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Effect of Composition on Physical Properties of Biofoam from the Combination of Sorghum and Dried Mango Leaves

Sabrina Rahmi Adiyar*, Ni Kadek Adnya Kusuma Sari, Salma Rahma Dewanti, Indro Sumantri
Department of Chemical Engineering, Diponegoro University, Semarang, Indonesia
*Corresponding e-mail address: shabrina.ashila@gmail.com

Abstract— *The aim of this study was to determine the potential and effective composition of a combination of sorghum (Sorghum bicolor) and dried mango leaves as environmentally friendly biofoam. The research was divided into three stages, named the material preparation stage, the biofoam molding stage, and the testing stage. The conclusion of this study is the combination of sorghum and dried mango leaves can be used as biofoam with the best composition, which is 196 grams of sorghum starch: 4 grams of waste fiber of dried mango leaves: 2 grams magnesium stearate: 80 cm^3 of glycerin; and 80 cm3 of polyvinyl alcohol.*

Keywords— *Sorghum, dried mango leaves, water absorption, thick development.*

I. INTRODUCTION

Basically, styrofoam is used as a protector for fragile items because it can restrain heat and cold properly. Because of its characteristics, then styrofoam is used as a food packaging that often found in restaurants or street sellers [1]. Moreover, styrofoam is very practical to use. But behind its all-practical use, styrofoam has a harmful effect on health and the environment.

Styrofoam is composed from the assortment of 90%-95% of polystyrene and 5%-10% of gas by using blowing agents such as Freon which potentially deplete ozone layer. From the statistics of EPA, Styrofoam waste is produced nearly 2,6 million tons and The Environmental Protection Agency (EPA) categorizes the process of making styrofoam as the fifth largest producer of hazardous waste in the world.

In order to overcome this problem, especially among researchers began to develop biodegradable foam or biofoam. Biofoam is an alternative packaging for Styrofoam made from environmentally friendly materials, which are then printed with the thermopressing process. The most important components in the making of biofoam are starch and fiber to strengthen the structure.

Before, researchers have conducted research to make biofoam from a combination of starch from banana peels and dried frangipani leaf waste added with glycerin, acetic acid, and a mixture of resin and hardener. But the products produced have large pores and high water absorption, which was an average of 26% with a thickness swelling of 10%. This was caused by the low starch content of the banana skin (0.98%) and the molding process which was only molded by Teflon in the oven with temperature of 250^{o}C [2].

Therefore, researchers are looking for ways to make the products produced better by using sorghum as the source of starch, which is then molded using a hotpress machine. Sorghum has a relatively high tanin content (0.40%-3.60%) and it makes the processed products less tasty to consume [3]. In addition, the use of grain sorghum has only been limited to traditional processed food[4] so it still has a low economic value. Even though the starch contents in grain sorghum reach 80.42%[5], where starch is the main component for making biofoam because of the characteristic of starch which is easily degraded into environmentally friendly compounds.

To strengthen the structure of biofoam, fiber component is used. Initially, researchers used banana peel fibers. But, banana peels tend to make black colored fibers and it affected the finished color of biofoam. It is because the banana itself turns brown or browning process[6]. Thus, the fibers turn black before formed into biofoam. Then, researchers looked for other way by using dried mango leaves. In general, leaves contain 35-50% cellulose from their dry mass and contain 15-30% hemicellulose [7]. So far, the dried of Mango leaves have not been optimally used and tend to just be thrown away.

II. PROBLEM FORMULATION

Based on previous research, banana peels and frangipani leaf waste can be used as components of biofoam, but the product produced is not maximum and have large pores because few amount of starch from its source and the molding process is still lacking.

On the other hand, sorghum grains have high starch content which is equal to 80.42%[5]. For fiber (strengthening the structure of biofoam) is used dried mango leaves, the leaves generally contain 35-50% cellulose from their dry mass and contain 15-30% hemicellulose [7]. So, the combination of sorghum and dried mango leaves have the potential to be used as styrofoam substitution material. But, it has not been scientifically proven.

III. PURPOSE OF RESEARCH

1. To find out the potential combination of sorghum (*Sorghum bicolor*) and dried mango leaves as biofoam that is environmentally friendly.
2. To find out the effective composition of combination of

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sorghum (*Sorghum bicolor*) and leaves waste of mango as an environmentally friendly biofoam.

IV. RESEARCH METHOD

This research was held out at UPT Diponegoro University Food and Tech Laboratory, Physical Metallurgical Laboratory of Mechanical Engineering at Diponegoro University, and Central for Leather, Rubber and Plastics Yogyakarta.

This study used an experimental method with data collection using a Completely Randomized Design (CRD). The treatment is:

TABLE I. Composition of Biofoam Treatments

Treatment	Starch (gram)	Fiber (gram)	Magnesium stearate (gram)	Glycerin (cm^3)	PVA (cm^3)
P 0 (+)	Commercial Styrofoam				
P 1	192	8	2	80	80
P 2	194	6	2	80	80
P 3	196	4	2	80	80
P 4	198	2	2	80	80

Each treatment is repeated 4 (four) times. So there are 20 research objects.

