Utilization of Solid Waste from Refined Sugar Industry (Filter Cake) as Biodegradable Foam (Biofoam)

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Abstract. Biodegradable foam (biofoam) is an environmentally friendly alternative packaging to replace Styrofoam. The aim of this research is to synthesize biofoam from blotong waste, obtain its characteristics and determine the economic feasibility of developing the produced biofoam product. This research was conducted with descriptive experimental methods and economic feasibility studies through NPV and PI calculations. The results of this study indicate that biofoam with the addition of a glycerol plasticizer of 15% w/w has the best characteristics, which contain water content (6.321%) and the lowest water absorption (17.181%) and tensile strength (6.7778 N/mm²) and elongity (174.5%) are higher when compared to styrofoam packaging. All biofoam can be completely degraded within 25-30 days. The addition of glycerol plasticizer generally affects the characteristics of the biofoam produced. Based on the results of the analysis of the economic feasibility study, the development of biofoam based blotong products is feasible (positive NPV; PI > 1).

1. Introduction
Our earth is now in the era of "plastic age" where human life without plastic is inconceivable. Almost all objects that are around us are made of this material. Plastic is a made synthetic polymer raw materials crude oil with the addition of various additives and is non-biodegradable [1]. Plastic is difficult to degrade and causes buildup in nature [2].

More than 10 percent of urban waste streams are plastic, of which less than 9% of plastic waste is recycled, 12% is processed in incinerators and 79% is found in landfills and open seas [3]. It is estimated that in 2050 the amount of plastic waste will be more compared to fish in the ocean [3].

One thing that can be done to reduce plastic waste is to replace the use of nonbiodegradable plastic packaging with biodegradable packaging products that are more environmentally friendly [4]. Biodegradable packaging or known as biofoam, is a packaging material that is made using biopolymers so that it can be degraded naturally. Various renewable biopolymers such as starch, protein, lignin, cellulose, lipids, etc. can be used as raw material for making biofoam [5].

In general, making biofoam is a mixture of biopolymers, plasticizers, and additives [6]. The types of plasticizers that are widely used are glycerol [7], while the additives are widely used are starch, magnesium stearate and polyvinyl alcohol (PVA). All of these materials are compatible with various polymers and biopolymers [7-8].

At present there are several studies related to biofoam making by utilizing biopolymers from industrial waste including research conducted [9], in this research biofoam is synthesized...
from tofu waste protein and keratin waste from chicken feathers. Other research conducted by [10-11] is by utilizing starch biopolymers found in corn, acid seeds and jackfruit seeds as raw material for making biofoam.

Other studies conducted by [12], in this study biofoam is made with raw materials of fiber from agricultural waste. The results showed that the biofoam produced had good mechanical properties but had a much greater density compared to Styrofoam.

Another waste that still has biopolymer content is blotong. Blotong or filter cake is an industrial waste produced by a sugar factory from the clarification of sugar cane juice and is fibrous solid [13]. Blotong composition consists of coir/cellulose, crude protein, wax and crude fat, sugar, total ash, SiO2, CaO, and MgO. The fiber and protein content in the blotong is very high, reaching 30-40% [14]. Based on this composition, blotong has the potential to be developed as a raw material for making biofoam.

This research wants to synthesize biofoam from solid waste from the refined sugar industry, get its characteristics and determine the feasibility of developing economically based blotong-based biofoam products.

2. Materials And Methode

2.1. Location, Time and study design

This research was conducted at the Ujung Pandang Polytechnic Laboratory and the Center for Plantation Products Industries (BBIHP) Makassar, in March-May 2019. The type of research used was descriptive.

2.2. Data collection method

The collection of data BioFoam characteristics includes density, water content, water absorption, tensile strength and elongates done by direct measurement methods for all samples at various additions of plasticizer glycerol.

