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Hybrid-Biodegradable Film Made From Polylactic Acid

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***Abstract:** In this experimental study, the biodegradability of PLA/EFB film with two different mixings; with and without lemongrass fibers (LG) were investigated by the landfill degradation. PLA/EFB film without the presence of lemongrass fibers showed the most significance of weight loss compared to the samples with the presence of lemongrass fibers. The highest weight loss percentage recorded in PLA:EFB:LG was in ratio 3 which is 8.42%. Meanwhile, in PLA:EFB, the highest weight loss percentage was recorded in ratio 3 (32.05%) and the lowest was in ratio 4 (19.22%). Ratio 1 acted as the comparison parameter in both composites mixing. Four different ratio of PLA/EFB showed significance improvement in Young's modulus with ratio 4 had the highest reading (1492.2 MPa) and ratio 2 with the lowest reading (1021.1 MPa). In MOR, ratio 2 exhibited the highest reading (30.14 MPa) while ratio 4 with the lowest reading (9.49 MPa).*

***Keywords:** Bio-composites, Lemon grass, Anti-microbial, Empty fruit bunches, Poly lactic acid.*

I. INTRODUCTION

Plastics can be created from three common sources of raw material; petroleum-based resources (oil and natural gas), bio based resources (plant) and blending of petroleum-based and bio based resources (i.e. a 50% bio based product). According to ASTM, biodegradable plastic or film or polymer is defined as conversion of all organic carbon in a plastic into biomass, water, carbon dioxide, and/or methane naturally with a consistent timeframes and ambient conditions of the disposal method. Aligns with the topic research in producing a biodegradable film, empty fruit bunches (EFB) had been adopted to achieve this. Biomass is defined as biological material derived from living organisms. In agriculture, it is simply the organic waste left behind. In an oil palm plantation, the biomass consists of every part of the palm tree that is not been utilized in producing palm oil such as fronds, trunk, empty fruit bunches, shells, fiber and palm oil mill effluent. Polylactic acid (PLA) is a thermoplastic polymer made from lactic acid and has vast application in biodegradable products such as plastics bags and planting cups (Oksman et al., 2003). PLA can also be used as a matrix material in composites. The use of natural additives had been considered as one of the key in the development of new multifunctional materials.

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The addition of additives could help in improving the food packaging materials in term of mechanical, barrier, antioxidant and antimicrobial properties (Valdés et al., 2014). In this research, the lemongrass powder will be used in providing an antimicrobial property to biodegradable film specifically towards Escherichia coli. This bacterium is known to cause food poisoning. This research sole purpose is to study the biodegradable film made from polylactic acid (PLA) and empty fruit bunches (EFB) with anti-microbial features.

II. RESULT AND DISCUSSION

Modulus of rupture (MOR) is a mechanical parameter for brittle material that determined the material's ability to resist deformation under load. The higher the MOR value shows the higher resistance of a material to break. In Figure 1, ratio 2 had the highest MOR value compared to ratio 4 by 20.65 MPa (59%) with 30.14 MPa in ratio 2 and 9.49 in ratio 4. Comparing the result obtained to the control sample i.e. ratio 1, ratio 2 proved a significant improvement in MOR by 16.4 MPa (47%) while ratio 4 showed a reduction by 4.25 MPa (12%). The addition of EFB fibers will not improve the tensile strength. A possible explanation of this can be an indication of poor adhesion between the EFB fibers and the PLA matrix. The stress is not transferred from the matrix to the stronger fibers. A study by Oksman K. *et al.* (2003) on the mechanical properties of PLA/flax composites had also shown a decreased in tensile stress value by 13% (9 MPa) between PLA/flax with a 30 wt.% (53 MPa) and PLA/flax with a 40 wt.% (44 MPa). Thus, by comparing to his work, it can be said by increasing the fibers, it will not improve the tensile strength.