This study consisted of three stages, namely the material preparation stage (starch and fiber), the printing stage, and the testing stage. The testing phase only focuses on testing physical properties which include water absorption and thick development. Testing of water absorption is carried out by the following steps:
1. Samples measuring 5 cm x 5 cm and 0.5 cm thick
2. Testing of water absorption is carried out simultaneously with thick development testing
3. Samples are weighed before soaking and after soaking. Value of absorption can be calculated by formula

$$Water\ Absorption\ (\%) = \frac{B2\text{-}B1}{B1} x\ 100\%$$

Information:
B1 = weight before soaking (g)
B2 = weight after soaking (g)

The unit of the indicator of water absorption is percent (%)

The thick development test is carried out by the following steps:
1. Samples measuring 5 cm x 5 cm, then measured thickness
2. Then samples are soaked in water approximately 3 cm below the surface of the water for 24 hours
3. After 24 hours thick measurements are made.

The thick development value is calculated using the formula:

$$Thick\ Development\ (\%) = \frac{T2\text{-}T1}{T1} x\ 100\%$$

Information:
T1 = thick before soaking water (cm)
T2 = thick after soaking water (cm)

The unit of indicator for thick development is percent (%)

V. RESULTS

Based on the research, the following results were obtained:

TABLE III. Water Absorption of Biofoam (%)

Treatment	Repetition				Total	Average
	I	II	III	IV		
P 0	0	0	0	0	0	0
P1	9.49	8.98	13.17	12.5	44.14	11.035
P 2	10.5	10.5	10.98	11.58	43.56	10.89
P 3	6.85	8.64	8.69	10.36	34.54	8.635
P 4	14.01	10.96	14.79	15.6	55.36	13.84

Based on Table II, it can be seen that P0 (+) using commercial styrofoam cannot absorb water. Treatment 4 has the highest water absorption average of 13.84% while treatment 3 has the lowest absorption capacity among the other treatments, with an average of 8.635%.

TABLE IIII. Thick Development of Biofoam (%)

Treatment	Repetition				Total	Average
	I	II	III	IV		
P 0	0	0	0	0	0	0
P1	0	0	0	0	0	0
P 2	0	0	0	0	0	0
P 3	0	0	0	0	0	0
P 4	0	0	0	0	0	0

Based on Table III, it was seen that all treatments did not undergo thick development after being immersed in water for 24 hours.

VI. DISCUSSION

The principle of material that can be applied in the process of making biofoam is starch and fiber which can strengthen its structure[1]. As for sorghum it contains 80.42% starch[5] and in general, leaves contain 35-50% cellulose from their dry mass and contain 15-30% hemicellulose[7]. Thus, a combination of sorghum and dried mango leaf waste can be used as biofoam because it is made from starch and fiber added with glycerin, PVA, and magnesium stearate.

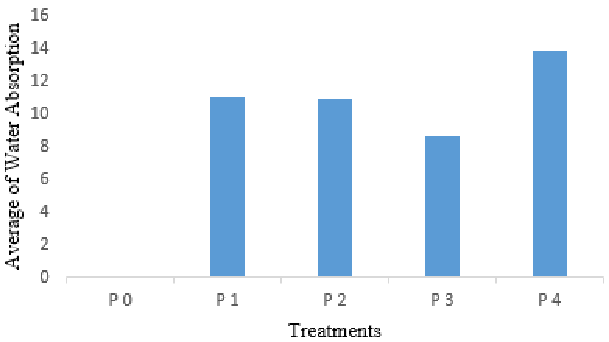

Fig. 1. Water absorption of biofoam

Based on Fig. 1, treatment three with composition of 196 grams of sorghum starch, 4 grams of waste fiber of dried mango leaves, 2 grams of magnesium Stearate, 80 cm^3 of

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glycerin, and 80 cm^3 of PVA is the best treatment because it has a low water absorption that is an average of 8,635 % and close to P 0 (+). While P 0 (+) is used as the testing standard. However, the other treatments, namely P 1, P 2, and P 4 have the percentage of water absorption which is not much different from treatment 3 (the best composition).

This is due to the high and the same glycerin composition in each treatment, which is 80 cm^3 of glycerin and 80 cm^3 of PVA. Addition of glycerin and PVA itself can reduce water absorption and increase the hydrophobicity of biofoam[1]. Research by Magi, et al., 2010 proves that the addition of PVA has been shown to improve the quality of biodegradable foam which is produced primarily in reducing the water absorbing properties, because the addition of PVA can reduce the air cavity in the biofoam[8]. So that when the testing process (biofoam is inserted into the water), the absorption is low.

In thick parameter development, the addition of PVA and glycerin is analogous to the adhesive in making biofoam from a combination of sorghum and dried leaf waste. The more adhesive added, the more small the thickness will be developed[9]. In this case 80 cm^3 of PVA and 80 cm^3 of glycerin were added. So that biofoam does not experience thick development when soaked in water for 24 hours.

When compared with products produced by Iriani, (2013) having a thick development of 39%, Nurfitasari's study, (2018) water absorption was 13.98%-31.62%. So that biofoam from sorghum and dried leaf waste has low water absorption compared to Iriani, (2013) and Nurfitasari, (2018).

VII. CONCLUSION

Combination of sorghum and dried mango leaves can be used as composition of biofoam with the best composition, which is 196 grams of sorghum starch: 4 grams of waste fiber of dried mango leaves: 2 gram magnesium stearate: 80 ml cm^3 of glycerin; and 80 cm^3 of PVA (treatment 3).

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