2.3. Tools and materials

The tools used in the study include container aluminum (aluminum bowl), mixer Kirin Mixer KSM 386, baking machine Kirin KBO 190 LW, oven, measuring cups, strainers, balance scales, glass dish, cutter, ruler, elongates and tensile strength Instrument test, long run, aluminum mold, and spatula.

Blotong raw material comes from the Refined Sugar Industry of PT. Makassar te'ne Makassar, while other ingredients such as starch, polyvinyl alcohol (PV A ), magnesium stearate, technical roll glise and styrofoam packaging (as a comparison) are obtained from chemical stores in Makassar City.
Figure 1. Picture of Blotong -based biofoam products

2.4. Making biofoam dough
Making biofoam dough is done at room temperature and temperature. Blotong mixed with additive such as starch (12.5%, w/w filter cake), PVA (12.5%, w/w filter cake), magnesium stearate (6%, w/w), water (125%, w/w) and glycerol plasticizers with varying concentrations of 5, 10, 15 and 20% w/w. The mixing process was carried out using a mixer with a mixing time of 8 minutes (the optimum mixing time was obtained through a preliminary experiment). The dough BioFoam then inserted into aluminum molds and baked (baking) at temperature 200°C for 10 minutes. The physical and mechanical properties of biofoam are then measured and compared with styrofoam packaging. The composition of raw materials and additives in making biofoam in full can be seen in table 1.

2.5. Determination of optimum mixing time
Determining the optimum mixing time is done by mixing and stirring batter BioFoam based blotong (glycerol composition of 10% w/w) pad a variation of a 2, 4, 6, 8, 10, and 12 minutes. 40 grams of the mixture is then filtered using a 40 mesh filter and the retained residue is weighed. The optimum mixing time is when the% residue is declared zero.

2.6. Test the characteristics of biofoam
Testing the characteristics of biofoam includes density, moisture content, water absorption, mechanical properties, and biodegradability. The biofoam density test was carried out using the same method as previously done by [15] by measuring the weight and volume of the sample. The density is the division of mass by the volume of the sample.

Biofoam moisture content testing was carried out in accordance with a technique previously carried out by [6] by heating the sample in an oven at 105°C for 4 hours and calculating the% weight loss of the sample by the gravimetric method. The value of% weight loss is equivalent to% of the sample moisture content. In addition to blood levels, this research was tested for biofoam water absorption using the ABNT NBR NM ISO 535 method.

The testing of mechanical properties includes measurements of tensile strength and biofoam elongity. Tensile strength is measured using a plastic test tensile strength instrument with
method ASTM D638-02a-2002, while the measurement elongates BioFoam test method IK-MT-30.71. In this study testing the level of degradability performed using soil-burial test is contacting the sample BioFoam by directly with the land and observe physical changes as well as weight every 5 days.

2.7. Data analysis
Data analysis was performed using the One-Way-Anova Statistical Program Package for Social Science (SPSS) 21, to determine whether the addition of glycerol plasticizer (%) significantly affected the characteristics of the biofoam produced. Analysis of the economic feasibility study of biofoam-based biofoam development activities using NPV (Net Present Value) and PI (Profitability Index) calculation methods. Activities are declared feasible if the NPV and PI values are each positive and more than one [16].

![Figure 2](image-url)

**Figure 2.** Graphic for determining the optimum mixing time for making biofoam dough
3. Results

3.1. Determination Results optimum mixing time
From the experimental results obtained when the optimum mixing properly accounting process dough BioFoam based blotong is for 8 minutes.

3.2. Biofoam characterization test results
In figure 1 is shown that biofoam the resulting light brown, densely textured and has a thickness ranging from 1.95-2.33 mm.

Table 2 is shown that biofoam has a value of the average density of between 1.462 - 1.504 g/mL, water content 6.351-12.059 %, water absorption 17.181-27.301%, tensile strength 2.325-6.777 N/mm² and the elongate of 61.7 - 174.5%. The whole BioFoam generated Dapat degraded in time 25 - 30 days.

