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Tensile Strength Analysis of Biodegradable Planting Bag Derived from Banana *(Musa Paradisiaca)* Peel

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Abstract:
The study discussed the utilization of banana *(Musa Paradisiaca)* peel incorporated into biodegradable planting bag. The use of banana peel (BP) in this study is mainly to replace the synthetic materials used in the conventional planting bag. Furthermore, the environmental pollutions can be reduced due to the usage of waste banana peels to produce a new value-added biodegradable plastic. The preparation of samples involved several stages where banana peels were isolated from the chaff and chopped into smaller sizes about 2 cm in length. Then, the peels were oven-dried at 70℃ and grinded into the range diameter of 23 mm particle sizes. Dried ground banana peels were then extracted by maceration method and later were incorporated into thermoplastic starch with eight different concentration of BP which are 5 wt.%, 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, 30 wt.%, 35 wt.% and 40 wt.%. Tensile strength test was carried out to analyse the strength and elongation at break of all the samples. Based on the findings, it is apparent that sample with 10% concentration of BP withstand the highest tensile strength of 39.303 MPa.
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1. Introduction

The world today seems unimaginable without plastics or synthetic organic polymer, however their large-scale production and use only dates back to 1950 [1]. The resulting rapid growth in plastics production is remarkable, surpassing most other man-made materials. The largest market for plastic is in packaging application where the growth was accelerated by a global shift from reusable to single-use containers. As a result, the share of plastics in municipal solid waste by mass had been up to 7.8 billion tons by 2015 [2]. At the same time, global solid waste generation, which is strongly correlated with gross national income per capita, has grown steadily over the past five decades [3].

Nowadays, the demand by the societies and environment for more 'greener' materials has brought on innovations in the plastic industry to develop new polymers that are derived from renewable biological resources and also polymers that are conceived as biodegradable [4]. This is because biodegradable plastics are easily decomposed by the microorganisms found in the soil due to the utilization of natural waste resources [5]. In developing countries, organic waste usually contributes highest percentage to the total waste generation where 50% of total generated waste in Malaysia is organic waste [6].

Banana *(Musa Paradisiaca)* peel is an organic waste that is extremely rich in basic nutrients such as carbohydrate, protein and several others that could support microbial growth. At present, banana peels are not being utilized for any purposes but largely being

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disposed as solid wastes at large expense [7]. Without a proper organic waste management, this condition would lead to a vast amount of methane gas production which consequently pollute the environment.

According to previous study, 310,220 tons of methane gas was generated from the landfill site in Peninsular Malaysia in year 2010. It was estimated that the figure would be increased until 350,000 tons in year 2015 and 37,000 tons in year 2020 [8]. Another important aspect for this study was thermoplastic starch (TPS) where tapioca starch was utilised to develop plastics that are described as isotropic, odourless, tasteless, colourless, non-toxic and biologically degradable [9]. Therefore, this research utilised extract banana peels (EBP) and tapioca starch as an alternative raw material to develop a new value-added biodegradable plastic applicable for planting bag application.

2. Materials and methods

Extract banana peels (EBP) and thermoplastic starch (TPS) were utilised to fabricate the biodegradable plastics in different concentrations as shown in the following Table 1.

Table 1. Percentages composition on the mixture of banana peels and matrix tapioca starch

Sample	EBP wt. (%)	Tapioca starch wt. (%)	Glycerol wt. (%)	Distilled water wt. (%)
A	5	5	1.5	88.5
B	10	5	1.5	83.5
C	15	5	1.5	78.5
D	20	5	1.5	73.5
E	25	5	1.5	68.5
F	30	5	1.5	63.5
G	35	5	1.5	58.5
H	40	5	1.5	53.5

2.1 Preparation of extract banana peel (EBP)

Banana peels were isolated and separated from the chaff and were chopped into smaller sizes about 2 cm in length. The peels were dried in the convection oven at 65℃ for 24 hours. Then, the peels were grinded into a diameter range of 0.2 to 0.4 mm particle sizes until they achieve powder-like consistency by using a grinder as shown in Figure 1 [10].

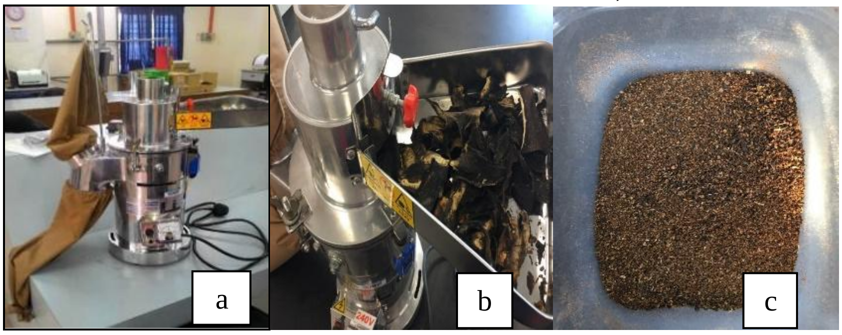

Figure 1. (a) Grinder (b) Grinding process (c) Ground banana peels

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Dried ground banana peels were extracted by Maceration method according to Adilah *et al.* [11], with slight modification. The ground banana peels were macerated in ethanol with ratio 1:10 for 24 hours. Later, the extract of the banana peels was divided into eight sets of different concentration which are 5 wt.%, 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, 30 wt.%, 35 wt.% and 40 wt.% for the fabrication of biodegradable plastics.

