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# Potential Use of Rise Husk as Filler in Poly Lactic Acid Bio-composite: Mechanical Properties, Morphology and Biodegradability

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**ABSTRACT:** About 408,000 metric tonnes of rice husk are produced annually yet not utilised fully. In agriculture, biodegradable plastics are desirable alternative to the current black low densities poly(ethylene) plastic. Therefore, a research on bio-polybag is needed to be investigated their properties of obtained polybag in terms of mechanical properties, surface structure, and biodegradability. The biomasses studied in this research are rice husk (RH) due to their abundance in Malaysia, and polylactic acid were used to mix with the biomasses in different compositions (10%, 30%, 50%, 70% and 90%). Three main tests including tensile strength test, aging test and Scanning Election Microscopy (SEM) were taken place to study the properties. As a result, 30% rice husk: 70% PLA is the best among the ratio, in terms of lower tensile strength, higher elasticity, and shows bigger void and gap. At ratio of 30% rice husk and 70% PLA has the tensile strength of 11.3 MPa, tensile modulus at 322.12 MPa, elongation at break at 3.508%, decomposition rate of 3.3% and SEM analysis showed many gaps yet with maximum used of biomass material. Hence, ratio of 30% rice husk and 70% PLA is the most suitable biomass to use as biodegradable polybag.

**KEYWORDS:** Rise husk; Agricultural waste; Bio-polybag; Poly lactic acid

## 1. Introduction

Since year 1974 production of rice in Malaysia has increase year to year, about 408,000 metric tonnes rice husk produces annually [1]. It is only small amount of rice husk is used for fertilizer and the rest become waste. This action leaks to waste disposal problem and high methane emissions [2]. At the same time, polylactic acid (PLA), the bio-plastic chosen to mix with the biomass is as well biodegradable derived from plant sources such as corn starch and sugar [3]. Meanwhile, polybags used in agricultural today are still non-biodegradable and inorganic, where plastic is the main component that is bringing negative impacts to the environment [4].

According to the standard American Society for Testing Materials (ASTM) D-5488-94d and European Standard EN 13432-2000, biodegradable refers to compounds that decompose into carbon dioxide, water or methane, inorganic compounds and new cell biomass [5]. The polybag targeted in this research is used for plant nursery purpose, it has to be able to support the initial growth of plant until it reaches the matured stage, and decompose fully after that. The time taken for every plant to grow varies from 6 – 12 months [6].

With this, three tests conducted to study the properties of the materials potentially used for the development of bio-polybag: (1) Tensile strength test which is used to determine the tensile strength, tensile modulus and elongation at breaks of the material. The result allows the understanding of biodegradability and the compliance to available product [7], (2) Aging test is an accelerated maturing procedure conducted to determine the duration of biodegradability of material over time, (3) Scanning Electron Microscopy (SEM) is a tool to generate a variety of signals at the structure of the material under a focused beam of high-energy electrons [8].

## 2. Materials and Methods

### *2.1. Materials*

The materials used in the projects were rice husk and polylactic acid (PLA). Rice husk was collected from PLS Marketing (M) Sdn Bhd, a rice process factory at Sekinchan. Polylactic acid was purchased from Sigma-Aldrich (M) Sdn. Bhd.

### *2.2. Sample Preparation*

Samples were prepared based on Yacaab, et al [9]. Prior to use, rise husk prewash by soaking in distilled water for 24 h in order to remove impurities from the materials. The materials were then dried in the oven at 60 $^oC$ and grinded into powder form of size 150 μm then sieves and ready to use.

### *2.3. Experimental Design*

In this study, five ratios of bio-polybags were prepared as shown in Table 1. Briefly, 240 g of each total samples of each ratio had been placed into Haake Polydrive with Rheomix R600/610 with a temperature 180$^oC$ and agitated at 5 rpm for 15-20 min. The mixed samples were proceeded with injection molding using Lotus Scientific LS-2202525. A square-shape mold with length 20 cm and thickness 4 mm was used, temperature was set at 185 $^oC$ and 45 $^oC$ for both controller 1 and 2 during hot and cold press, the overall pressure was at 15 mPa.