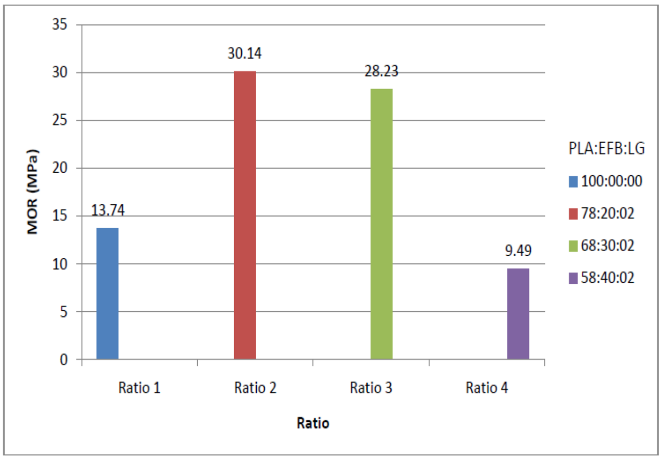

Figure 1. Modulus of rupture in MPa for four ratios.

In Figure 2, ratio 4 showed the highest young's modulus value with 1492.2 MPa while ratio 2 showed the lowest value, 1021.1 MPa.Young's modulus is a measure of stiffness of an elastic material and is used to describe the elastic properties of materials when they are stretched or compressed. Young's modulus is equal to the longitudinal stress divided by the strain. The higher the young's modulus value, the elastic the material is. By comparing both values with ratio 1, both showed an improvement in elasticity with ratio 4 showed a significant increment by 36% while ratio 2 with an increment of 6%. There was an increased by 29% from ratio 1 to ratio 4. A study by Ochi (2008) on PLA/kenaf composites with different fibers proportion showed an improvement with tensile and bending strength as well as Young's modulus linearly up to a fiber content of 50%. Pan *et al.* (2007) produced PLA/kenaf composites with different fibers mass ranging between 0% and 30%. And at 30%, the tensile strength improved by 30%. The improvement in young's modulus can be explained due to good fiber orientation during the compression molded process. It can be concluded that, with the addition of fibers, it can improved the young's modulus of the composites.

