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Effect Of Activated Carbon On The Mechanical Properties Of Sweet Potato Starch Bioplastic

[1]**Josef Vill S. Villanueva,** [2]**Virgilio Y. Abellana**
[1]Engineering Graduate Program, Department of Mechanical Engineering, School of Engineering, University of San Carlos, Cebu City 6000, Philippines
[1]Department of Mechanical Engineering, College of Engineering and Architecture, Negros Oriental State University, Dumaguete City 6200, Philippines
[2]Department of Mechanical and Manufacturing Engineering, School of Engineering, University of San Carlos, Cebu City 6000, Philippines
[1]josefvill1126@gmail.com, [2]vabellana@usc.edu.ph

Abstract– *Plastic pollution caused by single-use plastics has been a growing concern for environmentalists. This study explored the properties of sweet potato bioplastic samples to address plastic waste, focusing on tensile strength. The researchers created bioplastic samples using a mixture of sweet potato starch, vinegar, glycerin, and water. Tensile testing of 24 sweet potato bioplastics revealed that samples containing 7 mL of glycerin consistently exhibited greater ultimate strengths compared to those with 11 mL of glycerin. Specifically, samples containing activated carbon and 7 mL of glycerin had the highest mean ultimate strength (0.567 MPa), whereas those with no activated carbon but 11 mL of glycerin had the lowest (0.1483 MPa). Additionally, the samples with activated carbon and 7 mL of glycerin demonstrated the highest modulus of elasticity (1.3332 MPa) and yield strength (0.3311 MPa). These findings suggest that sweet potato bioplastics, particularly those with activated carbon and 7 mL of glycerin, have the potential to be a strong and sustainable alternative to conventional plastics. The study underscores the importance of optimizing the composition of bioplastics to enhance their mechanical properties and promote environmental sustainability.*
Index Terms– *activated carbon, bioplastic, sweet potato starch, rupture strain, yield strength*

I. INTRODUCTION

The Philippines is a major contributor to marine plastic pollution, producing 2.7 million metric tons of plastic waste annually, with an estimated 20 percent ending up in the ocean [1]. Studies show that the Philippines is the largest contributor of mismanaged plastic waste entering the ocean, generating 4 million metric tons of such waste annually [2]. This situation is exacerbated by the "sachet economy," where low-income households rely on small, affordable sachets of goods. Despite existing environmental laws like the Ecological Solid Waste Management Act of 2000 (RA 9003), poor implementation and the absence of a specific national policy addressing plastic pollution hinder progress in tackling the issue [3].

Reducing plastic waste and associated environmental damage is a major benefit of this feature [3]. Research has revealed that bioplastics can be made from starches with different glycerin concentrations and carbon quantities [4]. The hydrophobic characteristics of activated carbon reinforcement for bioplastic have been studied little

Starch is economically competitive with petroleum and has been used in several methods for preparing compostable plastics. However, a challenge to the development of starch materials is the brittle nature of blends with high concentrations of starch. Overcoming the brittleness of starch while achieving full biodegradability in blends can be accomplished by the addition of biodegradable plasticizers. Common plasticizers for hydrophilic polymers, such as starch, are glycerol and other low molecular weight – polyhydroxy – compounds, polyethers and urea. Plasticizers lower the water activity, thereby limiting microbial growth [5].

In the study conducted by Lubis et al., examines the effect of microcrystalline cellulose determined from sugar palm filaments and glycerol on the mechanical properties of bioplastics from avocado seed starch. Sugar palm strands experienced soluble base treatment, fading, and hydrolysis with HCl to create microcrystalline cellulose. Bioplastic was effectively created through the arrangement casting method. It

was organized from avocado seed starch and fortified with MCC from sugar palm strands with a composition proportion of 6:4; 7:3, 8:2, and 9:1 (w/w). Glycerol worked as plasticizer with variety of 0.1; 0.2; 0.3 and 0.4 (v/w of starch). Mechanical properties of bioplastic were decided by the ductile quality and stretching at break investigation where it is given that the finest condition of bioplastics gotten is from 7:3 proportion with 0.2 (v/w) glycerol included which is 2.74 MPa for ductile quality and 3.16% for stretching at the break [6].