**Tabel 1.** Formulations of Rise Husk and PLA composites

| Code | Rice husk composition (wt %) | PLA (wt %) |
|---|---|---|
| 10 rice husk / PLA | 10 | 90 |
| 30 rice husk / PLA | 30 | 70 |
| 50 rice husk / PLA | 50 | 50 |
| 70 rice husk / PLA | 70 | 30 |
| 90 rice husk / PLA | 90 | 10 |

### *2.4. Characterization of Bio-polybag*

Three tests were performed for characteristic analyses of the mechanical and thermal properties of the samples. The tests consist of tensile test, scanning electron microscopy (SEM), and accelerated aging test. In tensile test, tensile strength (MPa), modulus of elasticity (MPa) and elongation to break (%) were determined. The samples were cut into small pieces with dimension of 2.5 cm x 11.5 cm based on ASTM Standards D638 [10] and clamped on the universal tensile strength testing machine [11]. The fibre morphology was observed with the aid of SEM MV2300 (CamScan Electron Optics Ltd., UK) under magnifications of 100x, 200x, 500x and 1000x. Comparison was made with each sample before and after testing. To run aging test, 2.0 grams of sample were fully covered with organic soil and were placed into 100-ml test tube. The samples were then inserted into the Redline by Binder (115V) RI 115 incubator for 10 days at 55$^{o}$C [12]. The change in mass was measured every 3 days, to study the trend of biodegrability.

## 3. Results and Discussion

### *3.1. Tensile Analysis*

Fig. 1 showed the graph of tensile test of rice husk and PLA bio-composites. According to the figure, tensile strength decreased with the increment of composition in biomass. At the ratio of 30% of rise husk were the closest values towards the required value (10.3 MPa), which about 11.3 MPa. The tensile strength of 10% rice husk appear to be the highest at 18.06 MPa. This is mainly due to the high plastic composition at 90% of PLA, and the tensile strength decreases with the increment of biomass composition due to the poor interfacial adhesion between the hydrophobic PLA and hydrophilic fibres [9]. Besides, fibre acted as included filler in the resin matrix, which weakened the composite due to poor interfacial adhesion and obstructed the stress propagation, which leaded to reduction of tensile strength as the filler loading increases [9]. Unfortunately, samples with the ration of 70% rice husk and 90% rise husk were impractical for this test. This graph similar trend with the finding from Yacaab, *et al* [9]. For the tensile modulus test, the increased rise husk ratio had resulted in the decreased of tensile modulus with the closest values to requirement is by 30% rice husk at 322.12 MPa. In term of elongation, there is no trend defined (Figure 1c). The highest elongation is for 30% rice husk. meanwhile rice husk is more brittle where the elongation at break is only 0.742%.