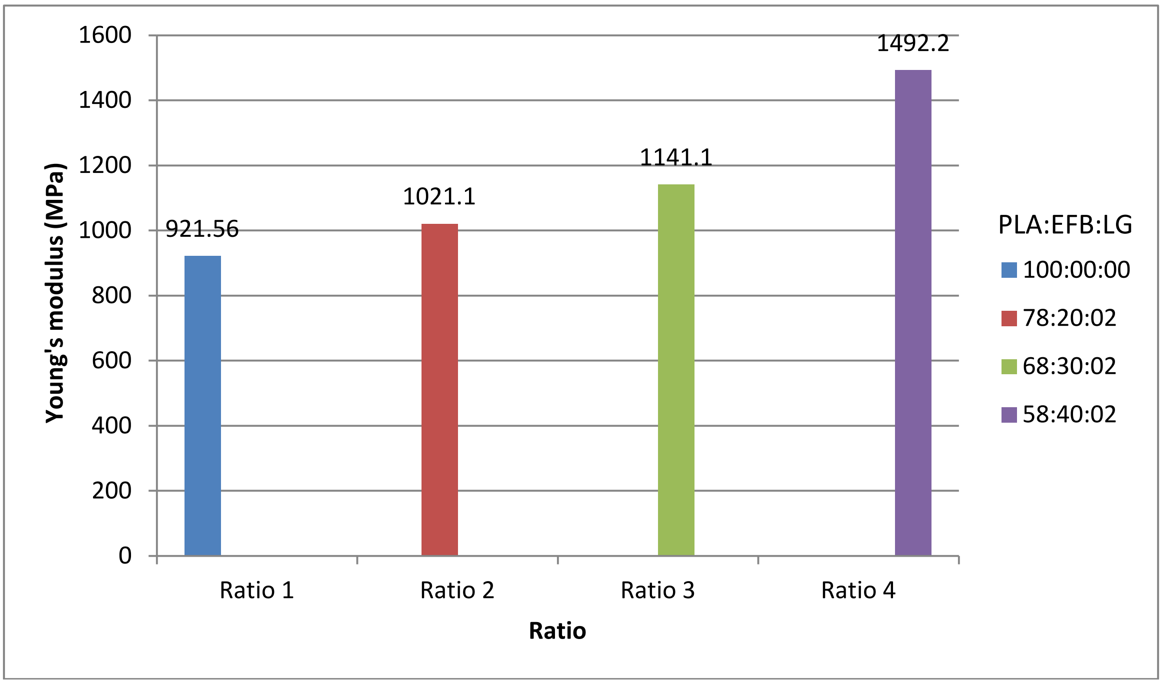

Figure 2.Young's modulus in MPa for four ratios.

III. LANDFIL DEGRADATION TEST

For most biodegradable materials, especially artificial polymers, passive hydrolysis is the most important mode of degradation. Microorganisms such as bacteria and fungi are involved in the degradation process too.

The weight losses were consistently measured for every two weeks within two months. The soil pH was measured in a range of 5.8 to 6.4 and the soil moisture was in a range of 2 to 4. Both pH and moisture were measured by pH and moisture soil meter. The weather conditions were ignored throughout the testing. This testing was conducted with two different blending ratios; with and without the lemongrass fibers to investigate the effect of lemongrass in the degradation rate. Table 1 showed readings samples on each four ratio throughout the testing burial period i.e. eight weeks.

Table 1.Weight loss readings for four PLA/EFB ratios with lemongrass fibers in grams by week.

Ratio	Week					Percentage weight loss (%)
	Week 0 (initial) W_i (g)	Week 2 W (g)	Week 4 W (g)	Week 6 W (g)	Week 8 W_f(g)	
100:00:00 (control)	2.6560	2.6512	2.6467	2.6475	2.6463	0.37
78:20:02	2.9231	2.9170	2.9123	2.8884	2.8795	1.49
68:30:02	3.3005	3.0953	3.0935	3.0508	3.0226	8.42
58:40:02	3.1703	3.15028	3.1221	3.0802	2.9194	7.91

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Figure 3.Weight loss readings for four PLA/EFB ratios with lemongrass fibers in gram by week.

In Figure 3, there were no dynamic fluctuated in the weight loss for the entire ratio. The line graph showed a steady declined in weight loss with ratio 3 had the highest percentage, 8.42% as tabulated in Table 1 as compared to ratio 1; 0.37% while ratio 2 had the lowest percentage weight loss with 1.49%. The percentage difference between the highest (ratio 3) and the lowest (ratio 2) in weight loss was 6.93%. Meanwhile, comparing them to the control sample (ratio 1) was 8.05% with ratio 3 and 1.12% with ratio 2. In theor y, the higher the fiber ratio content, the higher the rate of degradation. However, ratio 4 with the highest fiber ratio content showed a decreased in weight loss by 0.51% after an increasing trend from ratio 2 to ratio 3. But, since the decreased value was not significance, the decreasing weight loss percentage can be neglected.

Table 2: Weight loss readings for PLA/EFB ratios without lemongrass fibers in gram by week.

Ratio	Week					Percentage weight loss (%)
	Week 0 (initial) W_i (g)	Week 2 W (g)	Week 4 W (g)	Week 6 W (g)	Week 8 W_f(g)	
100:00:00 (control)	2.6560	2.6512	2.6467	2.6475	2.6463	0.37
80:20:00	2.8994	2.7824	2.6189	2.4629	2.2414	22.69
70:30:00	3.3114	3.344	2.9905	2.7191	2.2502	32.05
60:40:00	3.1891	3.1189	3.0021	2.6895	2.5760	19.22

