Characteristics of Biodegradable Foam (Bio-foam) Made from Cassava Flour and Corn Fiber

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Characteristics of Biodegradable Foam (Bio-foam) Made from Cassava Flour and Corn Fiber

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Abstract. Plastic in styrofoam is a synthetic polymer material that is very practical in its use. This garbage is very damaging to the environment if it is burned because it produces dangerous gases to human respiration. Styrofoam's use must be stopped and make an alternative effort for any eco-friendly packaging materials, namely bio-foam, which uses starch as the main raw material. The potential source of starch is cassava flour. The main source for fiber is corncob for several reasons, including plastics made from starch/biomass that are more degradable by nature and abundant and less utilized. This research was conducted using fiber from the corncob waste, then mixing it with cassava, sorbitol, Mg stearate, and PVA. After obtaining the bio-foam, a water absorption test and biodegradability test were carried out. The results of the water absorption test showed that the 1st treatment had the most significant water absorption, precisely at the immersion time in the amount of 15 minutes in 25.45%, while the biodegradability test with soaking time in the soil for 14 days showed that first treatment was the most easily degraded by 20.25%.

Keywords: corncob, biodegradability, bio-foam, cassava

1. Introduction

Plastic in the form of Styrofoam is a synthetic polymer material that is very practical in its use, but it takes thousands of years to decompose [1]–[3]. As shown in Figure 1, Styrofoam waste is very damaging to the environment if it is burned because it produces gas that is harmful to human respiration. If it is buried in the soil, it will pollute the soil because it is difficult to degrade [1], [4].

Styrofoam is made from polystyrene with practical use, cheap, leak-proof, resistant to temperature but has a substantial negative impact on the environment [5], [6]. Data from the Environment Protection Agency (EPA) states that styrofoam waste is designated as the fifth largest hazardous waste in the world [5], [7], [8]. Styrofoam's use must be stopped and make an effort for environmentally friendly alternative packaging materials [7]. One alternative to replace styrofoam is bio-foam, which uses the main raw material for starch. Starch has high biodegradability, low price, non-toxic, and has heat resistance, but it is inflexible and takes a long time to process. To correct this disadvantage, the addition of plasticizers, modifiers, natural polymers, fibers, and several other materials is required [9], [10].

Figure 1. Various styrofoam waste

The potential source of starch is cassava flour, and the main source of fiber is corncob waste. Corncob has 90% cellulose. Cellulose availability in large quantities will form strong fibers, insoluble in water, organic solvents, and produce white color [11]. Biodegradable foam can be increased in quality by adding a plasticizer. The physical properties that changed after the addition of plasticizers were: soft, water-resistant, and increased elastic properties.

This study aims to develop an innovative biodegradable foam production from cassava flour and corncob waste as a substitute for synthetic styrofoam in the market. This research was conducted as a solution and substitute the biodegradable styrofoam. Bio-foam is produced with cassava flour and corncob as a natural fiber source. A plasticizer is needed to have soothing properties, resistant to water, and increases in properties. The research's novelty can be seen from the raw materials we use for this research. We utilized the corncob waste as the main fiber source as bio-filler material in the bio-foam formulation.

1.1 Characteristic of Corncob Waste

In the agricultural industry, corncobs are thick and robust, about 0.8 - 3 m long and 2 - 4.5 cm wide (diameter). Corncob generally consists of leaves and stems, with cortex and essence at the ends. A large amount of digestion on the stem is one of the corncob characteristics. The leaves, cortex, and essence have a total weight of corncob of 40%, 35%, and 15%, respectively [11], [12].

The bark contains 64.8%, and the pith contains 35.2% by weight in the stem. Leaves weigh 40% of the corncob and have 30% of fiber. The leaves are thin, have a large outer surface, a smooth surface layer, low tensile strength, and are easily crushed into powder. Corn bark has a thickness of about 0.04 mm, a mass ratio of about 35%, and a fiber content of 50%. The skin is the most potent part of the corncob. Because the skin is a small part of the corn stem, the skin's utility, regardless of the other parts, will increase the price of raw materials [12]. The three main components (cellulose, hemicellulose, and lignin) are closely related to the corncob. The complex structural characteristics make corncob challenging to use directly [12].

1.2 Characteristic of Cassava Flour

One of the potential sources of starch in Indonesia is cassava. Cassava flour is a starch that is extracted from cassava. Cassava, also known as *singkong*, *manioc*, or *yucca*, is one of the most important food crops in humid tropical climates, which is very suitable for low nutrient conditions. It is resistant to drought. This plant can grow to a height of 1-3 meters, and several roots can be found in each plant. Although the leaves are sometimes consumed, the main organ harvested is the tuber, a swollen root.