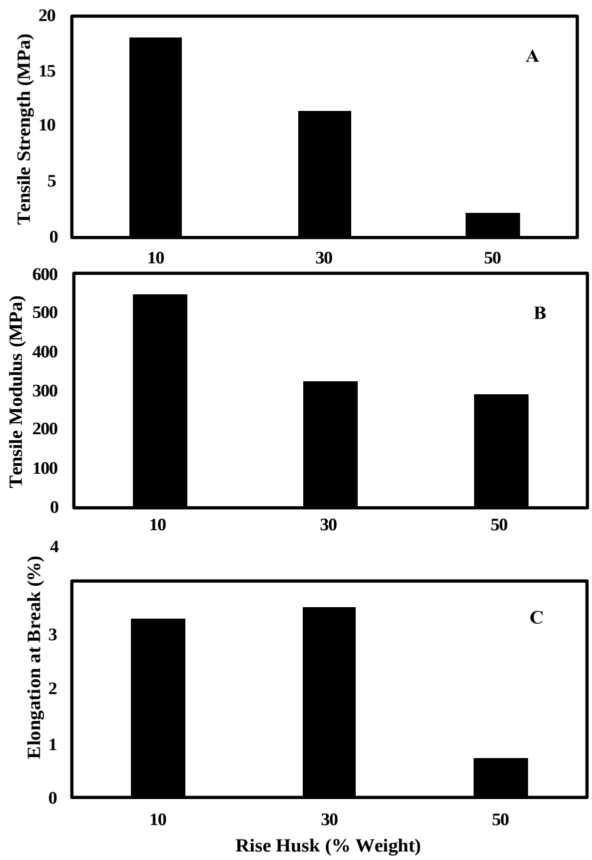


**Figure 1.** Tensile test of rise husk/PLA biocomposite (A) Tensile strength, (B) Tensile modules, (C) Elongation at break.

Based on tensile results, the best ratio to use as polybag was sample with 10% rise husk mixed with 90% PLA. Using a minimum PLA as possible as utilize agriculture waste was the main focus. It is however, 50% rise husk sample had weak strength that might not able to reach the required minimum strength of polybag. Therefore, based on tensile strength with the lease use of PLA, 30% rise husk of sample is the most suitable choice to use as a bio-polybag.

### *3.2. Scanning Electron Microscopy (SEM) Analysis*

SEM analysis of rise husk after tensile test presented the rough surface of rice husk and some gaps in the sample which were contributed to the reduce in strength of sample (Fig. 2). The presence of gaps was evidences of the poor interfacial adhesion resulting from the lack of compatibility between hydrophilic rice husk and hydrophobic PLA. Poor interfacial adhesion can then acted as a stress concentration point upon exertion of external forces and consequently result in premature failure due to poor stress transfer from matrix to the rice husk [9]. Hence, this can prove that samples can more easily to degradable compare with without biomass mixing due to it has many small holes, voids and gaps and the presence of voids and gaps are evidences of the poor interfacial adhesion resulting from the lack of compatibility between hydrophilic rice husk and hydrophobic PLA.

