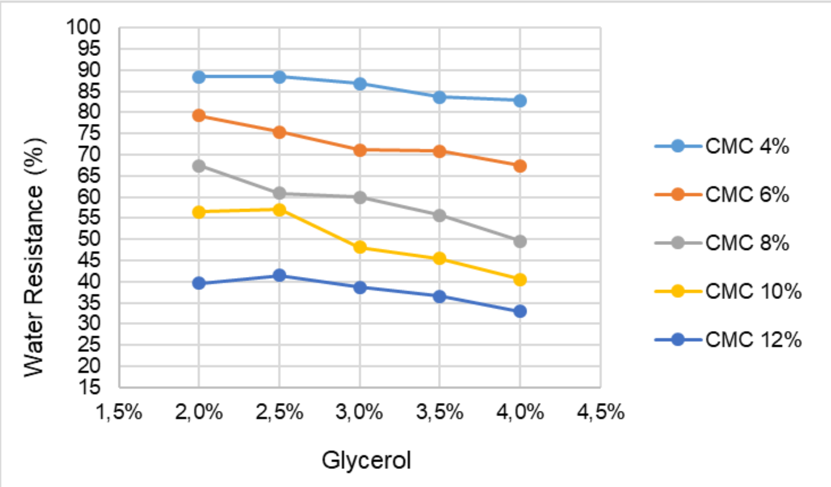


Figure 5. Relationship of bioplastic water resistance analysis results (%) with various glycerol concentration additions and CMC concentration variations

Figure 5 shows that the addition of glycerol concentration turns the results of water resistance analysis decreased but less significantly. Glycerol which is hydrophilic makes water easily enter the bioplastic matrix so that the absorbed water does not decrease causing bioplastics to be easily damaged. This is by the research of Rifaldi and Bahruddin (2017) which states that the value of water resistance is getting lower as the concentration of glycerol increases. The addition of CMC causes the water resistance value to decrease. The hydrophilic nature of CMC makes bioplastics easily absorb water so that the water resistance decreases. This is by research conducted by Ningsih (2019), which states that the more CMC is added, the value of water resistance in bioplastics decreases.

Based on the results obtained, the highest water resistance value is 88.46%, this result is obtained by adding 4% CMC concentration and 2% glycerol. According to the Japanese Industrial Standard (JIS 2-1707) the value of bioplastic water resistance is at least 50%.

### *Biodegradation analysis of bioplastics*

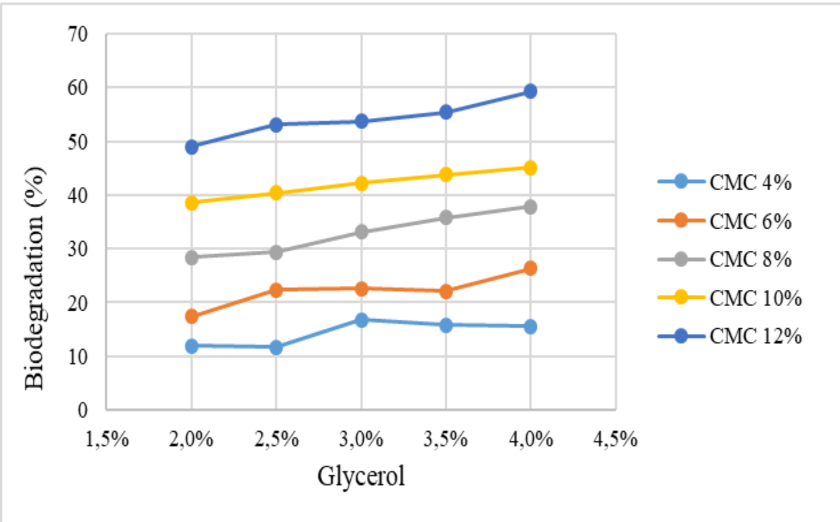


Figure 6. Relationship of bioplastic biodegradation analysis results (%) with various additions of glycerol concentration and CMC concentration variations

Figure 6 shows that as the addition of glycerol concentration increases, the percent degradation will increase. The increase in biodegradation value tends to be stable at each addition of glycerol concentration. This increase occurs due to the presence of water diffusing into bioplastics because the glycerol used is hydrophilic. In addition, the increase in biodegradation value tends to be stable at each addition of CMC concentration. The increase in biodegradation value is due to the hydrophilic nature of CMC, causing high water absorption so that bioplastics are more easily damaged and decomposed, making it easier for microorganisms to accelerate the degradation process. This is by the research of Indriani et al. (2023) where the percent degradation of bioplastics increases with the addition of CMC and glycerol concentrations. The results obtained the highest biodegradation value of 59.32% was obtained with the addition of 12% CMC concentration and 4% glycerol. According to the Japanese Industrial Standard (JIS 2-1707), the biodegradation value of bioplastics is <60% for 7 days.

