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Asian Journal of Plant Science and Research, 2021, 11 (5):171-175

ISSN : 2249-7412
CODEN (USA): AJPSKY

The Potential of Mango Starch and Snake Plant Fibers as Bio-Plastic

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ABSTRACT

Starch is cheap and very widely available natural resources that makes an excellent biodegradable plastic product that can be readily manufactured on existing processing with no modification. The aim of this research is to know the potency of mango seed starch and snake plant fibers as bio-plastic fillers and glycerol concentration as plasticizer on tensile strength and elongation at break, density, and heat resistance.

The samples prepared have three treatments and a control group containing different measurements of the materials. The citric acid addition improves the shelf-life of the material and improves the mechanical properties. The average thickness of the bio-plastics is 0.001 m. The average heat resistance content is 96.7 °C. Meanwhile, the water uptake is 33.3%. The average density of bio-plastic wass found to be 1.19 g/cm³. The maximum tensile strength of the bio-plastics was found to be 1.24 MPa. It was seen that the incorporation of natural fibers show moderate improvement in the tensile properties of the composites. Investigation of the hybridization of proposed starch and snake plant fibers materials with other biomaterials is another scope to consider.

Key words: *Mango starch; Snake plant fibres; Bio-plastic*

Introduction

Environmental degradation has been considered as the top problem in today's epoch of life. These environmental catastrophes have brought millions of life in grave. These problems concerning natural disasters nevertheless have just been a breakdown from a wider planetary distress called climate change.

Climate change has significantly affected the lives of every species in the planet. This scenario may have been associated to the human activities which were a result of apathy, and ignorance.

Based from the study conducted by Laura Parker, human activities such as burning of plastics and fuel may result to a dangerous effect both to life and the world [1]. Another study revealed from its findings that the use of synthetic or non-biodegradable plastics has been the most rampant cause of the pressing environmental issue [2]. It is quite evident that plastic wares are very common in all forms, from kitchen utensils to industrial technology. However, although this life changing invention has impacted the life of humans for scores and decades, its lasting negative effects have been so destructive.

Nonetheless, the concept of the revolutionary life science education has created an innovative product called bio-plastics. Basically, the term bio-plastics came from the word "bio" and "plastic" which means plastics out of biodegradable raw materials from living things. The degradation reaction happening in these bio-plastics after disposal is much higher since that its raw materials are all biodegradable. In all natural forms, degradation reaction happens after a hydrolysis reaction or introduction of water molecule in the chemical reaction.

It is quite beneficial to think that bio-plastics are the answer to augment this environmental awareness campaign. That is the reason why the researchers are very eager to study about the potential of mango starch with snake plant fibers as bio-plastics.

Research Objectives

This study focused on the potential of mango starch with snake plant fibers as bio-plastics. Specifically, this study sought to achieve the following objectives;

1. To test the potential of mango starch with snake plant fibres as materials for bio-plastic.
2. To test the quality of treatments of bio-plastic from mango starch with snake plant fibres based on the following:

- Tensile strength,
- Density,
- Heat Resistance and
- Water Uptake

3. To determine the significance differences between the 3 treatments of bio-plastic from Mango Starch with Snake Plant Fibres.

Materials and Methods

The present study utilized a product development experimental method of research in producing a bio-plastic material made from mango starch and snake plant fibers.

The materials used in this study are ¼ kilo mango starch (starch was first extracted from the mango seed through shredding and decantation process), ¼ kilo snake plant fibers, 1 liter glycerine, 10 ML vinegar/acetic acid and 1 liter water.

The equipment that used in this study were 3 beakers, 3 tripods, 3 alcohol lamps, 3 stirring rods, 1 beam balance, 2 graduated cylinders, 1 thermometer, 1 digital weighing scale, 1 weighing scale.

In order to test the potential of mango starch and snake plant fibers as Bio-plastics, the following procedures were undertaken.

- It will start in the preparation of the materials needed in the production of the bio-plastics.
- The order does not matter. Simply measure all ingredients and mix them together in the pot. Stir until combined, and then turn on stove to low/medium heat. The treatment formulas (percentage of ingredients in treatment 1-3) will be observed since that the experimental design is observed in this study.
- The mixture should be stirred regularly to avoid clumping. It is important to keep the heat low so that the heat is equally distributed throughout (Digital thermometer will be used to keep its temperature maintained. Keep stirring until the mixture thickens.
- Once the mixture is easily scoopable, turn off the heat. Then pour/scoop the mixture into an aluminium foil lined sheet.
- The mixture need to cool a bit before it can be formed. The plastic will begin to harden and does not stick to fingers when touched.
- Resist the urge to touch the finished product throughout the drying process, as it will still be soft.
- Once that the products are already produced, they will be then subjected to testing and evaluation.

