The Simple Degradation Test for Nata de coco-based Film as Alternative Biodegradable Plastic Materials

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Abstract. Plastic trash in Indonesia has reached 64 million tons per year. Consequently, a solution is required to decrease synthetic plastic waste. A film based on nata de coco has been made as an alternative to biodegradable plastic material using materials consisting of nata de coco, chitosan, and 1% acetic acid. The nata de coco based film was made by varying the composition of chitosan. The variations of chitosan used were 0.1 gram, 0.2 gram, 0.3 gram, and 0.4 gram. The biodegradation test used the soil burial test method by immersing the sample in the soil and the mixed microbial batch method using effective microorganisms 4/EM4 with an estimated time of 15 days. The results of the soil burial test method showed a variation of 0.1 experienced a weight loss of 100%. Meanwhile, variations of 0.2, 0.3, and 0.4 experienced a weight loss of 60-75%. Meanwhile, the results of the mixed microbial batch method showed that the nata de coco-based film underwent biodegradation as indicated by the tearing of the surface of the nata de coco-based film. From these results, nata de coco-based films can be said to be biodegradable plastics.

Keywords: film nata de coco; soil burial test; mixed microbal batch.

1 Introduction

The number of environmental problems increased significantly. The usage of synthetic plastics as food packaging is one of the environmental issues that is on the rise the most [1]. The synthetic plastics oriented polypropylene (OPP), low density polyethylene (LDPE), and polyethylene (PE) are frequently used for food packaging [2]. All individuals can afford synthetic polymers because they are light, robust, transparent, waterproof, and very inexpensive. It is believed that the nature of plastic facilitates human daily existence. However, the use of synthetic plastics can result in extremely damaging plastic waste for the environment.

According to information acquired from the Indonesian Plastic Industry Association (INAPLAS) and the Central Statistics Agency (BPS), Indonesia is the second greatest provider of plastic garbage in the world. Plastic trash in Indonesia has reached 64 million tons per year, with synthetic plastic garbage comprising as much as 3.2 million tons. Plastic garbage that is

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left on the ground will become a major pollution. If plastic garbage is burned, it will increase the concentration of greenhouse gases in the atmosphere and emit dioxin-containing hazardous vapors [3]. Inhaling dioxin chemicals is extremely harmful to humans. Dioxin chemicals can cause hepatitis, liver enlargement, problems of the neurological system, and depression [4]. Consequently, a solution is required to decrease synthetic plastic waste. Alternatives include substituting synthetic plastic with biodegradable plastic.

Bioplastic, also known as biodegradable plastic, is a type of plastic that is almost entirely comprised of renewable substances, such as starch, vegetable oil, microbiota, and cellulose. With its great biodegradability, this renewable material has the potential to replace biodegradable plastics. Biodegradable plastics disintegrate between zero and twenty times faster than synthetic plastics [5]. According to the Indonesian National Standard (SNI) 7188.7:2016, biodegradation of biodegradable plastic is greater than 60 percent each week.

Numerous researchers have investigated bioplastics-related materials, including those derived from cellulose. As a result of bacterial fermentation of Acetobacter xylinum in coconut water media, Nata de Coco can be utilized as a raw material for bioplastics since it includes cellulose components, hence the term biocellulose [6,7]. The Simple Degradation Test for Nata de coco-based Film as an Alternative Biodegradable Plastic Material is the subject of this study.

2 Research Methods

The methods used in making nata de coco-based films are mixing and casting methods. Making a film based on nata de coco begins by preparing 100 grams of nata de coco. Next, the process of separating nata de coco from the water contained in the packaging is carried out. This process is carried out to ensure that the nata de coco to be made as a biodegradable film does not contain sugar or sweeteners that can affect the color quality of the resulting film. The separation of nata de coco from the water contained in the packaging is done by washing the nata de coco with running water and boiling the nata de coco until it has no taste (pH = 7). Then, the nata de coco is mashed using a blender.