Meite et al. conducted a study that determines the basic and thermomechanical properties of starch-based plastic films strengthened with kaolin and metakaolin that have been considered by different procedures. Results showed that kaolin, a dormant fabric, anticipates the starch from losing its granular structure and solubilizing amid the warming, creating plastic films of Moo Young's modulus (7 MPa). On the other hand, metakaolin, an undefined and dehydroxylated fabric obtained after the warming of kaolin at 700°C for 1 hour, significantly progresses the thermomechanical properties of the plastic movies. The Young's modulus increments from 19 MPa to 25 MPa whereas the warm resistance increments from 90°C to 120°C. This was ascribed to the great scattering of the metakaolin within the polymer network after the misfortune of the granular structure of the starch amid warming [7] .

The primary goal of this study is to determine the mechanical properties of the sweet potato starch bioplastic. Various activated carbon concentrations and glycerin content will be used to formulate this bioplastic.

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 bubbled. 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 24 different sample concentrations for fabricating bioplastics. The table below (refer with: Table 1) shows the sample proportions for the bioplastic, which are numbered from 1 to 24 respectively.

Table 1 *Different Sample Concentrations for Fabricating Bioplastic*

Amount of Activated Carbon	Amount of Glycerin					
	7 mL			11 mL		
0 g	Sample 1	Sample 2	Sample 3	Sample 13	Sample 14	Sample 15
	Sample 4	Sample 5	Sample 6	Sample 16	Sample 17	Sample 18
0.4 g	Sample 7	Sample 8	Sample 9	Sample 19	Sample 20	Sample 21
	Sample 10	Sample 11	Sample 12	Sample 22	Sample 23	Sample 24

2. Characterization

Specific calculations are required for every sample in each variant to compare the different data in each sample. Samples were cut according to each test. The tensile strength was determined by the tensile stress formula provided below, wherein F is the maximum ultimate breaking force, and S is the surface area (refer with: Eq. 1).

$$T = F/S. \quad (1)$$

On the other hand, the percentage (%) elongation was determined by equation 2 below (refer with: Eq. 2), where L_f is the final sample length (mm) while L_0 is the initial sample length (mm)

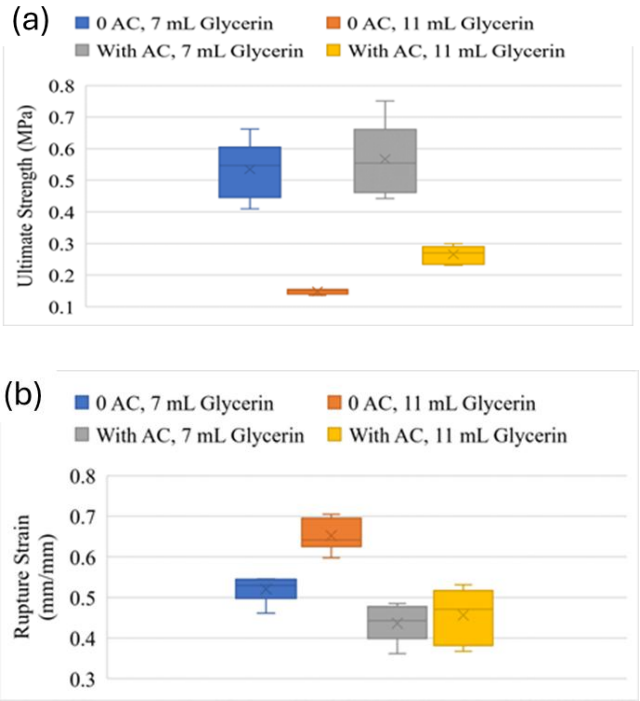
$$A(\%) = [(L_f - L_o)/L_o] \times 100. \quad (2)$$

ASTM D638 is the most common testing standard that involves determining the tensile properties of unreinforced and reinforced polymers in the form of standard dumbbell-shaped test specimens under defined conditions of pretreatment, temperature, humidity, and testing machine speed. This test method can be used to test materials with a thickness of up to 14 mm (0.55 in.). A 3D-printed cutter was used to cut the samples into the correct specimens with ease. Finally, the 24 sample configurations were tested under a Tensile Strength Measurement Test using the Automated Universal Testing Machine (AUTM).