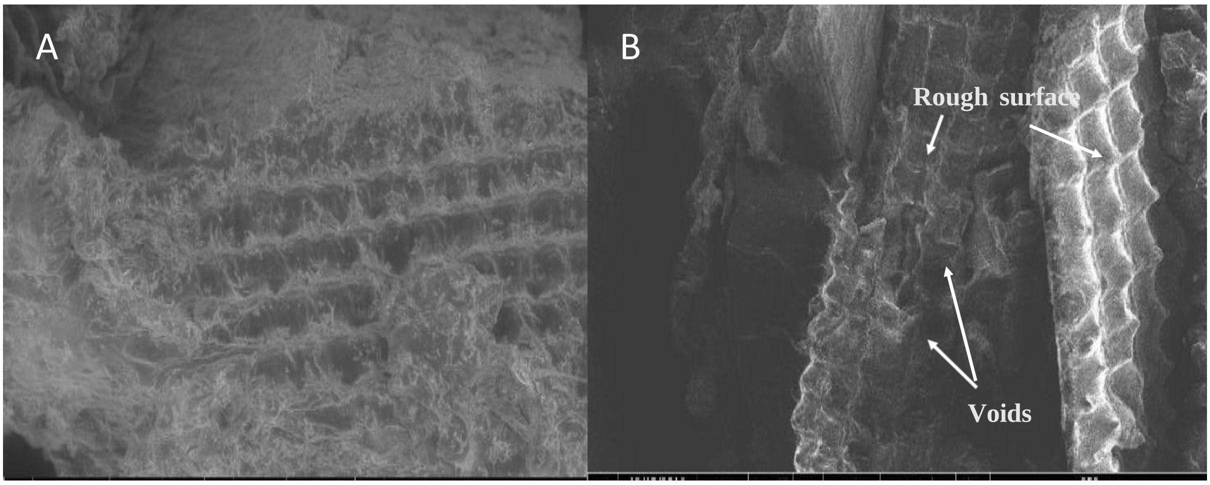


**Figure 2.** The view of 30 % rice husk, 70 % PLA at 500× under SEM (A) before tensile test, (B) after tensile test.

### *3.3. Accelerated Aging Analysis*

In order to understand the biodegradability and aging property, the change in mass over time was determined. Fig. 3 illustrated the trend of mass change after 9 days were decreased with the highest total weight loss was at ratio of 30% rise husk and 70% PLA (3,3%), however slight increment was occurred in day 3. This might due to oxygen uptake and the consequent increase of wettability, influencing the mass to be increased at the first place [13]. Based on results conducted, rise husk/PLA bio-polybag was proved that it can be biodegradable and it can more easily to degradable and shorten the durability performance of degradable. Because of the low brittle, it was suitable for using it to produce polybag.

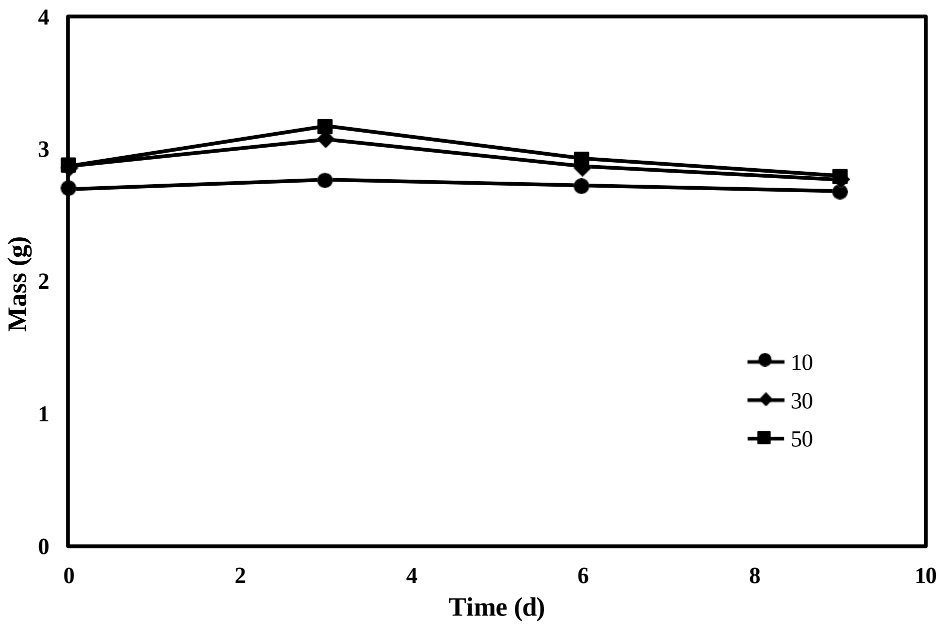


**Figure 3.** Mass Changes of Bio-composite during Accelerated Aging Test

## 4. Conclusions

In today market, the used and develop of biodegradable bag is growing larger and popular. In this study, we utilized rice husk for a biodegradable polybag instead of being dump and caused environmental problem. From the results, the tensile strength and tensile modules decreased by the increased of rise husk's ratio. While there was no defined trend in elongation. At the ratio of 30% rice husk and 70% PLA was chosen as optimum ratio for bio-poybag production. Through mechanical, morphology and biodegradability test, it has closed to the requirement for bio-polybag. The tensile strength of 11.3 MPa, tensile modulus at 322.12 MPa, elongation at break at 3.508%, decomposition rate of 3.3% and and SEM analysis showed many gaps yet with maximum used of biomass material. Hence, the rise husk biomasses have the potential to be used as a source to create bio-polybag.

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## Competing Interest

The authors declare that they have no known competing interests.

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