Effect of Oyster Mushroom on Biodegradation of Oil Palm Mesocarp Fibre

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***Abstract*—**Degradation of agricultural residues from palm oil industry is increasing due to its expansion. Lignocelloulosic waste from these industry represent large amount of unutilized resources, this is due to their high lignin content. Since, white rot fungi are capable of degrading the lignin, its potential to degradation was accessed for upgrading it. The lignocellluloses content was measured before and after biodegradation and the rate of reduction was determined. From the results of biodegradation, it was observed that hemicellulose reduces by 22.62%, cellulose by 20.97% and lignin by 10.65% from the initials lignocelluloses contents. Thus, to improve the digestibility of palm oil mesocarp fibre, treatment by white rot-fungi is recommended.

***Keywords*—**Biological, fungi, lignocelluses, oil palm.

I. Introduction

LIGNOCELLULOSIC waste is produced in large quantity by different industries. These potential valuable waste are treated as waste in many part of the word and it is still regarded as such in many developing countries which raises many environmental concern [1]. In some countries, there have been significant effort of converting this waste to valuable products, but the major constraint of using them is due to its lignocellulose nature. A palm oil mill industry produces waste after extraction of the crude palm oil. However, over 6.0 x 10^2 million of tons of harvestable palm oil biomass is being produced worldwide annually [2] , but, only about 10% of these are used as finished product, other remaining are discarded as waste which includes mesocarp fibres, empty fruit bunch, fronds, trucks, kernels, palm oil mill effluent

But, these wastes can be converted to a valuable product but due to its lignocellulose content is usually being avoided because when converted to any valuable product results to low yield of the expected product. The primary challenges of converting it by biological method is due to lignocellulose contents which consists three major components; cellulose, hemicellulose and lignin. The presences of these components bring about low yield due to low accessibility of (micro) crystalline cellulose fibres and presences of lignin and hemicellulose on surface of cellulose, which prevents cellulase from assessing the substrate efficiency [3].

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Oil palm mesocarp fibre is readily available in Malaysia but due to its non-easily degradation is hardily used for generation of renewable energies. Since, the world present economy is highly dependent on various sources of energy [4] and oil palm mesocarp fibre can be valuable in this resources. It can be used as a substrate for the cultivation of edible mushroom. In a research conducted by Saidu *et al* [5] shows that white rot fungi can be culture on oil palm mesocarp fibre and it produced edible mushroom (*Pleurotusspp*). White rot fungi degradation is performed by complex mixtures of celluloses [6], hemicelluloses [7] and ligninase [8], [9]. Since fungi obtained its nutrient during decomposition of agricultural by-product, during this process the lignin are being used as feed for fungi which leads to reduction of lignocellulose materials.

Due to its abundance and renewability, there has been a great deal of interest in utilizing lignocellulose oil palm mesocarpfiber inclusive for production and recovery of many value-added products [10]-[12]. Many products can be recover from oil palm mesocarp fibre just like any other lignocellulosic material including activated carbon, biogas, ethanol, animal feeds, fertilizer and other miscellaneous products [13], [14]. Apart of producing these products, it is also a source of environmental waste removal [15], but due to its longer period of hydrolysis the usage is not much compare to other raw materials. However, fungi and bacteria have been heavily exploded for their abilities to produce a wide range of cellulose and hemicellulases. Therefore, since fungi are capable of producing cellulases and hemiscellulases which are secreted to the medium for easy extraction and purification [16]. Hence, cultivation of oil palm mushroom using oil palm mesocarp fibre as a substrate has an impact on the biodegradation of the materials, and brings about improvement of digestibility [17]. The aim of this research was to determine the potential of using edible mushroom (*Pleurotusspp)* for biological treatment of oil palm mesocap fibre to enhance degradation.