After that, the composition optimization was carried out in making nata de coco-based films. Optimization is done by doing variations on chitosan. The variations of chitosan used were 0.1 gram, 0.2 gram, 0.3 gram, and 0.4 gram chitosan. Furthermore, chitosan must be dissolved using 1% acetic acid as much as 20 ml. Chitosan was dissolved with acetic acid using a magnetic stirrer for 30 minutes at a temperature of 60°C and 1000-1100 rpm. After that, the mixing method was continued by mixing the mashed nata de coco into the chitosan solution with a magnetic stirrer at the same temperature and speed for 30 minutes until homogeneous. Next, the casting/printing method was carried out by pouring a nata de coco-based film solution into a 27 cm x 19 cm x 6.5 cm container, flattening, and drying in the sun.

To determine the quality of the biodegradable film, a biodegradation test was carried out on the nata de coco-based film. The method used in biodegradation testing in this final project is to use 2 methods, namely soil burial test and mixed microbal batch method. Soil burial test is a degradation method that is carried out by planting samples in composted soil. Meanwhile, the mixed microbal batch method is carried out using a group of different species of microorganisms and inoculated in a liquid medium with the test object. Biodegradation testing using this method is carried out by burying or immersing the sample in the soil. The nata de coco-based film and 4 samples of synthetic plastic that are often used as food packaging were cut to a size of 2 cm x 2 cm and then buried using compost soil. The estimated time of burial in the soil was carried out for 15 days with modified observations once in 3 days. At the beginning before burial of the sample, the nata de coco-based film and 4 samples of synthetic plastic which are often used as food packaging were weighed initially and the weight changes every three days. Bidegradation testing in this method was carried out using the help of effective microorganisms 4 (EM4). The ability of biodegradation is seen based on the length of time for degradation by EM4 microorganisms. The biodegradation test was carried out by placing a sample of nata de coco-based film and 4 samples of synthetic plastic film which is often used as food packaging measuring 2 cm x 2 cm in a petri dish then adding 10 ml of EM4 and left for 15 days. The weight of each sheet of nata de coco-based film and 4 samples of synthetic plastic that are often used as food packaging, were measured before and after the degradation period using an analytical balance. The percentage of weight loss is determined based on the equation [8]. The results obtained were then identified the difference between the degradation test on nata de coco-based films and 4 samples of synthetic plastics that are often used as food packaging.

3 Results and Discussion

Nata de coco based film with 0.1 gram chitosan variation; 0.2 grams; 0.3 gram and 0.4 gram have been successfully made using mixing and casting method. Mixing and casting methods are often used in the manufacture of edible films because the material mixing process can be evenly distributed in the resulting film [9]. Figure 1 shows the physical appearance of the nata de coco-based film with variations of chitosan. Based on the picture above, it is found that all the variations made have a clear color like plastic. However, the level of transparency on the surface of the film produced in each variation shows a difference. Nata de coco-based film with variations of 0.4 grams of chitosan and variations of 0.3 grams of chitosan produced a very transparent surface compared to variations of 0.1 grams of chitosan and 0.2 grams of chitosan. This shows that the higher the concentration of chitosan added to the nata de coco-based film, the higher the transparency value of the film. This is because the form of chitosan is a white powder which when dissolved will form a clear suspension, so with the addition of a higher concentration of chitosan, it can increase the value of film transparency and will produce films with a large degree of clarity, as a result the degree of transparency increases [10].

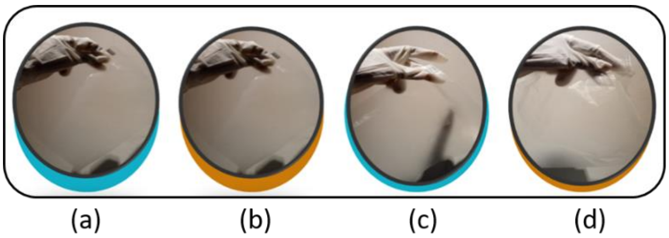

Fig. 1. Physical Appearance of Nata De Coco-Based Films with Chitosan Variations (a) 0.1 gram; (b) 0.2 gram; (c) 0.3 gram and (d) 0.4 gram.

