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# Exploring Oyster Mushroom (*Pleurotus Ostreatus*) Mycelium as a Sustainable Biodegradable Plastic Packaging

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## Abstract

This study was geared toward exploring oyster mushroom (Pleurotus ostreatus) as a sustainable biodegradable plastic packaging material. Plastics are commonly used as packaging materials in the market industry. However, the continuous use of conventional plastic is inadequate for the environment. The development of bioplastic packaging made from mushroom mycelium intends to lessen the use of plastics. The bioplastic samples were subjected to different tests and parameters to measure their mechanical properties, including tensile strength, water solubility, durability, biodegradability, and cost in the market. The following were the treatments for the development of mycelium bioplastic: Treatment 1 (no mushroom mycelium), Treatment 2 (5g mushroom mycelium), Treatment 3 (10g mushroom mycelium), Treatment 4 (15g mushroom mycelium), Treatment 5 (20g mushroom mycelium). The results revealed that Treatment 5 (20g mushroom mycelium) had the highest tensile strength (8.33 inches) among the treatments, which concluded that the more mycelium added, the stronger the bioplastic made. In terms of water solubility, all the mycelium bioplastic samples were dissolved. For its durability test, Treatment 5 (20g mushroom mycelium) stretched to inches and was considered highly durable among the treatments, which means that the mushroom mycelium made it more durable. For the biodegradability of the mycelium bioplastics, which were buried for 15 days, Treatment 5 (20g mushroom mycelium) had the highest percentage of biodegradability (5.63%). The results revealed that the higher the amount of mycelium present, the more elastic, soluble, durable, and biodegradable the bioplastics.

**Keywords:** Biodegradable, Bioplastic, Durable, Elastic, Mycelium.

## 1. Introduction

Plastic is a polymeric substance, meaning that its molecules are quite big and frequently resemble long chains composed of an apparently infinite number of interrelated links. Naturally occurring polymers like rubber and although silk is abundant, "plastics" found in nature have not been linked to environmental contamination because. According to Moore (2024), they don't survive in the environment. One of the most urgent issues nowadays is plastic pollution environmental concerns, as the manufacture of disposable plastics is growing at an accelerated rate, surpassing the capacity of the world to handle them. Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing production of disposable plastic products overwhelms the world's ability to deal with them. Some plastics can be reused or recycled—and many play an important role in areas like medicine and public safety—but other items, such as straws, are designed for only one use. In fact, more than 40% plastic is only used once before being discarded, where it remains in the environment for a very long time. It often breaks down into smaller and smaller particles, called micro-plastics, which can be ingested by both animals and people (National Geographic Society, 2024). In this matter, bioplastics could be produced which can both benefit humans and environment as well. Biodegradable plastics are typically plastics manufactured from bio-based polymers — stand to contribute to more sustainable commercial plastic life cycles as part of a circular economy, in which virgin polymers are made from renewable or recycled raw materials (Rosenboom et al., 2022). The often-cited advantages of bioplastic include reduced consumption of fossil fuels, resources, reduced carbon impact, and speedier decomposition. Bioplastic is less harmful and does not include bisphenol A (BPA), a hormone disruptor that is commonly found in conventional plastics. Bioplastics do over time they emit much fewer greenhouse gases


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than ordinary plastics. There is no net increase in carbon dioxide when they break down because the plants that bioplastics are made from absorbed that same amount of carbon dioxide as they grew (Cho, 2017). The vegetative portion is called mycelium, or mushroom root system. It's made up of filaments called hyphae, which look like thin threads with high tensile strength that create larger networks. They seek out water and minerals to sustain the main body of fungus, which are typically found underground. Mycelium is part of the fungi kingdom. It has generated enthusiasm as a potentially useful material for meals, buildings, packaging, and even clothes. Given the resource depletion is an increasing concern, and this substance has immense promise. Mycelium-based composite (MBC) materials are alternative and biodegradable packaging materials. Compared to plastic or foam, which can MCMs disintegrate quickly and can remain in the environment for years. The composting period is as short as 30 days, implying that MBCs generate less trash. As they decomposed, mycelia-based composites release nutrients into soil. They are therefore even more advantageous as alternatives to single-use packaging because they may after use, return to the environment. Waste reduction is important as we look for innovative ways to reduce the harmful effects of waste-producing materials (Patel, 2023). With the characteristics of mushroom mycelia, its potential as main ingredient of bioplastic was explored. Oyster mushroom *(Pleurotus ostreatus)* mycelium was utilized because this is one of the easiest types of mushrooms to grow. Tensile strength, water solubility, durability, and biodegradability were observed and determined.

