Effects of different biomass on the properties of *Pleurotus Djamor* eco-friendly foam

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Abstract. Plastic waste and polyurethane foam are major sources of pollution that threatens environments' biodiversity. The objective of the study is to create an eco-friendly foam from *Pleorotus djamor* mycelium, rice husk and sugarcane bagasse. The mushroom industry's overabundance of materials, like oyster mushrooms and biomass, has provided an alternative method to make foam that could be beneficial for the environment. The biomass, consisting of rice husk and sugarcane bagasse, both of which are necessary for the production of foam, was evaluated as a substrate. *Pleurotus djamor* was inoculated on both substrates and test was done on both produced foams. Mechanical tests showed that rice husk foam had higher hardness and less springy than sugarcane bagasse foam. The morphology of both foams was analyzed using a scanning electron microscope (SEM), and the results show that sugarcane bagasse foam is denser than rice husk foam.

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1 Introduction

In the last 50 years, people have used a lot more polymers and plastics. In some cases, these petrochemicals have been partly replaced with natural materials like wood, cotton, paper, wool, and leather, among others [1]. Due to the fact that expanded polystyrene (EPS) is unable to break down in its natural state, it is still being used extensively and leads to a lot of plastic waste, which has caused a lot of damage to the environment and create pollution. Furthermore, polyurethane (PU) is a malleable material with high resistance to environmental. Currently, researchers are focusing on polyurethane biodegradation as a possible solution to polyurethane pollution [2]. However, another solution could be by replacing polyurethane with eco-friendly foams. The biodegradability of the biomaterial's lifespan and the massive amount of biomass might ensure enhanced waste management in the future with effective application, similar to how waste can be used as a raw material or substrate [3].

Biomass, are the byproducts of the production process and are defined as residues from the cultivation and processing of raw agricultural product. In spite of the fact that rising agricultural output helps the Malaysian economy develop, it has an adverse effect on the environment since it generates more biomass waste. Biomass can be used to make substrates for growing fungi, which helps cut down on the amount of waste. In the meantime, it could be made into a new product called eco-friendly foam, which has a lot of economic value because of how it is made and what it is made of. Lignocellulosic wastes or biomass like paddy straw, rice husk, plant straw, and plant bagasse are often used to grow *Pleurotus* species mushrooms [4].

It has been suggested that biomass, such as rice husk and sugarcane bagasse, be utilized in the production of environmentally friendly foam to address problems caused by the overabundance of plastic trash and the accumulation of biomass. Hence in this study, growing oyster mushroom (*Pleurotus djamor*) in biomass results in eco-friendly foam. The oyster mushroom was chosen for this research because of its special features, including its rapid growth rate, low water and space needs, and high demand in the market [5]. Besides, because of its rich bioactive chemical content, oyster mushrooms are extremely valuable as a food source [6].

Fungal foam is produced by following a few simple steps, including selecting the substrate and fungi to be utilized. Within a certain period of the cultivation, it is very vital to encourage the growth of the fungi such as monitoring the growth and the environment. Foam was created by mixing fungus mycelium with substrates made of lignocellulosic materials such as biomass. The properties of the final product, however, will vary depending on the fungus and substrate employed, as well as the growing conditions, cultivation method, and habitat in which it was grown [7]. Mycelium is a natural adhesive and binding agent and as the mycelium grows around the biomass, it ties it together. After the mycelium has grown well, the fungi are dried with heat to make foam that is both strong and light [8]. The term "foam" applies to a spongy substance that can be formed into any shape and used for a variety of purposes in a variety of industries. To figure out how valuable the foams were, their mechanical, morphological, and chemical qualities were all examined. Different kinds of biomass and mushroom were used to create foams, and these foams were compared to one another to see which fungal foam would be the most practical and efficient for use in industry.

2 Methods

2.1 Preparation of Materials

The *Pleurotus djamor* mushroom, also known as the pink oyster mushroom, as well as rice bran were sourced from Perlis, Malaysia. Rice Husk was obtained from Syarikat Bernas, Kuala Perlis in Perlis, Malaysia, and then grinded using grinder into a powder. As for the sugarcane bagasse, it was imported from Kangar Perlis, Malaysia, soaked, sun-dried and oven-dried, and then grinded into fine powder.

2.2 Production of Foams

Biomass (rice husk and sugarcane bagasse), rice bran, and calcium carbonate were mixed into basins in the correct proportions (100:10:1) to make a medium for growing fungi [9]. The medium was mixed with distilled water until a clump formed, then packed into plastic cup at 7 cm height and sterilized in an autoclave at 121°C for 30 minutes. After being taken out of the autoclave, samples with medium were cooled at room temperature. After inoculating rice husk and sugarcane bagasse with *Pleurotus djamor* spawn, the samples were incubated at room temperature in a dark storage box. After the foams were completely produced, they were dried in drying oven at 70°C for 24 hours to stop fungi from growing.