Testing

Tensile strength and elongation at break: A tensile test is a fundamental mechanical test where a carefully prepared sample is loaded in a very controlled manner while measuring the applied load and the elongation of the sample over some distance. Tensile strength or ultimate strength is defined as the maximum load that results during the tensile test, divided by the cross-sectional area of the test sample. Therefore, tensile strength, like yield strength, is expressed in MPa. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties.

Density

The density of bio-plastic was investigated by the standard of ASTM D792-91 on film with size approximately 5 × 5 cm. The film's mass was measured using analytical beam balance. Density was calculated as follows.

$$Density = \frac{mass\ (gram)}{Volume\ (cm^3)}$$

Water Uptake

Water uptake was investigated by putting into a container filled with distilled water for 24 h. After immersion in water, the film was removed from the water and weighed to measure the wet weight. Water uptake was calculated as follows:

$$\text{Density} = \frac{\text{Wet weight} - \text{dry weight}}{\text{wet weight}} \times 100$$

Heat Resistance

The heat resistance was calculated when the produced bio-plastics are tested inside a microwave oven. The heat resistance for the produced product of each treatment was subjected to heating until it melted. The melting point at a specific temperature was the basis of the heat resistance.

Results and Discussion

Testing of Tensile Strength

The **Table 1** shows the tensile strength of the bio-plastics. The control has the lowest Mpa (0.26). Treatment 1 and 2 have tensile strength of 0.43 Mpa (36.78 N) and 1.04 Mpa (88.26 N), respectively. Among the treatments, treatment 3 has the highest tensile strength of 1.24.

The differing number value of tensile strength was proved through the use of fibers a structural support. This proves the study of Yang et al. which discussed the importance of fibers as support to plastics in order to carry heavier objects [3].

Testing of Density

Table 2 presents quantitative analysis on the density of bio-plastic in different treatments. Based from the data presented, all of the treatments are the same with the average density of 1.19 g/cm^3. The density values were comparable to an ABS/PC Flame retardant with a maximum density value of 1.19. Based from the study of Singan and Chiang, the density analysis was evaluated to determine its physical properties towards moisture condition [4]. The moister environment is, the higher the biodegradation process. The results related to density and degradation of biopolymers was immensely studied on the work of Chamas et al. yielding similar results [5].

Testing of Heat Resistance

The **Table 3** presents the heat resistance of bio plastic in different treatments. Table 3 presents the Treatment 1 there had 3 trials. The trial 1 in this treatment melted at the temperature of 90.3 °C, t2 and t3 melted at the same temperature of 96.5 °C. The average melting point of Treatment 1 is 94.43 °C. Next is the Treatment 2 also there had 3 trials. The trial 1 melted at the temperature of 92.3 °C, t2 melted at 95.5 °C, and t3 melted at 97 °C. The average melting of point of Treatment 2 is 94.93 °C. Last is the Treatment 3 also there had 3 trials. The trial 1 melted at the temperature of 93.9 °C, t2 melted at 97.1 °C, and t3 melted at 99.1 °C. The average melting point of Treatment 3 is 96.7 °C. Additionally, the thickness and mass of all the treatments are the same. These results prove the study of Peelman N, et al. that the new bio-based polymeric materials, focusing on starch, cellulose, PLA, and PHA are high resistant [6-8]. The highest melting point of a transparent film of bio-plastic is 130 °C, this study's highest melting point is only 96.7 °C.

Testing of Water Uptake

This **Table 4** shows the water uptake in different treatments given the formula used. Each treatment had been put in the container filled with distilled water in 12 h. The wet weight of each treatment is also the same with the weight of 15 g and in dry weight are also the same with the weight of 10 g [9,10]. Based from the study of Singan and Chiang, the water absorption in polymer blends such as starch-based bio-plastic films is important to evaluate the stability characteristics of such films in water that will affect their long-term performance in final products [4].