## 2. Materials and Methods

This study was conducted using two (2) stages; the manufacture and production of bioplastic and the analysis of the results of bioplastic after several tests. Culinary tools were used such as casserole and pans. The kitchen equipment was disinfected to avoid contamination.

The following are the list of materials needed for the study:

**Table 1.** Materials and Equipment needed in the development of Biodegradable Plastic.

|  |  |  |  |
|---|---|---|---|
| Water | Glycerine | Pectin | Gelatine |

|  |  |  |  |
|---|---|---|---|
| Oyster mushroom mycelium | Digital Weighing Scale | Facemask | Gloves |

### 2.1. Procedure

1. The gelatin and mushroom mycelium were dissolved in hot water in a glass.
2. Water was boiled in the casserole.
3. When it's boiling, heat was lowered and glycerin and pectin, were put altogether. It was mixed until fully boiled and then the dissolved gelatin and mushroom mycelium were poured.
4. When it's all done, the mixture was poured slowly into the silicon mold to avoid bubbles.
5. After 5 minutes, the sample mixture was patted. It was left for 3 days in a room temperature.
6. After 3 days, the sample mixture was removed from the silicon mold. It was cut and designed according to the preferred plastic shape.
7. It was sealed and then packed.


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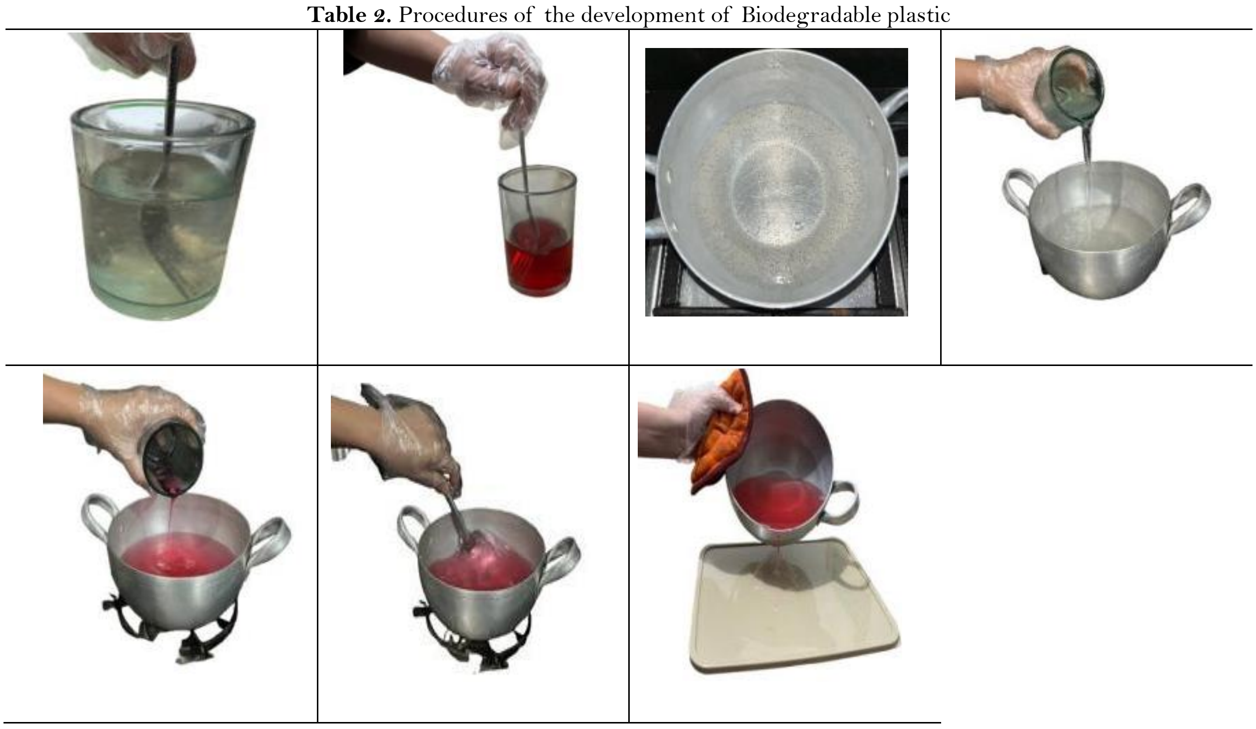
**Table 2.** Procedures of the development of Biodegradable plastic



## *2.2. Lay-Out of the Experiment*

The research utilized Complete Randomized Design. It was composed of five (5) samples replicated three (3) times.