2.3 Determination of Foams Properties

The mechanical properties, morphological properties, and chemical composition of foams were all examined. Texture Analyzer was used to test the hardness, resilience and springiness of eco-friendly foam. All of the samples were put on the compressor platens and tested using the P/75 probe, which has a round surface. In terms of morphological tests, a Scanning Electronic Microscope (SEM) was used to examine the microscopic structure of the foams. 1000x magnification was used to take SEM images of the eco-friendly foams, and a thin layer of platinum was sputtered on the foams before scanning to keep them from getting electrostatically charged during the testing procedure. Next, FTIR Perkin-Elmer Model Series 2 was used to analyze the chemical structures of the fungal foam produced under range of wavenumbers of 4000 to 650 cm^{-1}

3 Results and Discussion

3.1 Mechanical Properties

Figures 1 (a-c) show the mechanical features of environmental-friendly foams, such as how hard they are, how resilient they are, and how springy they are. Hardness is one of the most essential mechanical characteristics of materials [10], and in the case of foam, it signifies the material's ability to sustain the impact force that is usually employed for specific function. The resilience of fungal foam is a measure of its resistance to damage from external forces and its capacity to return to its former shape and size after being deformed [11]. The springiness of fungal foam refers to its capacity to recover its initial shape and form when pressure is released. Since the result of this study is fungal foam made from mushrooms, the samples are more springy because mycelium is itself elastic [12]. Figure 1 (a) shows that *Pleurotus djamor* foam made with rice husk is harder (25938 g sec) than foam made with sugarcane bagasse, which is only 16406 g sec. This explains the feature of the substrates themselves, since rice husk is made up of hollow tubes [13]. Figure 1 (b) also show that foam made from sugarcane is more resilient than foam made from rice husk. Figure 1 (c) additionally illustrates the same trend for how springy is the material. In fungal mycelium, the stress-strain relationship changes significantly with compression, as demonstrated by Islam *et al.,* [14]. Due to hyphal branching, which creates a random fiber network structure, fungus might restore their original shape and size when the strain is removed.

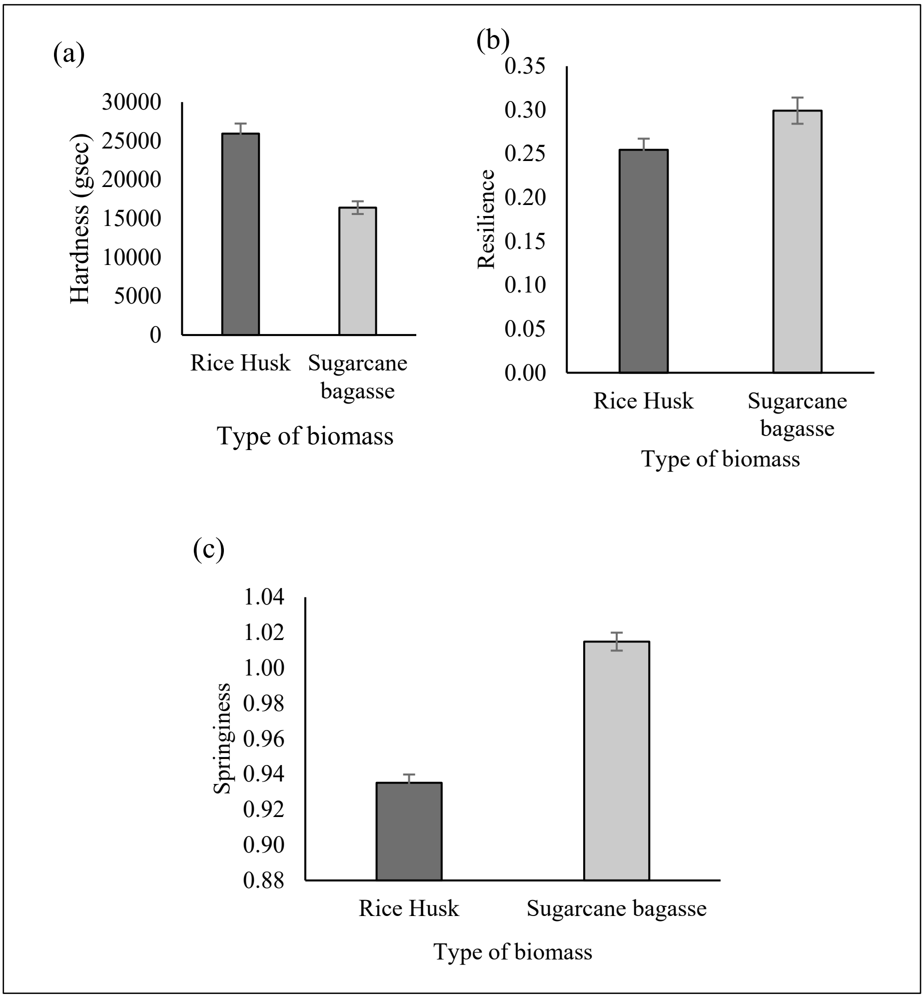

Fig. 1. Mechanical properties of eco-friendly foam using different biomass (a) hardness (b) resilience (c) springiness

3.2 Morphological Properties

Figures 2 (a) and Figure 2 (b) show SEM micrographs of environmentally friendly foams made by *Pleurotus djamor* from rice husk and sugarcane bagasse, respectively. Images that were taken under 1000x magnification showed how fungi and substrates in foams are attached together. The presence of hyphae was indicated by the presence of entangled, tube-like filaments. The mycelium is represented by the branches formed when hyphae combine. The white, fibrous parts of the image were called fungi, and the dark parts of the image were called substrates. Foaming fungi secrete an enzyme that indirectly influences how many hyphae adhere to surfaces [15]. Figure 2 (a) shows that the fungus that grows on rice husk is not as tightly packed as the foam that grows on sugarcane bagasse (Figure 2 (b)). This shows why foam made from sugarcane bagasse is more springy and not as hard as foam made from rice husk. The study of mechanical properties showed a contrasting relationship between hardness and compact filaments, suggesting that the mycelium filaments present in the fungal foam related to this property [12].