III. RESULTS AND DISCUSSION

The mixtures with activated carbon and 7 mL glycerin consistently exhibited the highest ultimate strengths of all the other mixtures. It is notable that the samples with 7 mL glycerin consistently had higher ultimate strengths compared to those with 11 mL glycerin (refer with: Fig. 1(a)). Additionally, there was a trend indicating that the mixtures with activated carbon were the strongest in terms of ultimate strength than the mixtures without activated carbon throughout the 7 mL and 11 mL glycerin groups. The data for the mixtures with 11 mL glycerin showed more clustering, while the data for the mixtures with 7 mL glycerin were more dispersed, despite having higher strengths. On the other hand, from the box plot (refer with: Fig. 1(b)), it is evident that the sweet potato bioplastic without activated carbon and with 11 mL glycerin demonstrated the highest rupture strains among all the mixtures. Comparatively, the mixtures with 11 mL glycerin displayed higher rupture strains than their counterparts containing 7 mL glycerin. Furthermore, the mixtures without activated carbon exhibited the highest rupture strains across the 7 mL and 11 mL groups.

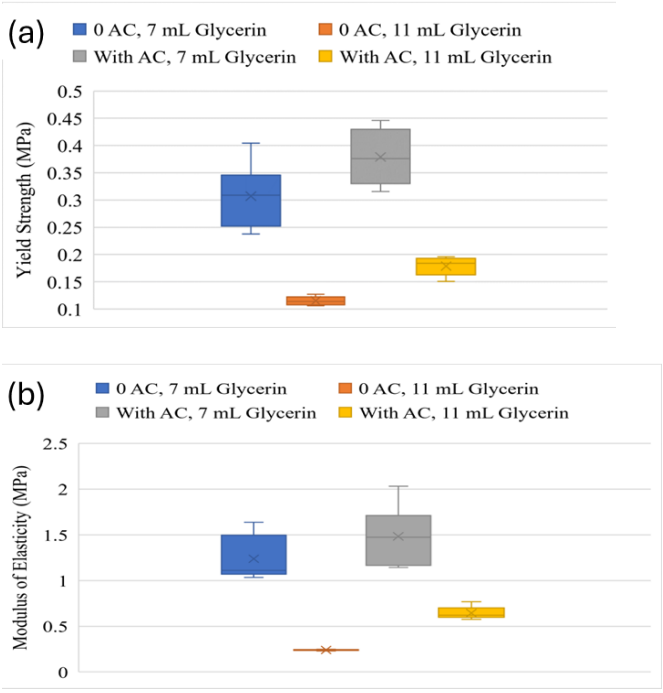
Figure 1 The Bioplastic's (a) ultimate tensile strength, (b) rupture strain



Similar to the data on ultimate strength, the mixtures with 7 mL glycerin consistently exhibited higher yield strengths compared to the mixtures with 11 mL glycerin (refer with: Fig. 2(a)). The mixture with activated carbon and 7 mL glycerin had the highest yield strengths among all the mixtures. The mixture without activated carbon had the lowest yield strengths. Furthermore, the bioplastic mixture with activated carbon and 7 mL glycerin displayed the highest modulus of elasticity among the mixtures (refer with: Fig. 2(b)). Once again, a trend can be observed where the mixtures with 11 mL glycerin exhibit lower

moduli of elasticity compared to their 7 mL glycerin counterparts. The mixtures without activated carbon consistently exhibited the lowest moduli of elasticity in both the 11 mL glycerin and 7 mL glycerin groups. These results are supported also by the densities of the samples where the bioplastic mixture containing activated carbon and 11 mL glycerin exhibited the highest densities among all the mixtures. It can also be observed that the mixtures with 11 mL glycerin generally had higher densities compared to their 7 mL glycerin counterparts. Lastly, the mixtures without activated carbon had the lowest densities among both the 7 mL and 11 mL glycerin groups

Figure 2 *Bioplastic's (a) Yield strength, (b) Modulus of Elasticity*



IV. CONCLUSION

In tensile testing of bioplastic samples, the combination of glycerin content and the presence of activated carbon (AC) significantly influenced the outcomes. The sample with 7 mL glycerin and 0.4 g AC achieved the highest ultimate strength at 0.567 MPa, while the 11 mL glycerin sample without AC had the lowest strength at 0.1483 MPa. Samples with AC generally performed better, indicating AC's positive impact on the bioplastic's structural integrity. The glycerin content also played a crucial role, with 7 mL concentrations outperforming 11 mL concentrations in strength-related tests.

Rupture strains and yield strength tests further highlighted the benefits of AC, as samples with 7 mL glycerin and AC exhibited lower rupture strains and higher yield strength. Moduli of elasticity testing showed significant results for 7 mL glycerin samples, particularly those with AC. In density testing, samples with AC had higher densities, and 11 mL glycerin concentrations produced denser materials than 7 mL concentrations, especially with AC. Overall, the 7 mL glycerin with 0.4 g AC sample yielded the most favorable results across multiple testing areas.

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