Research Article

Physicomechanical Properties of Edible Film-based Nata de Coco, Acetic Acid, and Chitosan

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Abstract.
In recent years, edible films are on the rise as they have a wide variety of advantages, including the use of edible packaging materials over synthetic films. Edible films are environmentally friendly and do not cause environmental pollution. Several researchers have conducted studies on materials for making edible wraps, one of which comes from cellulosic sources. One source of cellulose from food is nata de coco. In this research, edible films based on nata de coco and chitosan were made by mixing and molding methods. The results of the tensile strength test of samples with a variety of 20 mL acetic acid showed a value of 17.805 MPa. This value meets the bioplastic standard (10–100 MPa) and the Indonesian National Standard (SNI) for conventional plastic (24–302 MPa).

Keywords: edible film, nata de coco, chitosan, physicomechanical properties

1. INTRODUCTION

Nowadays, plastic is an important material used in various areas of our daily lives, such as automotive, agriculture, health, construction, packaging and textiles [1-4]. They are manufactured in different sizes and shapes according to their function. Since most waste is single-use waste, a large proportion of plastic is lost every year, accounting for 54% of total anthropogenic waste worldwide [5]. Global plastic production has increased over the years, reaching 335 million tons in 2016 [4]. Plastic packaging is a very popular type of packaging and is one of the packages that many business people choose. With the high demand for plastic, the amount of plastic waste is increasing. Because plastic has low degradation properties, it is the biggest source of environmental damage. Much research has been carried out to find more environmentally friendly substitutes for plastic, including bioplastics. Several researchers have conducted research on materials intended for bioplastic production, including cellulose [6]. One product that contains cellulose compounds is Nata de Coco. The aim of this research is to develop bioplastics from Nata de Coco raw materials. Nata de coco which is produced from the fermentation of Acetobacter xylinum bacteria in coconut water can be used as raw material for bioplastics because it contains cellulose compounds so it is called biocellulose [7]. However, based on observations made in several nata de coco industries, the use of nata de coco is currently still limited to food ingredients. Studies regarding the wider use of Nata have not been widely studied by researchers. Our previous research made bioplastic from a mixture of nata de coco and chitosan. We claim that this material is an edible material [8]. A study of the physic and mechanical (physicomechanical) properties related to edible films made from nata de coco and chitosan has never been carried out.

2. METHODOLOGY/ MATERIALS

2.1. Nata de coco preparation

The process of making Nata de Coco begins with the fermentation of the old coconut water, i.e. leaving it to stand for 4 to 7 days. The coconut water is then brought to a boil in a stainless steel pot. Boiling old coconut water remains heated for ± 15 minutes, filtering out impurities. Then dissolve the other ingredients (acetic acid, urea and sugar) in the freshly removed coconut water, stirring at 60 revolutions. Once all other ingredients have dissolved, the solution can be used as a growing medium for nata cultivation by pouring 1 liter into the bowl. Then immediately cover the solution with newspaper and tie the sides of the dish with rubber. Then let it rest for a night and then add the Acetobacter xylinum seeds to the tank at a rate of 10% of the coconut water volume in the tank. Keep the tray in a place away from bumps and touches until the nata forms. On days 7 to 14 the nata is ready to harvest.

2.2. Sample preparation

The steps in the plastic packaging sample manufacturing process start with cleaning the nata by first washing it under running water, boiling it to a boiling point and soaking it for 24 hours. The general production phase includes producing plastic packaging film samples using Nata de Coco as raw material and other additional materials using mixing and casting methods, then drying the samples. The mixing method involves mixing the ingredients with a hot plate stirrer or magnetic stirrer. The casting process is now solution casting. Nata de Coco was crushed in a blender then weighed with a mass of 16 grams. Then boil acetic acid at a temperature of 70°C on a hot plate, add 0.2 grams of chitosan after boiling and stir with a magnetic stirrer until homogeneous. Once the chitosan has dissolved, add the smoothed nata de coco, then lower the temperature to 50°C and cook for 15 minutes, stirring with the mixer. Make variations with 15 mL, 20 mL and 25 mL acetic acid compositions. Finally, print the sheet by pouring the mixture into the tray and distributing it evenly then dry.