II. Materials and Methods

a. Fungi Strains and Culture Media

The fungi strains culturing was conducted at Mushroom Ambra Biotech SdnBhd, Kulai Jaya, JohorBahru, Malaysia. The culturemediaof*Pleurotus spp*. was prepared as explained by [5]. Pure culture of *Pleurotusspp*for the spawn preparation was prepared on Wheat grain and the procedure by Patil *et al* [18]for spawn preparation was adopted. Therefore, grains were covered by the mycelium which rapidly colonizes the substrate [19].

b. Substrate Preparation for Cultivation

The oil palm mesocarp fibre used for this research was collected from Tai Tak Palm Oil Mill, Kota Tinggi, Johor State, Malaysia. The substrate was spread to dry and the impurities were removed manually, it was then milled my electric miller to reduce the particle size of <2 mm. A total of 10 kg was used and mixed to different ratios as shown in Table I: Sample A (100% mesocarp fibre), sample B (88 %, mesocarp fibre, 10 % rice bran and 2 % lime), Sample C (85% mesocarp fibre 10% rice bran, and 5% lime), and Sample D (50% mesocarp fibre, 38 % saw dust, 10% rice bran and 2% lime). The constituents of each sample were thoroughly mixed. Rice bran was added to balance carbon / nitrogen ratio and lime to maintain the pH of the mixture. The mixture was then transferred to polypropylene bags of 15 by 30 cm long. The top of the bags were fitted with PVC necks, which served as the opening, and then covered with brown paper. The bags filled with the mixture were taken to the autoclave and sterilized at 130°C for 4 h. After sterilization, the bags were left to cool and later inoculated with prepared spawn; 20 g of spawn to 1.3 kg of the mixture. The bags were then marked and stored on the shelf with an indirect sun light at a temperature of 26°C under 80 to 85% relative humidity.

c. Biodegradation Measurement

The lignocellulose contents determination was conducted at the Environmental Engineering Department Laboratory of universitiTeknologi Malaysia. The analysis was carried according to Datta[20] method and as modified by Arora and Sharma[21]; 1 g of lignocelluloses shredded material was suspended in 100 ml distilled water and maintained at 100^{0}C for 2 hours in a water bath and filtered on a tare crucible, the residue was dried at 90^{0}C till constant weight. Weight loss was considered as water soluble part. Dry residue was suspended in 100 ml of 0.5 M H_2SO_4 and also maintained for 2 hours at 100^{0}C in a water bath, the contents was filtered, dried and weighed as described above and the loss in weight was term the hemicelluloses content. For cellulose and lignin estimates, 10 ml of 72% (v/v) H_2SO_4 was added to the above dry residue and maintained at 30^{0}C for 1 hour on a rotary shaker at 200 rpm. After incubation the mixture was diluted up to 4% of H_2SO_4 and autoclaved at 1.06 kg/cm^2 for 40 min. The content was filtered, dried and weighed. The loss in weight was recorded as cellulose and the remainder residue considered as lignin. The same procedure was performed on the culture substrate to determine the loss in hemicelluloses, cellulose and lignin and percentage loss was determined.

III. Results and Discussion

Lignocellulose complex in oil palm mesocarp fibre (OPMF) and other plants residue is degraded very slowly by ruminants because of the physical barrier imposed by lignin polymers, which prevents free access of hydrolytic enzymes such as cellulases and hemicellulases to their substrates [22]. Hence, hemicellulose degradation is required before efficient lignin removal can commence. The mean initial pH of the mixed substrate was 10.6, but, after disinfection and during the mycelium growth the pH drop to 7.7 which was due to microbial activities which is making the carbon-nitrogen ratio to balance. Usually pH during culturing is an index of fungal activity and vice versa [17]. The mycelium growths of the different mix ratio are shown in Table I below. From the results it shows that samples C and D moves faster than sample A and B during the mycelium running time. But, sample C running time was faster during the third week, which indicates that the mixtures in these samples were better.

However, sample A shows a slow spawn running time compared to other samples, this is due to non-addition of other substrate and lime to balance C/N ratio and pH [23], since, the lignin, C/N ratio and N contents of residue normally affect the rate of decomposition [24], [25]. From the colonization rates, the mycelial growth rates in samples B and C were found to be best for substrate mixture for Oyster mushroom (*Pleurotusspp*) culturing on palm oil mesocarpfiber. The effect of using a substrate that has non-mixture shows a slow mycelium running time.