Furthermore, biodegradation tests were carried out on the resulting film samples, namely the soil burial test and mixed microbal batch methods. This test is intended to determine whether the resulting sample can be degraded. Tests were also carried out on several types of packaging plastics on the market to compare their degradation rates. The biodegradation process using the soil burial test method on nata de coco-based films and 4 samples of synthetic plastic that is often used as food packaging was carried out by burying the samples in compost soil media. The results of the degradation test on the nata de coco-based film sample with variations of chitosan were observed every three days as shown in Figure 2. It can be seen in the picture above that the physical changes of the nata de coco-based film after being given a variation of the degradation time. In the picture above, the 0-day sample is a nata de coco-based film that has not been treated with degradation. Visually, the nata de coco-based film in each variation has a surface that is not perforated. Samples on the 3rd day after being given degradation treatment showed differences from the previous day. In the 0.1 gram variation of chitosan, medium-sized holes were seen at the bottom left, middle, and top.

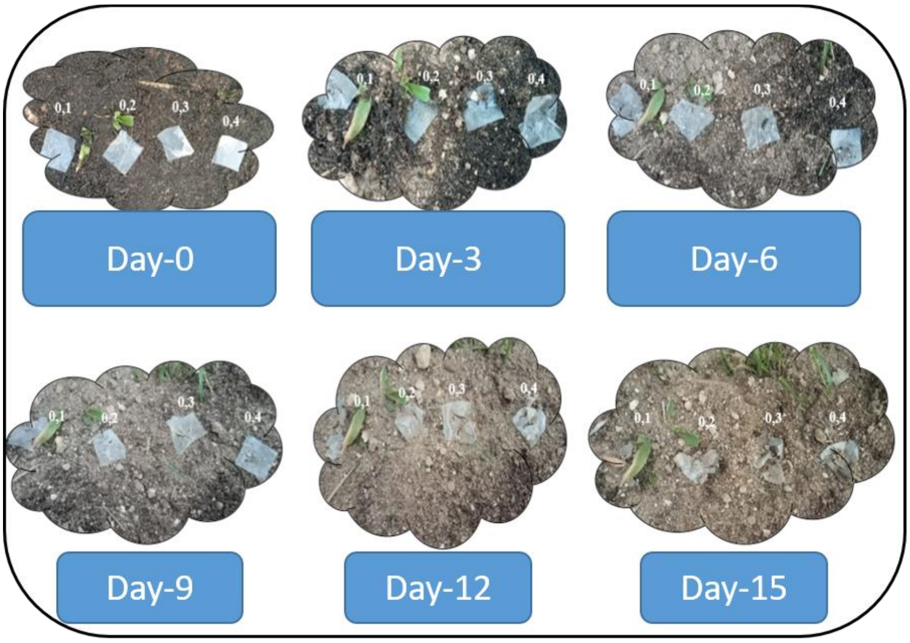

Fig. 2. Photo of nata de coco-based film before and after being given variations in biodegradation time.

In the variation of 0.2 grams of chitosan, it shows that on the side of the sample there are 2 very small holes and 3 very small holes at the bottom. In the variation of the 0.3 gram sample of chitosan on the side there are a few tears and there are 3 holes in the middle and one on the left side of the sample. As for the sample with a variation of 0.4 grams of chitosan, on the sides it looks hollow in the middle with a small hole size. On day 6, the physical condition of the nata de coco-based film after receiving degradation treatment showed more changes. In the 0.1 gram sample of chitosan, the nata de coco-based film sample had a very large number of holes with a very large size. In the 0.2 gram sample of chitosan, the nata de coco-based film experienced a large number of holes compared to the previous day but with a very small size. In the 0.3 gram sample of nata de coco-based chitosan film, it can be seen that there are quite a lot of medium-sized holes. In a sample of 0.4 grams of chitosan, a thinner physical form with the addition of holes. In the 9-day sample, the 0.1 gram sample of chitosan had a hole that was getting bigger so that it removed some parts of the sample. In the 0.2 gram sample of chitosan, there was a hole in the middle of the sample with medium size followed by small holes in the sample. Samples of 0.3 grams of chitosan suffered medium-sized tears followed by small holes on the surface of other samples. In a sample of 0.4 grams of chitosan, the tear was almost cut off and small holes were visible at the edge of the tear.