3.3. Results of data analysis
The results of data analysis using the One Way Anova Program SPSS method showed that the addition of glycerol levels significantly influenced biofoam characteristics (p < 0.05). The results of the analysis of economic study feasibility blotong based BioFoam product development shows that the product development activities biofoam based blotong feasible for in doing (NPV: 47.455 280; PI: 1.0678).
Table 1. The formula for biofoam based dough blotong

| Biofoam Dough Formula | Mass (g / 100 g solid) | Water (mL / 100 g) |
|-----------------------|------------------------|---------------------|
|                       | Blotong | Starch | PVA | Mg Stearate | Glycerol |       |
| 5                     | 80,000  | 10,000 | 10,000 | 6,000 | 5,211  | 125   |
| 5 '                   | 80,000  | 10,000 | 10,000 | 6,000 | 5,005  | 125   |
| 5 "                   | 80,000  | 10,000 | 10,000 | 6,000 | 5,189  | 125   |
| 10                    | 80,000  | 10,000 | 10,000 | 6,000 | 10,200 | 125   |
| 10 '                  | 80,000  | 10,000 | 10,000 | 6,000 | 10,145 | 125   |
| 10 "                  | 80,000  | 10,000 | 10,000 | 6,000 | 10,008 | 125   |
| 15                    | 80,000  | 10,000 | 10,000 | 6,000 | 15,200 | 125   |
| 15 '                  | 80,000  | 10,000 | 10,000 | 6,000 | 15,189 | 125   |
| 15 "                  | 80,000  | 10,000 | 10,000 | 6,000 | 20,001 | 125   |
| 20                    | 80,000  | 10,000 | 10,000 | 6,000 | 20,106 | 125   |
| 20 '                  | 80,000  | 10,000 | 10,000 | 6,000 | 20,008 | 125   |
| 20 "                  | 80,000  | 10,000 | 10,000 | 6,000 | 20,008 | 125   |

Table 2. Data on the results of biofoam characteristics

| Glycerol Composition (%) | Density (g / mL) | Water content (%) | Water Absorption (%) | Tensile strength (N / mm²) | Elongity (%) |
|-------------------------|------------------|-------------------|----------------------|---------------------------|-------------|
| 5                       | 1.565            | 12.058            | 27.301               | 3.8918                    | 61.7        |
| 10                      | 1.533            | 8.620             | 25.844               | 5.6123                    | 76.3        |
| 15                      | 1.518            | 6.351             | 17.181               | 6.7778                    | 173.8       |
| 20                      | 1.462            | 8.386             | 20.517               | 2.22325                   | 108.8       |

Styrofoam : 0.154, 1.754, 11.218, 3.977, 148.6

4. Discussion

In this study it was shown that biofoam can be synthesized from blotong waste. The characteristics of biofoam are significantly influenced by the addition of glycerol as a plasticizer and based on the results of an economic feasibility study the development of biofoam-based biofoam products is feasible.

Figure 2 shows that the optimum mixing time in making biofoam dough based on blotong is 8 minutes, this is much longer than the mixing time in making biofoam made from starch and protein which is about 4-5 minutes [6, 7]. Several factors that can influence the mixing process include the size and shape of the particles, the moisture content and characteristics of the material to be mixed [17]. Starch and blotong have different characteristics and levels of compatibility with plasticizers [17]. In addition, biofoam based blotong dough is more viscous so it requires more time and energy to be homogeneous.

The addition of glycerol levels affects the density of biofoam produced. The addition of glycerol as a plasticizer increases the density of the biopolymer matrix so that it makes it denser and thinner [18]. Biofoam has a density 10 times greater when compared to Styrofoam (0 , 154 g/mL). This is because the main component filter cake as raw material at research is a biopolymer fiber and protein have molecular weight t Heigh [19] In contrast with the styrofoam that in making use of the air/gas as filler material, so it became her very light.
Water content and water absorption best BioFoam get on adding gliserol by 15%, ie respectively 6.351% and 17.181%. In the packaging material, the lower the water content and water absorption, the higher the quality of the material. This value is still higher when compared to Styrofoam (water content: 1.754%; water absorption: 11%), but still far better than starch-based biofoam (water content: 11-40%; water absorption <26.12%) [11].