# 3. Results and Discussions

This chapter presents the result and discussion of data gathered after several tests and observations. The data were presented in tabular and in figurative form in accordance with the specific questions posted on the statement of the problem of this study.

## *3.1. Tensile Strength of Oyster Mushroom Mycelium Bioplastic Packaging*

As shown in Table 3, tensile strength is one of the mechanical properties of bioplastics. To ensure the quality of the plastics, different tests are performed.

**Table 3.** Tensile Strength of Oyster Mushroom mycelium bioplastic packaging.

| **Treatments** | **Tensile Strength (Inch)** | **Descriptive Interpretation** |
|---|---|---|
| T1- No Mushroom mycelium | 5.27d | Moderately resistant to deformation |
| T2- 5g Mushroom mycelium | 5.77c | Moderately resistant to deformation |
| T3-10g Mushroom mycelium | 6.77b | Moderately resistant to deformation |
| T4-15g Mushroom mycelium | 8.12a | Highly resistant to deformation |
| T5-20g Mushroom mycelium | 8.33a | Highly resistant to deformation |
| CV | 3.42% | |

**Source:** Means with the same letter are not significantly different at $p \leq 0.05$ using Least Significant Difference (LSD) Test.

The researchers utilized ANOVA to evaluate and analyze the data. As stated in the above results, Treatment 5 with 20g of mushroom mycelium got the highest tensile strength (8.33 inch) among the treatments, while Treatment 1 got the lowest tensile strength (5.27 inch). Based on the results, it shows that the more mycelium it has, the stronger the bioplastic made. e results, it shows that the more mycelium it has, the stronger the bioplastic made.

| Treatment 1 (no mushroom mycelium) | Treatment 2 (5g mushroom mycelium) | Treatment 3 (10g mushroom mycelium) | Treatment 4 (15g mushroom mycelium) | Treatment 5 (mushroom mycelium) |
|---|---|---|---|---|

**Figure 1.** Tensile Strength of mycelium bioplastic.



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An important characteristic for determining the suitability of materials for a building is their compressive strength, which quantifies their capacity to withstand the direct pressure of an applied compression force. Several factors have been noted to influence the compressive strength of mycelium bioplastics, such as the type of fungal strain, processing method, and the longevity. Many authors including Ghazvinian et al., Zimele et al., Elsacker et al., and STOWA have determined the compressive strength of MBCs developed from various substrates. Zimele et al. investigated mycelium-based bioplastics as alternative materials. The compressive strengths of hemp mycelium composites were determined to be 0.36 MPa and 0.52 MPa respectively, and these values were found to be comparable (Elsacker et al.) Resent research concentrated on improving the microstructure of material to raise its elastic modulus and comprehensive strength, primarily to survive the compressive pressures created by the structure. (Sydor et al., 2022) studied the elastic and strength characteristics of mycelium bioplastic in both tension and compression and discovered that the compressive strength is nearly three times the tensile strength.

### *3.2. Water Solubility of Oyster Mushroom mycelium bioplastic packaging*

Table 4 shows the water solubility of Oyster Mushroom mycelium bioplastics. It is one of the important mechanical properties of a bioplastic as it indicates the extent to which a bioplastic dissolves in water, aiding in the assessment of its applicability for particular purposes. The results from a water solubility test can contribute to enhancing thewater resistance of the oyster mushroom mycelium bioplastic packaging.

**Table 4.** Water Solubility of Oyster Mushroom mycelium bioplastic packaging

| Treatments | Hours | Water Solubility (G) | Descriptive Interpretation |
|---|---|---|---|
| t1- no mushroom mycelium | 24 | 1.47e | dissolved completely within 24 hours |
| t2- 5g mushroom mycelium | 24 | 2.35d | dissolved completely within 24 hours |
| t3- 10g mushroom mycelium | 24 | 3.88c | dissolved within 24 hours |
| t4- 15g mushroom mycelium | 24 | 5.30b | partially soluble in water |
| t5- 20g mushroom mycelium | 24 | 8.07a | insoluble in water |
| **cv** | | **8.01%** | |

**Source:** Means with the same letter are not significantly different at $p \leq 0.05$ using Least Significant Difference (LSD) Test.