The 12-day sample received degradation treatment, the structure of the sample was clear and the compost was thinly attached to the sample. Samples of 0.1 grams of chitosan samples look increasingly brittle. In the sample of 0.2 grams of chitosan the sample looks separated into several parts. In the 0.3 gram sample of chitosan the holes in the sample increased. The 0.4 gram sample looks torn and some parts of the sample are detached. In the 15-day sample, the degradation of the sample structure was clearly visible and the compost adhering to the sample was clearly visible. Samples of 0.1 grams of chitosan, the sample is almost invisible. In the 0.2 gram sample of chitosan the sample looks broken into several parts. In a sample of 0.3 grams of chitosan, the holes in the sample increased with a small size. In the sample of 0.4 grams of chitosan, the sample looks torn large in the middle of the sample. Samples on day 12 and day 15 are variations in peak biodegradation time because the sample has started to become brittle and some parts of the sample are released (fall off). In fact, in the variation of 0.1 grams of chitosan after receiving degradation treatment for 15 days, the sample was barely visible or there were only a few samples left. This is because the less chitosan is added, the faster the degradation process will occur. The antimicrobial properties of chitosan can inhibit the degradation process of edible film because the greater the concentration of chitosan, the more hydrogen bonds contained in the edible film, so it requires a large amount of energy to break the bond [11].

Furthermore, the degradation rate test was also carried out on 4 types of synthetic plastics on the market as shown in Figure 3. In the figure below, the 0-day sample is a synthetic plastic sample that has not been treated with degradation. Visually, the synthetic plastic film on each type of synthetic plastic from code 1 to code 4 still looks transparent and does not have holes. The sample for 3 days after being given the biodegradation treatment showed that there was no change in the 4 types of synthetic plastic after receiving the degradation treatment. On the 6th day, the physical condition of the synthetic film still did not show any change. In the 9-day sample up to 15-day sample received degradation treatment, the physical condition of the sample was still the same as the sample condition on the previous days and did not show any change. This is because the synthetic plastic degradation process takes a long time. The degradation of synthetic plastics takes a very long time, which is around 1000 years [12].

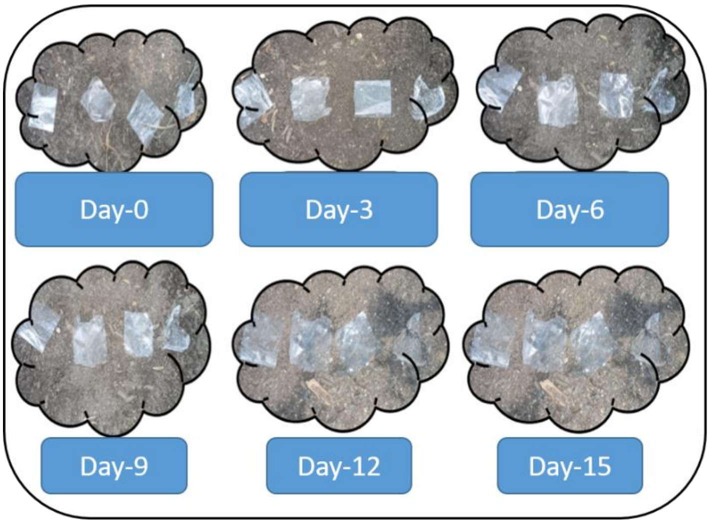

Fig. 3. Photos of synthetic plastic before and after being given variations in biodegradation time.

The microbial consortium used in the mixed microbal batch method is Effective Microorganisms 4 (EM 4). Effective Microorganisms 4 (EM4) which contains about 80 genera of fermenting microorganisms, including photosynthetic bacteria, Lactobacillus sp., Streptomyces sp., Actinomycetes sp. and yeast capable of decomposing organic waste [13]. The test results on Nata De Coco-based films with variations of chitosan using the Mixed Microbal Batch Method are shown in Figure 4.