The results of the study obtained bioplastics that meet the Japanese Industrial Standard (JIS), namely the addition of a CMC concentration of 8% and glycerol variations of 3% - 3.5%. The results obtained a tensile strength value of 0.51-0.57 MPa, an elongation value of 70.01- 71.49%, a water resistance value of 55.65-59.93%, and a biodegradation value of 33.16-35.81% where it is by Japanesse Industrial Standart (JIS 2-1707). The best results of the analysis were then carried out SEM and FTIR tests, to determine the surface structure and functional groups of bioplastics.

***SEM analysis of bioplastics***

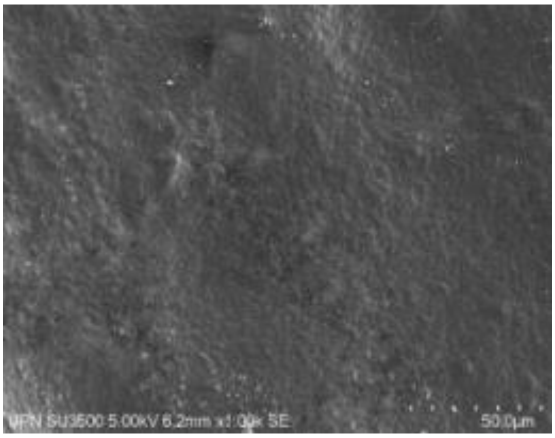

Figure 7. SEM results of bioplastics

Figure 7 is the visual appearance of the bioplastic surface at a concentration of CMC 8% and glycerol 3.5%. The results of SEM (Scanning Electron Microscopy) analysis on bioplastics with a magnification of 1000 times show that the bioplastics produced are quite good. In the picture, it can be seen that the surface of the bioplastic is quite flat and there are no cracks in the bioplastic. Bioplastic particles bind to each other and the bioplastic structure is very tight. CMC acts as a filler to increase the density value of bioplastics, as well as an evenly distributed (homogeneous) stirring process.

***FTIR analysis of bioplastics***

The results of FTIR testing are shown in Figure 8 that bioplastics have wavelength values similar to the constituent raw materials, namely wavelengths of 690-900 cm-1 showing the C-H functional groups of cellulose, glycerol, and CMC. Peaks appear at wavelengths of 1050-1300 cm-1 indicating C-O functional groups of cellulose and glycerol. The peak at 2850- 2970cm-1 indicates the C-H functional group of cellulose, glycerol, and CMC. The peak at the wavelength of 3500-3650 cm-1 indicates the presence of O-H functional groups indicating cellulose, glycerol, and CMC functional groups. From all the cluster identification results, it show the functional groups of bioplastics. This is to Hayati et al. 's research (2020) where the process of making bioplastics is a mixing process only so that it matches the constituent functional groups.

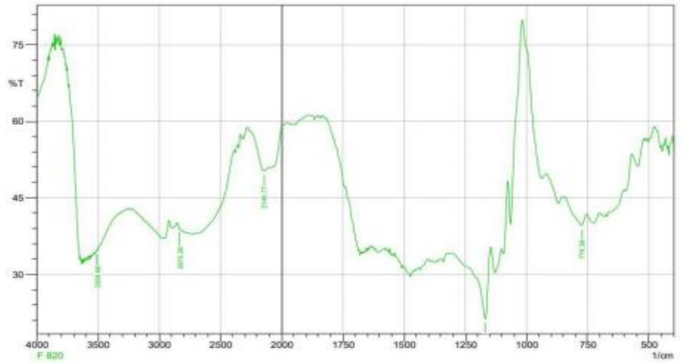


Figure 8. FTIR bioplastics

## Conclusion

Based on the research that has been done, it can be concluded that the addition of CMC concentration and glycerol variations affects the characteristics of bioplastics, which results in increased flexibility and tensile strength. The bioplastics produced have met the Japanesse Industrial Standart (JIS) including the value of tensile strength, elongation, water resistance, and biodegradation, where a tensile strength value of 0.51-0.57 MPa was obtained, an elongation value of 70.01-71.49%, a water resistance value of 55.65-59.93%, a biodegradation value of 33.16-35.81% obtained in the addition of 8% CMC concentration with 3% - 3.5% glycerol variation.

## Suggestion

As for further research, we recommend using different raw materials to obtain better bioplastics.

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