The addition of glycerol as a plasticizer affects the water content and the absorption of biofoam produced. Glycerol is a simple triglyceride compound which has a light molecular weight, which is around 116.1 g/mol [20]. This allows it to diffuse into the spaces between the bonding chain biopolymers. Glycerol blocking the entry of water molecules into the spaces are and interfere with the absorption of water into the biopolymers.

Strong pull and best elongates BioFoam obtained in addition gliserol by 15%, ie each -masing amounted to 6,7778 N / mm² and 174,5%. This value is better when compared to styrofoam (tensile strength 3,9765N/mm²; elongates 148, 6%), BioFoam starch-based (tensile strength of 0,11 - 0,75 N / mm²; elongates 2, 19-9, 04%) and starch-fiber-based biofoam (tensile strength 0,9444 N / mm²; elongate 24, 3%) [21].

The addition of glycerol plasticizer concentration affects the value of tensile strength and biofoam elongate. Glycerol molecules that diffuse into biopolymers will weaken the interaction between biopolymer bonds. Glycerol molecules reduce intermolecular energy (van der waals) biopolymer chains which can increase the flexibility, softness and elasticity of biopolymers [39]. With the same method the glycerol molecule changes the structure of three-dimensional biopolymer molecules so that it reduces the energy in the hydrogen bonds between the biopolymer molecular chains and the energy needed for the molecules to move and makes them more elastic [23].

The degree of plasticization of plasticizer addition to a material varies depending on the chemical composition of the material, the weight and functional group of the plasticizer molecule and the compatibility of the plasticizer used [24]. In this study, the best degree of plasticization was obtained with the addition of glycerol by 15%.

The whole BioFoam produced can be degraded completely after 25 - 30 days with the method of soil-burial test. In figure 3 we can see that after planting 10 days and 15 days there was a decrease in mass and changes in physical biofoam. In this condition may have been a fragmentation of the material that is mass reduction, smell, taste and shape caused by factors biotic and non-biotic [25]. After cultivation for 25 - 30 days, had not found the rest of BioFoam on the ground. This shows that in these conditions biofoam has undergone complete biodegradation.

Based on the results of test data analysis using the One-Way-Anova Program Statistic Package for Social Science (SPSS) 21, obtained the value p-value for the addition of glycerol on the characteristics of BioFoam ranges from 0.000 to 0.005 or dib a wah α = 0.05. So it can be said that in general the addition of glycerol plasticizer levels affects the characteristics of the biofoam produced.

From the results of the analysis of the economic feasibility of product development BioFoam based blotong obtained NPV worth po acquisitive and PI > 1. This shows that the profit generated in the development of biofoam-based biofoam products is higher than the costs. In other words, these activities are economically profitable and feasible to do right.

5. Conclusions and Suggestions

In this study, biofoam can be synthesized from the refined sugar industry blotong solid waste. The results showed that blotong-based biofoam with the addition of a glycerol plasticizer of 15% had the best characteristics, which contained water content (6.321%) and the lowest water absorption (17.181%) and tensile strength (6.7778 N / mm²) and elongate (174.5%) is better when compared to styrofoam packaging. The whole BioFoam can be degraded perfectly after 25 - 30 days with the method of soil-burial test. The results of the data analysis test using the One-Way-Anova Statistical Program for Social Science (SPSS) 21 program show that the addition of glycerol plasticizer affects the characteristics of the produced biofoam. In addition, based on the results of an economic feasibility analysis using the NPV and PI value calculation methods, the
development of biofoam-based biofoam products is feasible. In further studies, further experiments should be conducted to improve the absorption of biofoam water and microbial biomass testing such as CO$_2$, CH$_4$ and H$_2$S, to determine the biodegradation time of biofoam materials more accurately.

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