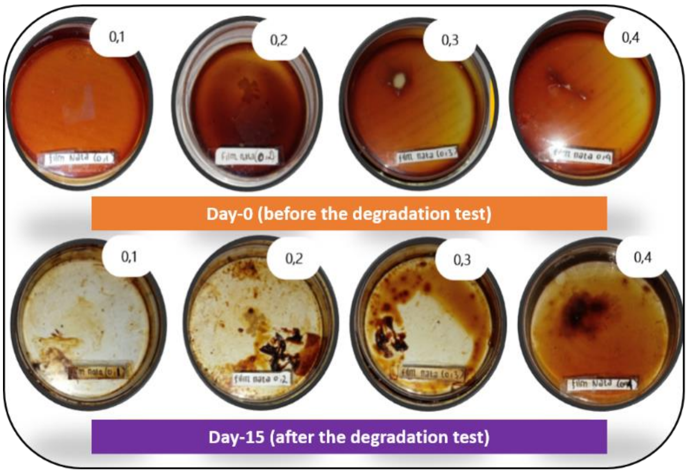

Fig. 4. Photo of nata de coco-based film before and after being given variations in biodegradation time using effective microorganisms (EM4).

From the test results with EM4 it can be seen that the nata de coco-based film tested with EM4 undergoes biodegradation within 15 days as indicated by the tearing of the surface of the bioplastic film. Based on this data, the nata de coco-based film can be said to be a biodegradable plastic. Furthermore, with the same method, the degradation rate test was also carried out on 4 types of synthetic plastics on the market and the results are as shown in Figure 5.

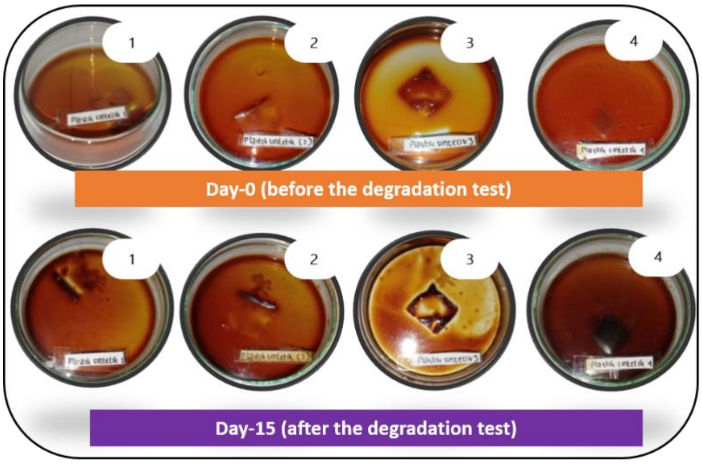

Fig. 5. Photo of synthetic plastic before and after being given variations in biodegradation time using effective microorganisms (EM4).

It can be seen in Figure 5 that from the test results with EM4 it can be seen that the synthetic plastic did not degrade within 15 days as indicated by the condition of the surface of the film that remained intact and did not change. From these results, synthetic plastics can be said to be non-biodegradable plastics. The results of the percentage reduction in weight were obtained from the results of biodegradation tests using the soil burial test method. The percentage of weight loss also shows the percentage of degradation of the film. The results of the measurement of the percentage of degradation of the nata de coco-based film with variations of chitosan are shown in Figure 6. After the degradation test was carried out for 15 days, the nata de coco-based film with variations of 0.2 grams of chitosan, 0.3 grams of chitosan, and 0.4 grams of chitosan experienced degradation by 30-35%.

Meanwhile, the variation of 0.1 gram of chitosan experienced the greatest degradation by 60%. This shows that most of the nata de coco-based films have been degraded by the soil (biodegradation). This biodegradation ability is due to the use of cellulose and chitosan which contain –OH groups which are able to bind and have the ability to bind moisture from the air so that they are rapidly degraded [14]. Based on SNI 7818:2014, biodegradable plastic will be degraded <60% for 7 days. Thus, the film based on nata de coco has met the standards of SNI 7818:2014. Of all the variations that have been done, the variation of the film with 0.1 grams of chitosan is the fastest variation in the biodegradation process. This is because the higher the addition of chitosan, the edible film undergoes a longer degradation process due to the antimicrobial properties of chitosan so that it slightly inhibits the degradation process of edible film [15].