2.2 Preparation of thermoplastic starch (TPS) and biodegradable plastics

A mixture of tapioca starch (5 wt.%), glycerol (1.5 wt.%) and distilled water (88.5 wt.%) were used for the development of the matrix TPS. In order to prepare the biodegradable plastic, a fraction of distilled water was replaced by the desired concentration of banana peel extract (10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, 30 wt.%, 35 wt.% and 40 wt.%). The mixture was stirred slowly by using a spatula to ensure both solutions are well mixed until no lumps and bubbles were visibly seen. Next, the mixture was poured into a mould with the size of 7 cm x 5 cm. The mould then was left under the surrounding temperature for 48 hours to dry out the samples. After that, the samples were taken out from the mould and the thickness of the samples were measured by using a Vernier calliper. Eight different samples were prepared with different concentrations of extract banana peels which are 5 wt.%, 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, 30 wt.%, 35 wt.% and 40 wt.%. Tensile strength and elongation at break for all samples were analysed by using Universal Testing Machine (UTM) according to standard method ASTM D638.

3. Results and discussion

The results obtained from tensile strength test that was carried out according to standard method ASTM D638 are summarized as in Figure 2. As can be seen in the graph, it is apparent that the sample with 10% concentration of banana peel withstand the highest tensile strength of 39.303 MPa followed by 15% concentration of banana peel with 38.589 MPa. For samples with 5%, 20%, 25%, 30% and 35% concentration of banana peel, the tensile strengths were 23.772 MPa, 30.635 MPa, 29.963 MPa, 23.055 MPa and 20.856 MPa. Meanwhile, sample with 40% concentration of banana peel displayed the lowest tensile strength of 15.538 MPa. As can be seen from the graph, the tensile strength increases from 5% up until 10% where it exhibited the highest tensile, however, the tensile value started to gradually decreases until the reaches the lowest tensile value.

The potential cause for high tensile strength at low plasticizer concentration could be the domination of strong hydrogen bonds resulted from starch-starch intermolecular interaction over starch-plasticizer attraction. Despite that, there were also numerous studies that contrary to this claim where the tensile strength of starch-based films decreases as the concentration of plasticizer increases. This condition can be explained through the role of plasticizers in diminishing the strong intra-molecular attraction between the starch chains and promoting the formation of hydrogen bonds between plasticizers and starch molecules [12,13].

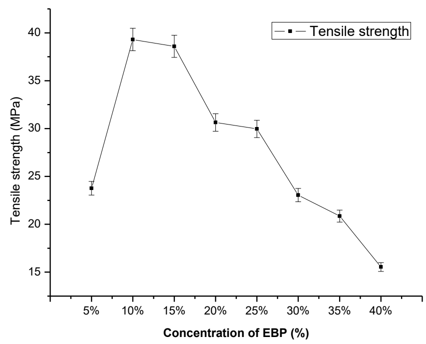

Figure 2. Tensile strength of samples with different concentration of EBP

Figure 3 presents the graph of Young's Modulus against the concentration of banana peel. From this graph, there is a fluctuation in the stiffness of the samples where starting from the lowest concentration of banana peel, there was an increased in stiffness up to 10% with 31.048 MPa. Then, the stiffness dramatically declined to 13.609 MPa followed by a fluctuating trend up to the highest concentration of banana peel. This finding is contrary to that of Pellisari *et al.* [14], who reported that

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Young's modulus of composites should increase upon addition of banana peel as filler. This means that incorporating banana peel into the starch matrix results in strong interactions between banana peel and the starch matrix, which restrict the chain motion of the starch matrix. Hence, the higher the concentration of banana peel, the higher the stiffness of the composite.

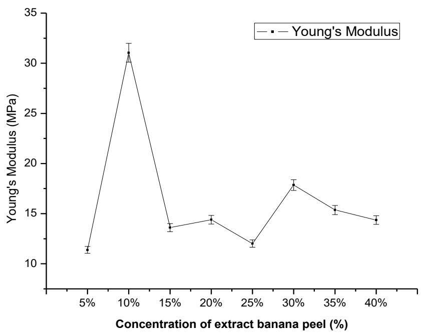

Figure 3. Young's Modulus of samples with different concentration of EBP

Figure 4 illustrates the stress-strain behaviour for each sample with different concentration of banana peel. From this stress-strain curve, it can be seen clearly that sample with 10% concentration of banana peel demonstrated the highest yield strength as compared to the rest of the samples. This proves that sample with 10% concentration of banana peel is very brittle whereas sample with 35% concentration of banana peel that demonstrated the lowest yield strength is very ductile.

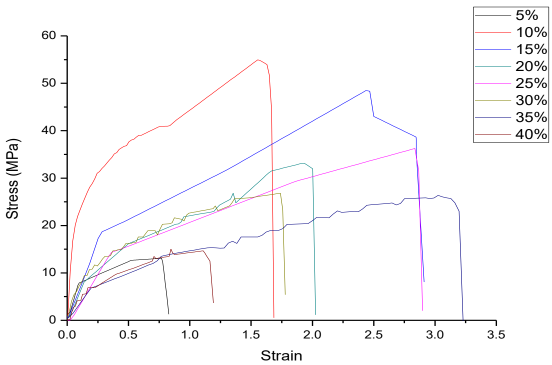

Figure 4. Stress-strain curve of different concentration of EBP

4. Conclusion

From the results, it is discovered that there is a high possibility that banana peels can be utilized to produce biodegradable plastic to be applied as a planting bag as it withstands tensile strength up to 39.303 MPa. This research is significant as it brings forth improvements on the properties of biodegradable plastic based on banana peel for planting bag application. It is found that this biodegradable plastic based on banana peel can give good performance on its mechanical properties. This research is believed to produce a new, improved and low-cost biodegradable plastic based on banana peel for planting bag application.

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