TABLE I
WEEKLY SPAWN RUNNING TIME WITH DIFFERENT MIX RATIO

Sample	Mix ratio (%)	Mycelium running per week (cm)				
		1st week	2nd week	3rd week	4th week	5th week
A	100 (MF ONLY)	4.00	5.50	5.60	5.78	5.86
B	88:10:2 (MF:RB:L)	5.5	14.00	21.20	25.30	27.00
C	85:10:5 (MF:RB:L)	6.4	14.3	21.30	25.50	27.10
D	50:10:38:2 (MF:RB:SD:L)	6.20	13.80	21.0	25.40	26.90

Note: MF, Mesocarp fibre; RB, Rice bran; SD, Saw dust; L, lime.

Biodegradation pattern of palm oil mesocarpfibrr during biological pretreatment with *Pleurotusspp*were evaluated. The spectrum of mesocarp fibre pretreatment with *Pleurotusspp*revealed a proportional decrease in the lignocellulose contents. From Fig. 1, the raw lignocellulosemesocarp fibre shows 35.1% of hemiscellulose, 29.95% of cellulose, and 21.62% of lignin. Since, hemiscellulose, cellulose and lignin are the main constitutes of lignocellulose materials, but, it still has some primary polymers. Hemiscellulose is heteropolysaccharide composed of different hexoses, pentoses, and glucoronic acid, which makes it more soluble than cellulose and lignin, is highly irregular and soluble polymer consisting of phenylpropanoid sub unitsnamely*p*-hydroxyphenyl (H-type), guiacyl (G-type), and syringyl (s-type) units.

Therefore, the results of the biological degradation of the OPMF shows from Fig. 1 that there was reduction on the content of hemiscellulose, cellulose and lignin. According to Waldrop *et al* [26], lignocellulose is not dependent on environmental conditions alone, but also the degradation capacity of microbial population. Hemicellulose shows 10.91% remaining on the substrate which indicates 24.17% reduction, the pattern of hemicellulose degradation of cellulose, since biodegradation reduced the cellulose content by 29.97%.

Lignin degradation by white rot-fungi (*Pleurotusspp*) is an oxidative process and phenol oxidases fare the enzymes [27],

[28]. The lignin reduced after the biodgradation by 10.65% which indicate that the lignin content has been reduced and the hemicellulose and cellulose are now expose to any form of degradation. The enzymes act and remove hemicellulose-lignin association, without mineralization of the lignin [29], but, lignocellulose is essentially a race between cellulose and lignin degradation. It shows that the treated OPMF can better hydrolyze and converted to other usage than untreated one. The removal of lignin gives a better accessibility for cellulose degradation. And these results confirm the finding of Bisaria *et al* [30]. Hence, it shows a better degradation within the period of fungi cultivation. Since lignin is responsible for integrity, structural rigidity and prevention of swelling lignocelluloses [31].

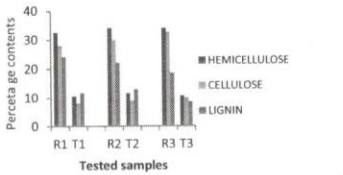

Fig. 1 Level of biodegradation of lignocellusic materials

The degradation of POMF by *Pleurotusspp*which resulted to average of about 10% reduction of lignin after 30 days of incubation is a selective system of degradation by the fungi. Results presented in Fig. 1, together with spawn running time suggested that the edible mushroom grown the POMF play an important role in lignin degradation.

IV. Conclusion

Due to an increase in palm oil production in Malaysia, more are produced which contribute to environmental problems, their bioconversion potential are problems because of ligninocellulose content. Treating of these agricultural wastes, before any bioconversion, aid in reducing the lignocellulose of the materials. The research serves as a system of upgrading lignocellulosic waste. One potential of is the production of edible mushroom (*Pleurotus spp*) which also improved the digestibility of the substrate.

V. References

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