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Enhanced Hydrophobicity Of Sweet Potato Starch Bioplastic Reinforced With Activated Carbon

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Abstract *– Sweet potato starch was employed to generate activated carbon-reinforced bioplastics in the study. Water absorption, solubility, and moisture analysis were used to investigate the hydrophobicity of sweet potato-based bioplastics. The samples were immersed in still distilled water for 24 hours to test water absorption. Water absorption was lowest in Sample B (7mL glycerin with 0.4g activated carbon) at 33.447% of weight gain and greatest in Sample F (11mL with 0g) at 41.578%. Water solubility was measured by stirring samples every hour for 24 hours. Sample B (7mL glycerin with 0.4g activated carbon) had the lowest water solubility with 11.434% weight loss, whereas sample F (11mL with 0g) had the greatest with 12.571%. Sample moisture was measured with the Satorius Moisture Analyzer. Sample G (11mL glycerin with 0.4g activated carbon) had the lowest moisture content at 18.72833%, whereas Sample F (11mL without activated carbon) had the highest at 22.391667%. The water absorption and solubility tests showed that activated carbon reinforcement increased bioplastic hydrophobicity.*
Index Terms *– activated carbon, bioplastic, sweet potato starch, water absorption, water solubility*

I. INTRODUCTION

In today's fast-paced world, the packaging industry plays a vital role in our daily lives, ensuring the safe transportation and preservation of goods. The rapid urbanization and economic development have drastically increased the amount of plastic waste produced over time. Over nine billion tons of waste products across the globe came from plastics since 1950's, 165 million tons tossed in the ocean, and only nine percent of plastic gets recycled [1].

The Philippines ranks third in plastic pollution with 2.7 to 5.5 million metric tons produced annually, 20% of which escapes. If nothing is done, plastic waste might reach 9 million metric tons by 2040 and 11 million by 2060 [2]. Due to its widespread use of single-use plastics like multilayer sachets and pouches, the Philippines has established a "sachet economy" and high marine plastic pollution. Some estimates put Philippine sachet use at 163 million pieces daily. Over 65,600 cubic meters of Dumaguete's 24,900 tons or 124,000 cubic meters of plastic rubbish were dumped in Candau-ay – a dumping site found in the locality of Dumaguete. Most of the trash thrown 12 meters above the road is plastic. Bioplastics changed the manufacture of eco-friendly polymers [3].

Reducing plastic waste and associated environmental damage is a major benefit of this feature [4]. Research has revealed that bioplastics can be made from starches with different glycerin concentrations and carbon quantities [5]. The hydrophobic characteristics of activated carbon reinforcement for bioplastic have been studied little.

The primary goal of this study is to examine the hydrophobic characteristics of the bioplastic, which will be strengthened by various activated carbon concentrations and glycerin content. These characteristics will be evaluated primarily with a water absorption test, a water solubility test, and moisture analysis. This research aims to create a bioplastic that can endure water and is biodegradable as an alternative to conventional plastics.

II. Experimental Procedure

1. Material preparation and mixing process

Bioplastics will contain 10 g of sweet potato starch, 5 mL vinegar, 60 mL water, and other components. Every test sample has a distinct activated carbon ratio. Each test has 6 samples based on ratio. 24 bioplastic samples will be made and tested for the water hydrophobicity properties of the bioplastic. Data on bioplastic changes will be documented.

Before cooking, the ingredients were properly mixed and stirred until thickened and bubbling. After heating and spreading on the stove, return the mixture to the container. The samples were repeatedly baked to remove moisture. Each sample was roasted at 125°C and rotated for three hours to equally bake both sides.

Table 1 shows 10 different sample concentrations for fabricating bioplastics. The table below (refer with: Table 1) shows the sample proportions for the bioplastic, named Sample A, B, F, and G. Sample A and B comprise the 7mL variation, while Sample F and G comprise the 11mL variation.

Table 1 *Different Sample Concentrations for Fabricating Bioplastic*

Amount of Glycerin (mL) per Activated Carbon	7 mL	11mL
0g	Sample A	Sample F
0.4g	Sample B	Sample G

2. Characterization

In testing for water absorption, the methodology will follow the experimental procedure of Halimatul as stated in the literature section [6]. The research design will be followed but with modifications. The percentage of water absorption is then calculated using the equation below (refer with: Eq. 1).

$$\text{Water Absorption} = \frac{W_f - W_i}{W_i} \times 100\%. \quad (1)$$

The research design for testing the water solubility of bioplastics will follow Marichelvan and Halimatul's procedure as stated from the literature section [6]. The design will have some minor modifications. The fixed weight will be recorded, and the percentage of total soluble matter will be calculated using the formula below (refer with: Eq. 2).

$$\text{Water Solubility} = \frac{W_o - W_f}{W_o} \times 100\%. \quad (2)$$

The Sartorius Moisture Analyzer will be used to measure the moisture content of the samples. The equipment is available at the NORSU Innovation and Technology Support Office, and all necessary documents will be submitted so that the researchers can use the machine. There will be a total of ten samples and each sample will consist of ten trials and the results will be photographed, documented, and analyzed.

III. RESULTS AND DISCUSSION

The researchers claim that there is an impact on the presence of activated carbon in the absorption capability of the bioplastic made from sweet potato starch since there is a downward trend in the water absorption percentage when the amount of activated carbon has a higher concentration (refer with: Table 2). It is observed from the results that the highest percentage of water absorption came from Sample F having a concentration of 11 mL glycerin without AC. Furthermore, the lowest percentage of water absorption came from Sample B having a concentration of 7 mL glycerin with 0.4g AC. The results indicate that the 7 mL variations (Sample A & B are more resistant to water absorption than the 11 mL (Sample F & G).

