Bio-packaging based on a composite of paper waste and coconut fiber

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Abstract. Indonesia is the largest contributor to marine plastic waste in the world after China. One solution to reduce plastic use is to develop a packaging that can be degraded by nature and eco-friendly, called bio-packaging. In this paper, we create bio-packaging made from a composite of waste paper and coconut fiber. In addition to composites’ physical characteristics such as mechanical properties and its biodegradability, this research also measured community responses to the bio-packaging products. This bio-plastic can be applied to making packaging with a lifting strength of more than 10 N. Also, it can be degraded into freshwater and seawater. According to the perceptional test, the bio-packaging is superior to single-use plastic except in the strength aspects.

1. Introduction

Today, the uses of plastic as packaging material faces various environmental problems [1]. Plastics are made from synthetic polymers, which are limited in number and cannot be renewed [2]. Microplastics are derived from plastics that break down into small particles—fragments of plastics that degrade into microplastics, which have less than 5 mm. Microplastics can accumulate in high amounts in seawater and sediments. On the otherside, plastic is difficult to decompose in the environment, both on land and in waters [3].

Indonesia is the largest contributor to marine plastic waste in the world after China and the annual plastic production of 4.68 million tons [4]. If this continues, then there will be significant environmental damage in Indonesia in the future.

One solution to reduce plastic use is that people are diverted to use bio-packaging rather than disposable plastic. Bio-packaging is a packaging that can be degraded by nature, and it has eco-friendly properties. In terms of storage durability and strength, the development of engineered material-based bio-packaging has promising prospects [5].

The interesting waste to be used as bio-packaging is waste paper and coconut fiber. Coconut production in Indonesia reaches 5.6 million tons/year, with coconut fiber waste reaching 1.7 million tons. However, its utilization is not optimal, and it can pollute the environment [6]. On the other hand, the amount of paper waste in Indonesia can reach 1,599,000 tons/year. In line with the increasing number and activity of the population, the amount of paper waste will increase [7]. Some of the primary agricultural wastes such as corn husks and bagasse are processed into 100% environmentally friendly packaging, which is biodegradable. Also, tapioca stalks, rice husks, and corn stover as raw materials are
included in the list of potential agricultural waste that can be converted into biodegradable packaging. However, previous research has concluded that consumers' daily purchasing behavior is often inconsistent with their environmentally friendly preference rather than conventional ones. Paper produced for packaging applications in 2009 accounted for 51.7% of producers' total production with the function of protecting products from damage. To reduce the adverse impact on the environment, the paper recycling method can be applied as a solution to the use of waste paper [8,9].

Bio-packaging based on paper waste will be developed in this research, and it combined with coconut fiber waste. Coconut fiber contains natural fiber material which can act as a reinforcing material. This composite is environmentally friendly and does not endanger health [10-12]. This research was conducted with simple technology to reduce production costs and can be applied by the community. In addition to composites' physical characteristics, such as mechanical properties and biodegradability, this research also measured community responses to the bio-packaging products.

2. Methods
Before being used, waste paper in this study was formed into pulp. On another side, coconut fiber is cut into small pieces. Composite-based bio-packaging is made from a blend of both materials with PVA as a binder. The ratio between waste paper and coconut fiber is 4:1. In this study, we varied the amount of PVA by 1 to 4 grams. The results of a mixture of coconut fiber, paper, and PVA are then put into wooden molds, and it dried in the sun.

Tensile strength is carried out by lifting paper as high as one meter for five minutes, which has been given a load variation—furthermore, the degradation test we conducted using a variation of two solutions, namely freshwater and seawater. To speed up the measurement, we added NaOH solution, and we stirred the solution.

The bio-packaging perception test is carried out through public response to the product compared to plastic. Before being tested, the best composite obtained is formed into a package which is carried out manually using a folding technique. The packaging perception assessment is done based on parameters: a) appearance, b) perception of strength, c) eco-friendly perception, and d) perception of increasing the selling value of the product with the packaging.

3. Results and Discussion
Based on the test results, it can be seen differences in texture in the composite-based paper of bio-packaging. The composite-based paper using 1 gr PVA has a rougher texture compared to using 4 gr PVA. Thus we can state that PVA can refine the surface of the paper.

![Figure 1. Composite-based paper](image)

Tensile strength measurement is carried out by lifting a load using the packaging with variations of 1, 2, 3, 4, 5, and 10 N. The length and width of the composite-based paper used are 25x5 cm the results as described in Table 1. In Table 1, a checkmark indicates that the sample successfully passed a series of load-lifting tests. It appears that all samples in this research can be used to lift loads up to 10 N.
Table 1. Tensile strength measurement of composite-based paper

| PVA amount (gr) | Load (N) |
|----------------|----------|
|                | 1        | 2        | 3        | 4        | 5        | 10       |
| 1              | ✓        | ✓        | ✓        | ✓        | ✓        | ✓        |
| 2              | ✓        | ✓        | ✓        | ✓        | ✓        | ✓        |
| 3              | ✓        | ✓        | ✓        | ✓        | ✓        | ✓        |
| 4              | ✓        | ✓        | ✓        | ✓        | ✓        | ✓        |

In Figure 2, the degradation test process is shown, and the results are written in Table 2. It appears that the degradation process in seawater is faster than freshwater. Also, the composite-based paper that contains PVA in large quantities will be more easily degraded.

Table 2. Degradation test measurement of composite-based paper

| Type of Water | PVA amount (gr) | Thickness (mm) | Degradation time (min) |
|--------------|----------------|----------------|------------------------|
|              | 1              | 0.023          | 10                     |
|              | 2              | 0.021          | 16                     |
|              | 3              | 0.030          | 20                     |
|              | 4              | 0.033          | 25                     |
| Seawater     | 1              | 0.023          | 20                     |
|              | 2              | 0.021          | 26                     |
|              | 3              | 0.030          | 30                     |
|              | 4              | 0.033          | 35                     |
| Freshwater   | 1              | 0.023          |                        |
|              | 2              | 0.021          |                        |
|              | 3              | 0.030          |                        |
|              | 4              | 0.033          |                        |

Figure 2. (a) Composite-based paper for measurement (b) degradation test process

Before evaluating community perception, the bio-packaging composite synthesized in this study was formed into a packaging product, as shown in Figure 3. A perception test was carried out on 53 respondents, and the result is written in Table 3. The appearance value for bio-packaging is 3.509, and plastic is 3.113. Furthermore, for the perception of strength, it appears that plastic is more dominant than bio-packaging. In the perception of environmental friendliness, bio-packaging is superior to plastic. The eco-friendly points in bio-packaging are 4.490 and plastic is just 2.50. Then, the perception of an increase in the selling value of bio-packaging products is still superior. This is because the uniqueness of bio-packaging products is a unique attraction for consumers. Thus, based on the assessment of packaging perception, it can be stated that bio-packaging is relatively more attractive to the public compared to conventional plastic.
4. Conclusions
Waste paper and coconut fiber composites can be used as bio-packaging materials. The composite can be applied to making packaging with a lifting strength of more than 1 kg. Also, it can be degraded in freshwater and seawater. Through the community perception test, it is also known that bio-packaging is more attractive to the public than conventional plastic.

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