Using the Analysis of Variance, **Table 5** shows that the significance value of 0.000002 is less than the significance value of 0.05. Therefore, the null hypothesis is rejected. This only implies that there is significant difference between the treatments in terms of tensile strength.

Table 1: Tensile strength of the different treatments.

Treatments	Thickness (m)	Width (m)	Cross-sectional Area (m2) = Thickness x Width	Max. Applied force (lb.)	Max. Applied force (N)	Tensile Strength N/m2 or Pa = F/ area	Tensile Strength MPa
1	0.001	0.085	0.000085	8.27	36.78	10,197,647	0.43
2	0.001	0.085	0.000085	19.84	88.26	1038352.9	1.04
3	0.001	0.085	0.000085	23.7	105.43	1240352.9	1.24
Control	0.001	0.085	0.000085	8.01	22.3	3086505.2	0.26

Table 2: Density of bioplastic of the different treatments.

Treatments	Mass (g)	Volume (cm^3)	Density (*p= m/V*)
Treatment 1	10 g	8.435 cm^3	1.19 g/cm^3
Treatment 2	10 g	8.435 cm^3	1.19 g/cm^3
Treatment 3	10 g	8.435 cm^3	1.19 g/cm^3
Control	10 g	8.435 cm^3	1.19 g/cm^3
Average	10 g	8.435 cm^3	1.19 g/cm^3

Table 3: Heat resistance of bioplastic in different treatments.

Treatments	Volume (cm^3)	Mass (g)	Melting Point (^{0}C)
Treatment 1			
Trial 1	0.4	0.4	90.3 ^{0}C
Trial 2	0.4	0.4	96.5 ^{0}C
Trial 3	0.4	0.4	96.5 ^{0}C
Average	0.4	0.4	94.43 ^{0}C
Treatment 2			
Trial 1	0.4	0.4	92.3 ^{0}C
Trial 2	0.4	0.4	95.5 ^{0}C
Trial 3	0.4	0.4	97 ^{0}C
Average	0.4	0.4	94.93 ^{0}C
Treatment 3			
Trial 1	0.4	0.4	93.9 ^{0}C
Trial 2	0.4	0.4	97.1 ^{0}C
Trial 3	0.4	0.4	99.1 ^{0}C
Average	0.4	0.4	96.7 ^{0}C

Table 4: Water uptake of the different treatments.

Treatments	Time	Wet Weight	Dry Weight	Water Uptake Results
Treatment 1	12 h	15 g	10 g	33.3%
Treatment 2	12 h	15 g	10 g	33.3%
Treatment 3	12 h	15 g	10 g	33.3%
Control	12 h	15 g	10 g	33.3%
Average	12 h	15 g	10 g	33.3%

Table 5: Summary of results of all treatments.

Tensile Strength	Sum of Squares	df	Mean Square	F	Sig. Value	Descriptive Interpretation
Between Groups	1.080	2	0.540	258.622	0.000002	S
Within Groups	0.013	6	0.002	-	-	-
Total	1.093	8	-	-		-

At 0.05 level of significance; S – Significant; NS - Not Significant

Conclusion

The results showed that the samples prepared from the mango starch and snake plant fibers have good biodegradability. Such as,

- The average thickness of the bioplastics is 0.001 m. The maximum tensile strength of the bioplastics is found to be 1.24 MPa. It is seen that the incorporation of natural fibers shows the moderate improvement in the tensile properties of the composites.

- The average density of bioplastic is found to be 1.19 g/cm^3. All the treatments have greatly physical properties towards moisture condition.
- The average heat resistance content was resulted effectively and greatly in Treatment 3 with 96.7 ^{o}C. The greater the starch in the specific measurement of glycerol the higher the melting point.
- The solubility in water or the water uptake is 33.3%. All the treatments had the stability characteristics that will affect their long-term performance in final products.
- From the above test results, it can be concluded that bioplastics can be used as packing materials and can be used as an alternative to LDPE and HDPE plastic straws. The properties of snake plant fibres strongly help the strength of the bioplastic. Due to the obtained properties of bioplastic, it would be interesting to prepare straws using this bioplastic with assumed lower cost. Investigation of the hybridization of proposed starch and snake plant fibers materials with other biomaterials, and with different plasticizers, was an interesting scope for this research.

Acknowledgements

This study was not possible without the cooperation of Bio-plastic group of ONHS STEM club.

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