Table 2 – A *The bioplastic's water absorption*

Sample	Water Absorption		
	W_i (g)	W_f (g)	$\%W_a$
A	0.4562	0.7137	36.042
B	0.495	0.7438	33.447
F	0.45	0.7708	41.578
G	0.4715	0.7532	37.332

Table 2 – B *The bioplastic's water solubility*

Sample	Water Solubility		
	W_i (g)	W_f (g)	$\%W_a$
A	0.4043	0.3555	12.072
B	0.5225	0.4627	11.434
F	0.6158	0.5383	12.571
G	0.5847	0.512	12.442

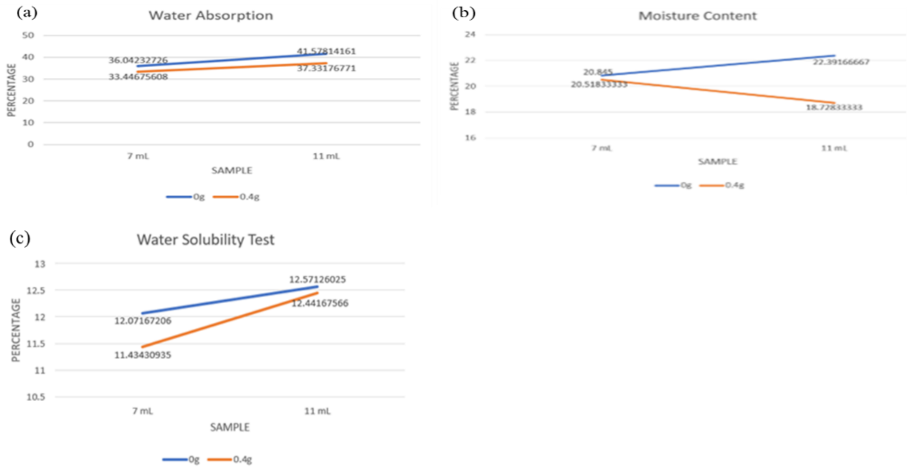
Table 2 – C *The bioplastic's moisture content*

Sample	Moisture Content	
	W (g)	%Moisture
A	1.055833	20.845
B	1.044	20.518333
F	1.055167	22.391667
G	1.044167	18.728333

On the other hand, the researchers also claim that there is an influence on the presence of activated carbon in the solubility of the bioplastic made from sweet potato starch since there is a downward trend in the water solubility percentage when the amount of activated carbon has higher concentration. It is observed from the results; the highest percentage of water solubility came from Sample F having a concentration of 11 mL glycerin without AC. Furthermore, the lowest percentage of water solubility came from Sample B having a concentration of 7 mL glycerin with 0.4g AC. The results indicate that the 11 mL variations (Sample F & G) are more soluble in water than the 7 mL (Sample A & B) variations. Shown in the figure below (refer with: Fig. 1(c)) is a line graph that represents the relationship of the values of each concentration.

Furthermore, the researchers further claim that there is no influence on the presence of activated carbon in the moisture content of the bioplastic made from sweet potato starch since the results on the moisture test analysis are very extreme. The researchers claim that the reason behind an extreme result of the data is due to the samples not being directly tested for their moisture content right after the fabrication of bioplastic process. Some of the samples were a week or a month older than the others when the specimens were tested, which may have contributed to the extreme results. Nevertheless, it is observed from the results, the highest percentage of moisture content came from Sample F having a concentration of 11 mL glycerin without AC. Furthermore, the lowest percentage of moisture content came from Sample G having a concentration of 11 mL glycerin with 0.4g AC. Shown in the figure below (refer with: Fig. 1(b)) is a line graph that represents the relationship of the values of each concentration.

Figure 1 *The Bioplastic's (a) water absorption, (b) moisture content, and (c) water solubility*



IV. CONCLUSION

Based on the findings of the research, it can be inferred that the glycerin and activated carbon concentration differences have contributed to the hydrophobicity property of the bioplastic.

For water absorption, it was found that sample B having a concentration of 7 mL Glycerin with 0.4g AC showed the least water absorption while sample F having a concentration of 11 mL without AC showed the maximum water absorption. From the graph illustrations, it is evident that the 7 mL sample variations displayed the most resistance to water absorption than the 11 mL variations implying that the higher the concentration of glycerin in the bioplastic sample the more absorptive it is to water. Similar results on higher composition of activated carbon of samples showed less water absorption.

For water solubility, it is observed from the results that the highest percentage of water solubility came from Sample F having a concentration of 11 mL glycerin without AC. Furthermore, the lowest percentage of water solubility came from Sample E having a concentration of 7 mL glycerin with 1.6g AC. The results indicate that the 11 mL variations (Sample F & G) are more soluble in water than the 7 mL (Sample A & B) variations. The results also implied that samples with higher activated carbon content will most likely have low water solubility and thus hydrophobicity is induced.

For the moisture content analysis test, it is observed that sample H having a concentration of 11 mL glycerin with 0.4g AC had the lowest average percentage of moisture content with 12.898% while sample F having a concentration of 11 mL glycerin without AC gained the maximum percentage average of moisture content with 22.46%.

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