**Legend:**

| | |
|---|---|
| 8-10 – Insoluble in water | 3-4 – Dissolved within 24 hours |
| 5-7 – Partially soluble in water | 0-2 – Dissolved completely within 24 hours |

The researchers utilized ANOVA to evaluate and analyze the data. As stated on the above results, Treatment 1 (no mushroom mycelium) got the lowest water solubility (1.47g), which means that it was dissolved easily. On the other hand, Treatment 5 (20g mushroom mycelium) got the highest water solubility (8.07g). Based on the results, it shows that bioplastic samples with mushroom mycelium were insoluble.



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| | | |
|---|---|---|
| Treatment 1<br>(no mushroom mycelium) |  |  |
| Treatment 2<br>(5g mushroom mycelium) |  |  |
| Treatment 3<br>(10g mushroom mycelium) |  |  |
| Treatment 4<br>(15g mushroom mycelium) |  |  |
| Treatment 5<br>(20g mushroom mycelium) |  |  |

**Figure 2.** Water Solubility of Oyster Mushroom mycelium bioplastic.

The difference between the MBCs' (dry) weights and their weights during a certain amount of time in the presence of moisture is the water absorption rate. When water is absorbed, MBM thickness grows, which weakens MBCs' mechanical strength and other characteristics. One of the most important application characteristics needed in the design for the commercialization of mycelium-based products, particularly in structural applications like building and construction, is the water absorption rate of MBCs.

### *3.3. Durability of Oyster Mushroom Mycelium Bioplastic Packaging*

Table 5 shows the results of durability testing of Oyster Mushroom mycelium bioplastics. Tests were conducted to determine how durable the bioplastics under controlled stress. This is important to observed the durability of bioplastic to measure if it can perform over a longer period of time.

**Table 5.** Durability of Oyster Mushroom mycelium bioplastic packaging

| **Treatments** | **Durability (Inch)** | **Descriptive Interpretation** |
|---|---|---|
| T1- No Mushroom mycelium | 5.10e | Moderately resistant to deformation |
| T2- 5g Mushroom mycelium | 5.52d | Moderately resistant to deformation |
| T3- 10g Mushroom mycelium | 6.10c | Moderately resistant to deformation |
| T4- 15g Mushroom mycelium | 6.53b | Moderately resistant to deformation |
| T5- 20g Mushroom mycelium | 7.40a | Moderately resistant to deformation |
| **CV** | **3.09%** | |

**Source:** Means with the same letter are not significantly different at $p \leq 0.05$ using Least Significant Difference (LSD) Test.

**Legend:**
8-10 – Highly resistant to deformation 3-4 Resistant to deformation
5-7 Moderately resistant to deformation 0-2 Not resistant to deformation

The researchers utilized ANOVA to evaluate and analyze the data. As stated on the results above, the most durable bioplastic sample was Treatment 5 which contains 100g of mycelium (7.40 inch). On the other hand, that the less durable bioplastic was Treatment 1 with no mycelium present (5.10 inch). Therefore, it concludes that the more mycelium added, the more it gets durable.



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| | |
|---|---|
| Treatment 1 (no mushroom mycelium) |  |
| Treatment 2 (5g mushroom mycelium) |  |
| Treatment 3 (10g mushroom mycelium) |  |
| Treatment 4 (15g mushroom mycelium) |  |
| Treatment 5 (20g mushroom mycelium) |  |

**Figure 3.** Durability of Oyster Mushroom mycelium bioplastic.

When compared to equivalent non-pressed and cold-pressed materials, the heatpressed materials' elasticity modulus was greater. During three-point bending, a comparable pattern was seen. After which there is a linear elastic regime of strain hardening until rupture at 25-30% strain. Mycelium under compression exhibits an elastic regime at low loads, followed by a regime of strain localization where the effective tangent stiffness is dramatically lowered due to the elastic-plastic. Following unloading from the compression tests, the elastic deformation is largely recovered, but some plastic deformation is left behind (Pohl et al., 2022).

### *3.4. Biodegradability of Oyster Mushroom Mycelium Bioplastic Packaging*

Table 6 shows the biodegradability of bioplastics. It was tested by burying them in soil and observing their mass loss for fifteen (15) days. This was evaluated by the comparison of blank compost to a test compost that contains composted mycelium bioplastic.