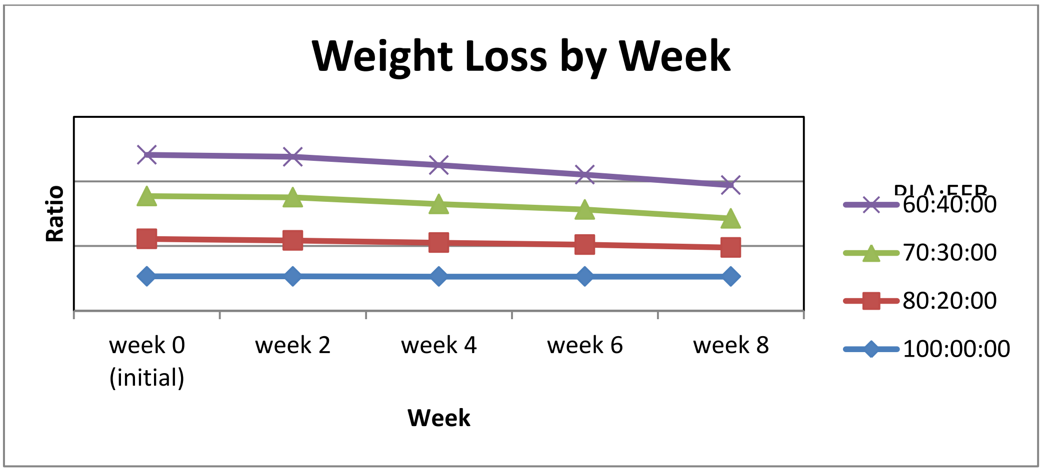

Figure 4.Weight loss for PLA/EFB ratios without lemongrass fibers in gram by week.

In Figure 4, there were significant fluctuated in the weight loss for ratio 3 and ratio 4. The line graph showed a steady declined in weight loss with ratio 1 and ratio 3. Ratio 3 had the highest percentage weight loss; 32.05% as tabulated in Table 4.3 as compared to ratio 1; 0.37% while ratio 4 had the lowest percentage weight loss with 19.22%. The percentage difference between the highest (ratio 3) and the lowest (ratio 4) in weight loss was 12.83%. Meanwhile, comparing them to the control sample (ratio 1) was 31.68% with ratio 3 and 18.85% with ratio 4. Ratio 4 showed a decreased in weight loss percentage by 13% after an increasing trend from ratio 2 to ratio 3.

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The addition of EFB fibers will not improve the degradation weight loss. A possible explanation of this might be due to the optimum fiber ratio achieved by ratio 3 resulting in no more increment in weight loss beyond this ratio.