Based on data from FAO statistics on world cassava production in 2008, Indonesia is in fifth place with many 21,593,052 producers. Cassava is an energy source that is rich in carbohydrates but very poor in protein. The chemical composition of cassava can be seen in table 1.

Table 1. Chemical composition of cassava flour per 100 g

Parameter	Score
Calories	146 cal
Protein	1.2 g
Fat	0.3
Carbohydrate	34.7
Calcium	33 mg
Phosphor	40 mg
Iron	0.7 g
Vitamin A	0 mg
Vitamin B1	0.06 mg
Vitamin C	30 mg
Water	62.5 g

Source: Food Security and Extension Agency of Yogyakarta Special Region, Indonesia

Cassava is mostly used as food for humans and smaller quantities for animal and industrial feed. Cassava can be used as mocaf flour (Modified Cassava Flour) for analog rice materials. Mocaf flour is flour obtained by grinding the cassava that is already modified by fermentation with microorganisms' help. The modification process referred to modifying the cells in cassava through fermentation with lactic acid bacteria (LAB), which produce pectinolytic and cellulolytic enzymes that can destroy the cell walls of cassava so that starch granules are liberated. Making mocaf flour is by peeling the cassava, and then it comes clean. Clean cassava, cut into pieces, and ferment for 5-7 days. The fermented cassava is then dried and powdered to produce mocaf flour. The advantages of mocaf flour are that the amylose content is the lowest, around 17%, and the amylopectin content is relatively high at 83%.

1.3 Technology of Bio-foam Production

One of the methods of making bio-foam is an extruder, wherein the production of bio-foam uses an extruder. Thermoplastic extrusion is a high volume production process in which raw plastic is melted and formed into a continuous profile. The molten plastic is then transferred to the mold by screws to produce a material with a cross-section in the die's shape.

Another technique often used is the thermo-pressing method, where bio-foam is made using a tool that can simultaneously hold and heat materials simultaneously [13]. In thermo-pressing technology, the bio-foam shape and size can be adjusted according to the needs [14]. In the thermo-pressing process, the processing time and dough volume will affect the raw material's expansion ability, which affects the bio-foam that will be produced [14].

2. Materials and Method

The main raw material used in research is cassava flour, corncob waste, and chemicals for analyzing the product. The variable of this research includes control variables and independent variables. The control variables include water in ratio 1:1 with dry weight, the concentrate of Sorbitol and Mg Stearate respectively 5% of dry weight and 1.5% of dry weight. The independent variable of this research shows in table 2.

Table 2. Independent Variables of the Research

Treatment	**Cassava Flour (gram)**	**Corn Fiber (gram)**	**PVA (gram)**

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1	21.25	63.75	15
2	63.75	21.25	15
3	18.75	56.25	25
4	56.25	18.75	25

2.1 Production Process of Bio-foam

The preparation of bio-foam is presented in Figure 2. The chemicals such as sorbitol and magnesium stearate are added to the container. After that, the addition of PVA is required to make the bio-foam more elastic, and mix it all using a mixer. After the dough expands, we add the starch from cassava flour and fiber that has been mashed in a ratio of 3:1 to the dough, then stir it all. Next, we pour the dough into the Petri dish to be mold. Then, put it in the oven at 100°C for 1 hour. After that, cool the foam at room temperature for four days [15].

2.2 Water Absorption Test

Testing the absorption of water on biodegradable foam using the ABNT NBR NM ISO 535 method. Bio-foam is cut into a size of 5 x 10 cm, weighed, and assessed as the initial weight (W_0). The bio-foam is then immersed in water for 60 seconds, then dried using a tissue to remove the remaining air attached to the bio-foam. Weighing again and recorded as the final weight of bio-foam (W_1). The difference in initial and final weight was identified as the amount of water absorbed by the bio-foam [15]. The equation represents below:

$$\text{Weight Loss } (\%) = \frac{W_1 - W_0}{W_1} \times 100\% \quad (1)$$

where,
W_0 = Early Mass (gram)
W_1 = Final Mass (gram)

2.3 Biodegradability Test

Bio-foam produced from cassava and corncob fiber waste was tested for its degradability by immersing it in the soil for 14 days. Initial weighing is carried out to see the bio-foam's weight before it is buried in the soil. After being buried in the soil, weighed again to see the degraded bio-foam.