**Table 6.** Biodegradability of Oyster Mushroom mycelium bioplastic packaging.

| **Treatments** | **Days Of Buried** | **Biodegradability (G)** | **Descriptive Interpretation** |
|---|---|---|---|
| T1- No Mushroom mycelium | 15 | 1.70d | More residues or byproducts |
| T2- 5g Mushroom mycelium | 15 | 2.13d | More residues or byproducts |
| T3- 10g Mushroom mycelium | 15 | 3.35c | Minimal residues or byproducts |
| T4- 15g Mushroom mycelium | 15 | 3.95b | Minimal residues or byproducts |
| T5- 20g Mushroom mycelium | 15 | 5.63a | Few residues or byproducts |
| **CV** | | **9.28%** | |

**Source:** Means with the same letter are not significantly different at p ≤ 0.05 using Least Significant Difference (LSD) Test.

**Legend:**

8-10 – No residues or byproducts    3-4 Minimal residues or byproducts
5-7 Few residues or byproducts    0-2 More residues or byproducts

The researchers utilized ANOVA to evaluate and analyze the data. The decomposition of mycelium bioplastics was tested for fifteen (15) days. The sample had a decomposition of a relatively lower degree than the rest of the samples. The reason could be the absence of mushroom mycelium. While those samples with mushroom mycelium were easily decomposed. Based on the results, the higher the amount of mushroom mycelium, the higher its biodegradability. Meaning, it could easily be decomposed.



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**Figure 4.** Biodegradability of Oyster Mushroom mycelium bioplastic.

| | | |
|---|---|---|
| Treatment 1 (no mushroom mycelium) |  |  |
| Treatment 2 (5g mushroom mycelium) |  |  |
| Treatment 3 (10g mushroom mycelium) |  |  |
| Treatment 4 (15g mushroom mycelium) |  |  |
| Treatment 5 (20g mushroom mycelium) |  |  |

Decomposition means to breakdown it refers to the rupture or breakdown of some complex organic matter into a simpler inorganic matter. Also, in ecosystem, it's the important process, thus, we can say it is a metabolic process that takes into a new compound or as raw materials, it converts and processes them to a simple compound. According to the study of BYJU'S (2020), there is so many factors that can affect the decomposition of compound in terms of their litter quality depends on the structural and chemical properties of litter, temperature regulates the growth and activity of microorganisms, aeration when oxygen present in the pores of the soil helps in the growth of microorganisms, soil helps in the growth of microorganisms, soil pH that presence of cations and anions govern the pH of the soil, which in turn affects microbial growth, and inorganic chemicals also a factors that can affect the decomposition. The process of decomposition is fragmentation, leaching, catabolism, humification, and last is the mineralization (Zimette et al., 2020).

## 4. Conclusions and Recommendations

### *4.1. Conclusions*

Mycelium bioplastic packaging have a lot of potential as a sustainable and environmentally friendly alternative. The bioplastics have demonstrated remarkable mechanical qualities including high strength, durability, and water solubility, making them appropriate for use in a variety of packaging. Though it may take a further study to optimize their economic feasibility, but the promise of mycelium bioplastic packaging for a sustainable future is clear. Therefore, this study concluded that mycelium bioplastic packaging is a durable, adaptable, and environmentally beneficial substitute for conventional packaging materials.

### *4.2. Recommendations*

Based on the conclusions of the study, these are the recommendations:

This biodegradable material, derived from the root structure of fungi, is not only eco-friendly but also renewable and non-toxic. The mycelium bioplastics decomposed naturally, significantly reducing long-term waste and pollution. This study recommended to use the addition of mushroom mycelia as one of the components of biodegradable plastic. It is also recommended as a biodegradable plastic packaging as it disintegrate spontaneously without leaving any unwanted residues behind. These are a far more environmentally friendly choice than polystyrene, which take hundreds of years to degrade. For future researchers, the use of varied amount of mycelium may be explored. Other natural components may be tried on the development of biodegradable plastic which could enhance their scalability, strength, and versatility.