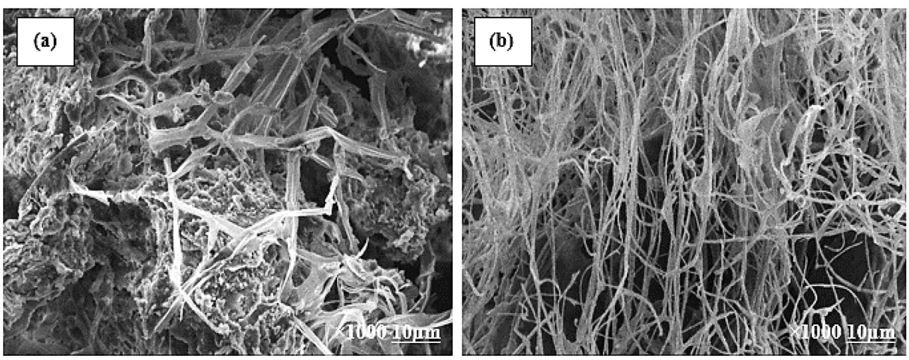

Fig. 2. SEM fracture of micrograph of eco-friendly foam in (a) rice husk (b) sugarcane bagasse

3.3 Functional Group Identification

Figure 3 shows the FTIR spectrum of *Pleurotus djamor* in rice husk and sugarcane bagasse. The O-H group is represented by the strong and broad absorption band between 3374 and 3252 cm^{-1}. Alternatively, the presence of waxes and oils in the foams explains the broad band between 2925 and 2918 cm^{-1}, which is a result of the stretching vibration of C–H groups. The carbonyl stretching vibration of the acetyl group in hemicelluloses and methyl ester was found to have peaks between 1650 and 1646 cm^{-1}. Also, the peaks at 1381–1376 cm^{-1} were caused by the stretching vibration of aromatic rings in lignin. In polysaccharides, peaks at 1096–1066 cm^{-1} have been attributed to C–O, C–C, and C–O–C stretching vibrations.

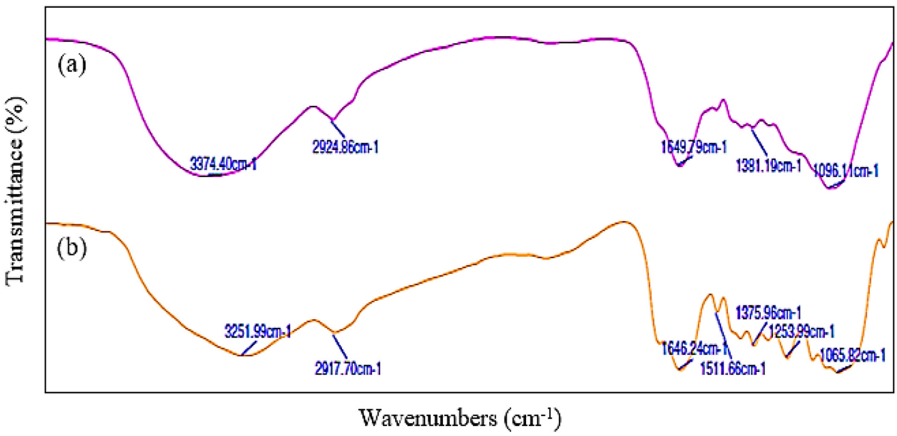

Fig. 3. Wavelength of eco-friendly foam in (a) rice husk (b) sugarcane bagasse using FTIR

4 Conclusion

In conclusion, although biomass is considered waste, they still have their own distinct value, which implies that this biomass can be used effectively for many commercial applications. Besides, this biomass can be transformed into beneficial product. Reducing waste and maintaining environmental sustainability were both achieved through the processing of biomass into products like eco-friendly foam. This research shows that *Pleurotus djamor* can be cultivated using either rice husk or sugarcane bagasse as a source of biomass. In terms of mechanical qualities, eco-foam made from rice husk was substantially harder than sugarcane bagasse, but it was less springy and resilient. From scanning electron microscope, compact morphology of eco-foam can be seen in sugarcane bagasse that responsible for its springy characteristic. On the other hand, FTIR shows that there is presence of O-H group, C–H groups, acetyl group, and C–O, C–C, C–O–C stretching vibrations. In summary, foams made from oyster mushroom biomass will have great qualities, but foams made from other types of biomass will exhibit different characteristics.

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