2.3. Sample Characterization

The physical and mechanical properties of the resulting samples were tested by measuring grammage, thickness and tensile strength. The principle used in grammage testing is by weighing a sample measuring 10 cm x 10 cm, the weight in grams/100cm^2 will be obtained which is then multiplied by 100 to obtain the basic weight in g/m^2. The experiment was carried out several times and then the average basic weight was calculated. Meanwhile, for thickness testing, the principle used in thickness testing is to place a sample sheet measuring 10 cm x 10 cm between the two surfaces of the micrometer tool, the thickness of the sample can be read directly on the scale indicated by the tool. The experiment was carried out several times and then the average thickness was calculated. For tensile strength testing, a tensile machine testing tool was used at the Chemical and Packaging Center in Jakarta Indonesia.

3. RESULTS AND DISCUSSIONS

The main ingredient in making edible film samples is nata de coco. Nata de Coco is obtained through fermentation by the bacterium Acetobacter xylium in coconut water. Old coconut water as a raw material for this process is stored covered for 4 days, then boiled and other ingredients such as acetic acid, urea, sugar and Acetobacter xylinum seeds are added. Rahmayanti et al. [8] stated that after more than seven days of incubation, coconut water forms a gel on its surface due to the activity of Acetobacter xylinum bacteria with nutrients (coconut water or crystallized sugar). This gel then becomes Nata. Once the finished nata is neutralized or sterilized, it is washed under running water and cooked until boiling and then soaked for one night until the resulting pH is 7. The general production step includes the preparation of leaf samples using Nata de Coco raw materials and also other additional materials. Using the mix and pour method and then drying the sample. The results of the composition optimization observations were also carried out in the production of edible films. In this study, the mass of acetic acid as an additional ingredient varied between 15 mL, 20 mL and 25 mL, while the mass of nata de coco and chitosan used remained at 16 grams and 0.2 grams. When viewed directly, all samples produced have a plastic-like appearance. The sample with a variation of 15 mL of acetic acid shows a uniform visual result, transparent, odorless but fragile. Meanwhile, the 20 mL and 25 mL variants of acetic acid showed a stronger sample when collected. However, the sample with the 25 mL acetic acid variant had a strong sour smell. This occurred due to the high acetic acid content in the mixture during sample preparation.

In this study, grammage was measured using an analytical balance. For comparison, the three types of plastic commonly used on the market (plastic A, plastic B and plastic C) were also tested. The results of the weight test are shown in Table 1. The samples tested for grammage were only samples with variations of 15 mL and 20 mL acetic acid, while 25 mL was not tested. The results of testing the basis weight of the samples with variations of 15 mL of acetic acid gave a basis weight of 29.6 g/m^2, which means that each m^2 has a basis weight of 29.6 grams. The sample weight with an acetic acid variation of 20 mL gave higher results, namely 30.1 g/m^2. These results show that the weight is almost the same as that of plastic packaging available on the market, namely Plastic A.

The thickness test on the sample is measured with a micrometer. For comparison, thickness tests were also carried out on the three types of plastic commonly available on the market (plastic A, plastic B and plastic C). The results of the thickness tests are shown in Table 1. The only samples tested for thickness were samples with variations of 15 mL and 20 mL of acetic acid, while 25 mL was not tested. The test results of the sample thickness with acetic acid variation of 15 mL showed a thickness of 25.8 microns, while the sample thickness with acetic acid variation of 20 mL showed a higher result, 27.1 microns. These results show a thickness of 27.8 microns, which is almost the same as that of packaging plastic (Plastic A) available on the market.

The results of the tensile strength characterization of edible film samples made with the composition of 16 grams of nata de coco, 0.2 grams of chitosan and 20 ml of acetic acid are shown in Table 2. We carried out tests on 7 edible film samples with this composition. Tensile strength is the most important indication for measuring the strength of a material. The table shows that the average tensile strength value is 169.59 kgf/cm^2; 201.40 kgf/cm^2; 170.42 kgf/cm^2; 172.06 kgf/cm^2; 188.48 kgf/cm^2; 181.02 kgf/cm^2;

Table 1: The Result of Characterization of Physical Properties.