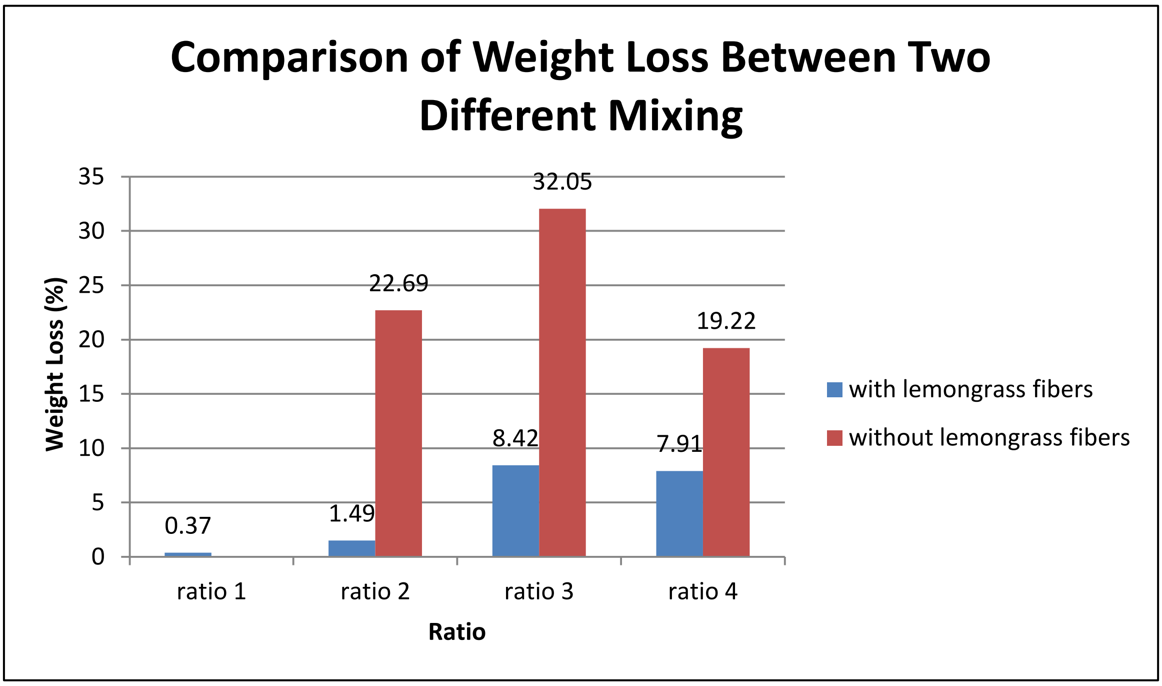

Figure 5.The weight loss comparison in percentage for four PLA/EFB ratios with two different mixing; with and without the presence of lemongrass fibers.

Figure 5 showed a comparison of weight loss between two different mixing; with and without the presence of lemongrass fibers. From the bar chart constructed, it can be concluded that there was a significance difference in weight loss with the different mixing. PLA/EFB without the lemongrass fibers had higher percentage weight loss with ratio 3 was the highest percentage (32.05%) then, the lowest with ratio 4 (19.22%). On the other hand, PLA/EFB with the presence of lemongrass show a minimal weight loss with ratio 3 was the highest percentage (8.42%) and the lowest was ratio 4 (7.91%). Ratio 1 was presented as a control sample or comparison. The presence of lemongrass fibers in PLA/EFB films had been proven to have a significance difference in weight loss during degradation test. Lemongrass had been known for its antimicrobial property thus, it inhibit the bio agents presence in the soil such as bacteria to aid in the composite biodegradation.

In biodegradability of wood fiber/ polylactic acid composites studied by Guo W. *et al.* (2012), the molecular weight of polylactic acid in wood fiber/ polylactic acid composites decreased more as compared to 100% polylactic acid specimens that had undergo soil burial for 6 months. Another study conducted by Tserki V. *et al.* (2003) on effect of compatibilization on the performance of biodegradable composites using cotton fiber waste as filler showed that polybutylene succinate (PBS) composites with 40 w% cotton fibers degrade faster than pure PBS in a soil burial test. Study on biodegradability of bio-flour filled biodegradable polybutylene succinate biocomposites in natural and compost soil by Kim H.S. *et al.* (2006) showed that rice-husk flour (RHF)/PBS composites were improved with the increasing RHF due to the ease of microorganisms attacked to RHF.

IV. CONCLUSION

The presence of lemongrass fibers in PLA/EFB films had been proven to have a significance difference in weight loss during degradation test. The highest percentage weight loss recorded was 32.05% in ratio 3 (70:30:00) without the presence of lemongrass. Meanwhile, with the presence of lemongrass fibers, the highest percentage weight loss recorded was only 8.42% in ratio 3 (68:30:02). There was a difference of 23.63% between the highest percentage weight loss with and without the presence of lemongrass. The difference in weight loss can be explained by the presence of lemongrass fibers itself that affecting the biodeterioration. The lowest percentage weight loss recorded were 19.22% in ratio 4 (60:40:00) without the presence of lemongrass and 1.49% in ratio 2 (78:20:02) with the presence of lemongrass. Young’s modulus was one of the most important data obtained that was used to describe the elastic properties of materials when they are stretched or compressed. Ratio 4 exhibited the highest young’s modulus with 1492.2 MPa while ratio 2 showed the lowest value with 1021.1 MPa. However, all ratios showed a significant improvement in elasticity when compared to ratio 1 with the addition of fibers. The trend in young’s modulus readings were increased as the fiber ratio increased.

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