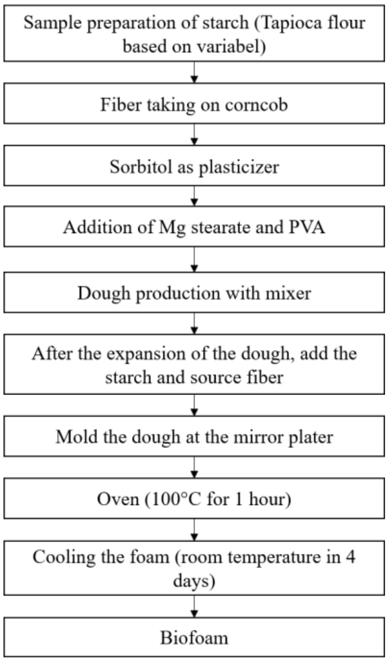

Figure 2. The step of the research

3. Result and Discussion

Production of bio-foam can be done in various processes, including extrusion, thermo-pressing, microwave-assisted molding, and the thermo-plasticization process. The form of bio-foam produced from these various processes shows that thermo-pressing technology is the most potential to be used as an alternative packaging for food product containers at all times. Thermo-pressing technology, the shape, and the bio-foam size can be adjusted as needed. Besides, the thermo-plasticization process commonly used in bioplastics cannot be applied to bio-foam production because the foaming process will be hampered. Because of that, we use the thermo-pressing method for this research. The bio-foam that we produced is tested for water absorption for foam resistance to water and biodegradability test. The water absorption test is carried out by calculating the weight change due to the amount of air swept by the foam. The amount of water absorption is expressed as the percent of water absorption. The function of each chemical that adds to the mixture is sorbitol as a plasticizer, Magnesium Stearate to prevent the dough from sticking to the media, PVA as a biopolymer that can make a transparent layer, strong, and elastic.

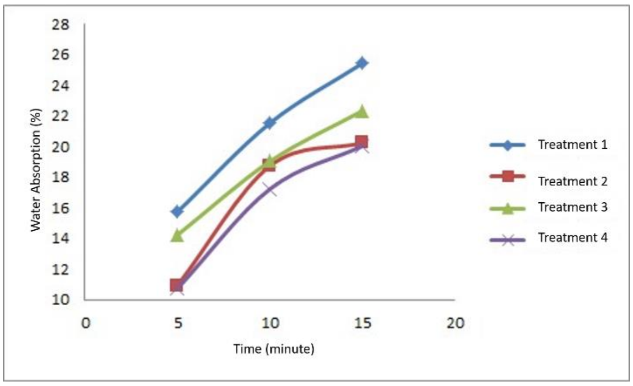

Figure 3. Correlation between immersion time and water absorption

From the water absorption test results, it is known that Polyvinyl alcohol's addition affects the foam's quality, which can be degraded. The added content affects the water absorption ability because the higher the fiber composition, the better the foam's water absorption ability. Therefore, treatment 4 produces the best bio-foam from the treatment carried out because the ability to absorb water is the smallest. The score of water absorption is influenced by the addition of PVA that is more hydrophobic than the starch.

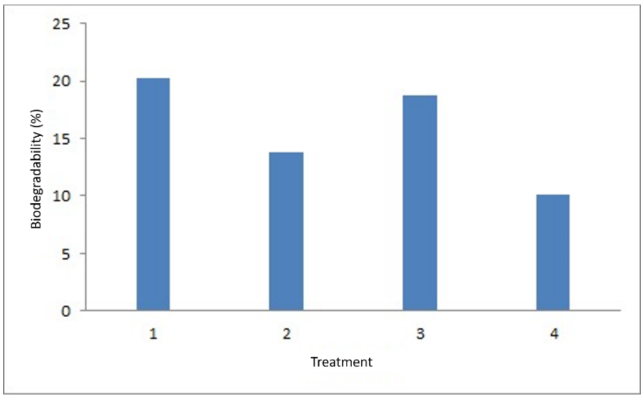

Figure 4. Correlation between composition to the biodegradability

The biodegradability test was carried out to see biodegradable foam's degradability. This test is done by burying the sample in the soil. The soil's bacteria will degrade the biodegradable foam containing starch by breaking the polymer chains into monomers through the enzymes produced from these bacteria. The immersion time observed in this study was 14 days.

The amount of the fiber affects water absorption in foam and impacts the foam's rate of degradation because microorganisms need water for metabolism [16]. The foam will absorb the more fiber added, the more water. The foam will degrade more quickly due to the acceleration of the metabolism of degrading microorganisms, so it indirectly affects the foam's ability to be degraded.

4. Conclusion

The biodegradable foam characteristics from cassava starch and corncob waste fiber that we produce have been tested for water absorption and biodegradability. The water absorption test results showed that treatment 1 has the biggest water absorption value, namely at the immersion time of 15 minutes that is 25.45%, and treatment 4 has the smallest score of water absorption that is 20.05%. The biodegradability test with soaking time in the soil for 14 days shows that treatment 1 is the most easily degraded by 20.25%.

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