## References

Abhijith, R., Ashok, A., & Rejeesh, C. R. (2020). Sustainable packaging applications from mycelium to substitute polystyrene: A review. Materials Today: Proceedings, 5(1), 2139–2145. https://doi.org/10.1016/j.matpr.2017.09.211

Aiduang, W., Chanthaluck, A., Kumla, J., Jatuwong, K., Srinuanpan, S., Waroonkun, T., et al. (2022).
Amazing Fungi for Eco-Friendly Composite Materials: A Comprehensive Review. Journal of Fungi, 8(8). https://doi.org/10.3390/jof8080842

Alemu, D., Tafesse, M., & Mondal, A. K. (2022).
Mycelium-Based Composite: The Future Sustainable Biomaterial. International Journal of Biomaterials.
https://doi.org/10.1155/2022/8401528



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Attias, N., Danai, O., Abitbol, T., Tarazi, E., Ezov, N., & Pereman, I., et al. (2020).
Mycelium bio-composites in industrial design and architecture: Comparative review and experimental analysis. Journal of Cleaner Production, 246, 119037. https://doi.org/10.1016/j.jclepro.2019.119037
Butu, A., Rodino, S., Miu, B., & Butu, M. (2020).
Mycelium-based materials for the ecodesign of bioeconomy. Digest Journal of Nanomaterials and Biostructures, 15(4), 1129–1140.
https://doi.org/10.15251/djnb.2020.154.1129
Fairus, M. J. M., Bahrin, E. K., Arbaain, E. N. N., & Ramli, N. (2022).
Mycelium-Based Composite: A Way Forward for Renewable Material. Journal of Sustainability Science and Management, 17(1), 271–280.
https://doi.org/10.46754/jssm.2022.01.018
Angelova, G. V., Brazkova, M. S., & Krastanov, A. I. (2021).
Renewable mycelium based composite sustainable approach for lignocellulose waste recovery and alternative to synthetic materials – a review. Zeitschrift Für Naturforschung C, 76(11-12), 8–9. https://doi.org/10.1515/znc-2021-0040
Ritchie, H., & Roser, M. (2022). Plastic pollution. Our World in Data. https://ourworldindata.org/plastic-pollution (Note: This is a web article, no DOI.)
Flagel, J. (2020). Mycelium: Using mushrooms to make packaging materials. Matmatch Blog.
https://matmatch.com/resources/blog/mycelium-using-mushrooms-to-make-packaging-materials (Note: This is a blog post, no DOI.)
Jose, J., Uvais, K. N., Sreenadh, T. S., Deepak, A. V., & Rejeesh, C. R. (2021).
Investigations into the Development of a Mycelium Bioplastics to Substitute Polystyrene in Packaging Applications. Arabian Journal for Science and Engineering, 46(3), 2975–2984. https://doi.org/10.1007/s13369-020-05247-2
Joshi, K., Meher, M. K., & Poluri, K. M. (2020). Fabrication and Characterization of Bioplastic from Agricultural Waste Using Fungal Mycelium for Renewable and Sustainable Applications. ACS Applied Bio Materials, 3(4), 1884–1892. https://doi.org/10.1021/acsabm.9b01047
Lee, T., & Choi, J. (2021). Mycelium-composite panels for atmospheric particulate matter adsorption. Results in Materials, 11, 100208.
https://doi.org/10.1016/j.rinma.2021.100208
Ncube, L. K., Ude, A. U., Ogunmuyiwa, E. N., Zulkifli, R., & Beas, I. N. (2020).
Environmental impact of food packaging materials: A review of contemporary development from conventional plastics to polylactic acid-based materials. Materials, 13(21), 1–24. https://doi.org/10.3390/ma13214994
Rajendran, R. C. (2022). Packaging applications of fungal mycelium-based biodegradable composites. In Fungal Biopolymers and Biocomposites (pp. 189–193). https://doi.org/10.1007/978-981-19-1000-5_11
Escaleira, R. M., Campos, M. J., & Alves, M. L. (2020). Mycelium-based composites: A new approach to sustainable materials. In Advances in Science, Technology & Innovation, 261–264. https://doi.org/10.1007/978-3-030-35533-3_30
Robertson, O., Høgdal, F., McKay, L., & Lenau, T. (2020). Fungal Future: A review of mycelium biocomposites as an ecological alternative insulation material. Proceedings of the NordDesign 2020 Conference. https://doi.org/10.35199/norddesign2020.18
Sivaprasad, S., Byju, S. K., Prajith, C., Shaju, J., & Rejeesh, C. R. (2021). Development of a novel mycelium bio composite material to substitute for polystyrene in packaging applications. Materials Today: Proceedings, 47(40), 5038–5044. https://doi.org/10.1016/j.matpr.2021.04.622
Zimele, Z., Irbe, I., Grinins, J., Bikovens, O., Verovkins, A., & Bajare, D. (2020). Novel mycelium-based biocomposites (Mbb) as building materials. Journal of Renewable Materials, 8(9), 1067–1076. https://doi.org/10.32604/jrm.2020.09646


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