Sample	Grammage (g/m^2)	Thickness (micron)
Various Acetic Acid 15 mL	29.6	25.8
Various Acetic Acid 20 mL	30.1	27.1
Plastic A	31.8	27.8
Plastic B	46.2	30.1
Plastic C	37.4	29.3

187.94 kgf/cm^2 with an average value obtained of 181.56 kgf/cm^2 or around 17,805 MPa. This value meets the bioplastic standard (10 - 100 MPa) [9] and the Indonesian National Standard (SNI) for conventional plastic (24 - 302 MPa) [9]. We also obtained elongation values for edible film samples which are shown in Table 2. The table shows that the average tensile strength values are 7.85%; 7.85%; 7.66%; 7.99%; 7.86%; 8.08%; 8.49% with an average score obtained of 7.97%.

Table 2: The Result of Characterization of Mechanical Properties.

Test	Tensile strength (kgf/cm^2)	Elongation (%)
1	169.59	7.85
2	201.40	7.85
3	170.42	7.66
4	172.06	7.99
5	188.48	7.86
6	181.02	8.08
7	187.94	8.49
Average	181.56	7.97

Figure 1 shows a graph of the tensile strength of an edible film sample made with the composition of 16 grams of nata de coco, 0.2 grams of chitosan and 20 ml of acetic acid. Based on the tensile strength test results, Young's modulus can be estimated. The tensile strength test measurement graph shows the elongation line at break which determines the elastic strength of a material.

4. CONCLUSION AND RECOMMENDATION

Edible film has been successfully made with a mass composition of 16 grams of nata de coco, 0.2 grams of chitosan and varying volumes of acetic acid, namely 15 ml, 20 ml and 25 ml. If observed directly, all the samples produced show a visual appearance

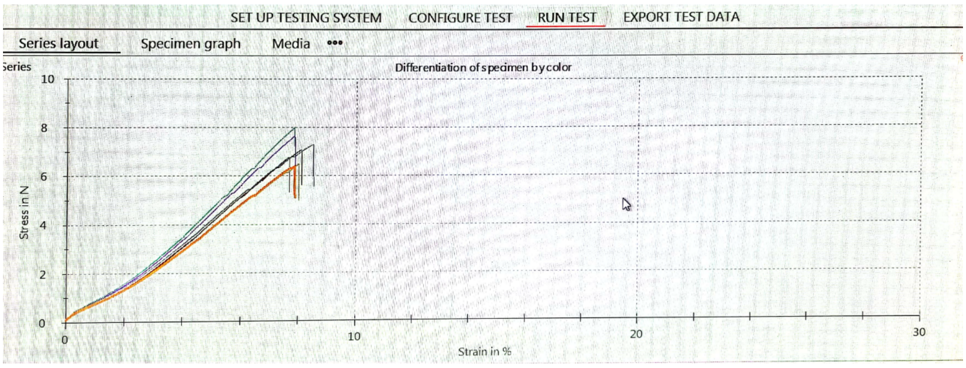

Figure 1: Stress vs strain curve of edible film samples.

like plastic. The sample with a variation of 15 ml of acetic acid showed a visual that was even, transparent, odorless but fragile. Meanwhile, the 20 ml and 25 ml variations of acetic acid showed a stronger sample when drawn. However, the sample with the 25 ml acetic acid variation showed a strong sour odor. The sample grammage with a 20 ml acetic acid variation showed a result of 30.1 gr/m2. This result is almost the same as the plastic packaging on the market, namely plastic A. The results of testing the thickness of the sample with a variation of 20 ml acetic acid showed a thicker result, namely 27.1 microns. These results show a weight that is almost the same as plastic packaging on the market (plastic A) of 27.8 microns. The results of the tensile strength test of samples with a variety of 20 mL acetic acid showed a value of 17.805 MPa. This value meets the bioplastic standard (10 - 100 MPa) and the Indonesian National Standard (SNI) for conventional plastic (24 - 302 MPa).

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