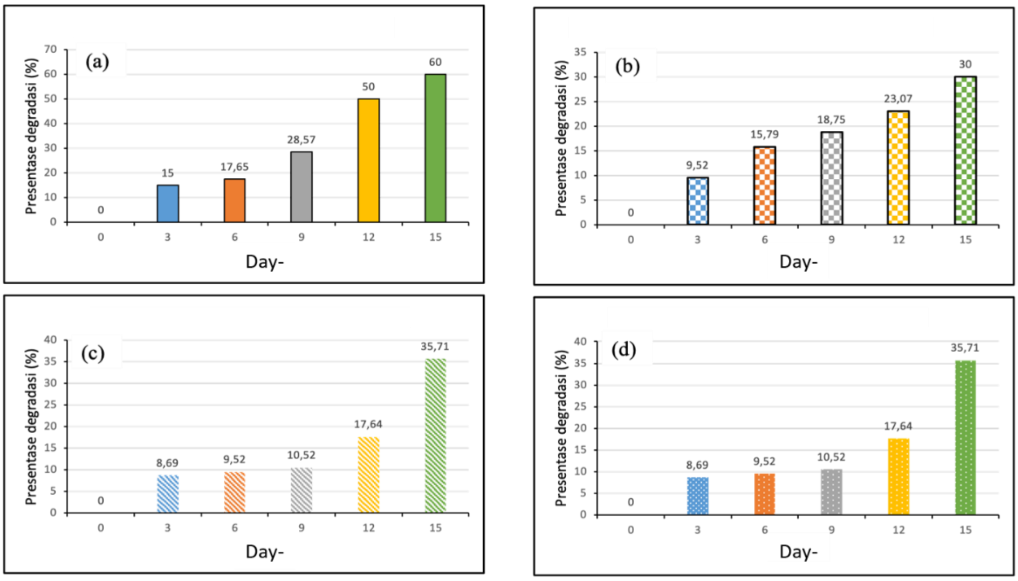

Fig. 6. Graph of the percentage of degradation of nata de coco film with variations of chitosan with time (a) 0.1 grams, (b) 0.2 grams, (c) 0.3 grams and (d) 0.4 grams.

Figure 6 shows a graph of the relationship between the percentage of degraded sample mass (%) with time variations. The graph shows that the longer the time (days) the sample is buried in compost soil media, the greater the percentage of the mass of the degraded sample will be. On the other hand, when testing the degradation of 4 types of plastic samples that are often used for packaging on the market for 15 days, all of these plastics tend not to experience a decrease in weight (0%) from day 0 to day 15. This means that the synthetic plastics that are often used as food packaging are not degraded. This is because synthetic plastic takes a relatively long time to degrade in the soil.

4. Conclusion

Based on the biodegradation tests that have been carried out, the soil burial test method showed that the nata de coco-based film has the ability to decompose. In the variation of the biodegradation time that has been carried out for 15 days, the results show that the nata de coco-based film with a variation of 0.1 grams of chitosan has decreased weight by 60%. Meanwhile, variations of 0.2 grams of chitosan, 0.3 grams of chitosan, and 0.4 grams of chitosan decreased by 30-37.5% in weight. Thus, the nata de coco-based film has been able to be degraded by the soil (biodegradable). Meanwhile, the test results on the four types of plastic packaging on the market did not show a change in weight, which means that the sample was not degraded. This is in line with the results of biodegradation testing using the mixed microbal batch method with effective microorganisms 4 (EM4). The nata de coco-based film tested with EM4 underwent biodegradation within 15 days as indicated by the tearing of the surface of the nata de coco-based film. From these results it can be concluded that nata de coco-based film can be said to be a biodegradable material that can be used as future plastic packaging.

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