

Development of Biodegradable Packaging from Agricultural Waste and Fungal Mycelium

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Abstract: The alarming rise in plastic pollution has driven the demand for eco-friendly, biodegradable alternatives to conventional petroleum-based materials such as Styrofoam. This study explores the development of sustainable packaging material using the fungal strain *Pleurotus ostreatus* cultivated on agricultural waste substrates like wheat straw and rice straw, supplemented with organic additives including wheat bran, wheat flour, and coco peat. A total of 11 experimental trials were conducted using a 3:1 substrate-to-spawn mixing ratio. The results showed significant variation in the mycelial colonization and biomass yield across different substrate and supplement combinations. Among the tested substrates, wheat straw with no supplementation exhibited the lowest dry weight (66.1 g) which indicates that it can replace Styrofoam in low weightiness. Some combinations, such as wheat straw with coco peat and rice straw with coco peat, led to contamination or yielded no observable results, indicating the sensitivity of *P. ostreatus* growth to substrate conditions and contamination risk. The study highlights that agricultural residues supplemented with appropriate nutrients can be effectively utilized for mycelium-based composite formation, offering an eco-friendly alternative to synthetic packaging. This biodegradable material not only valorises agricultural waste but also contributes to reducing environmental impact by offering a compostable substitute for plastic-based products. The findings affirm the feasibility of scaling up mycelium-based packaging solutions using locally available biomass and low-cost organic supplements, supporting the vision of a circular bio economy and sustainable material science.

Keywords: Mycelium-based packaging, *Pleurotus ostreatus*, Biodegradable material, Agricultural waste, Wheat straw, Rice straw, Sustainable packaging

How to cite this article: Rajnandini Rajput. (2025). The Mathematics Behind Machine Learning Algorithms. 6th International Conference on Interdisciplinary Approaches in Science, Engineering and Technology-2025, Proceeding in IJSMRT, ISSN: 2582-8150, Volume-21, Issue-03, Number-09, Dec-2025, pp.46-49, URL: <https://www.ijsmrt.com/wp-content/uploads/2026/01/IJSMRT-25120309.pdf>

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IJSMRT-25120309

I. INTRODUCTION

The development of sustainable and biodegradable substitutes for petroleum-based packaging materials like Styrofoam has attracted a lot of attention due to the growing global concern over plastic pollution. A possible bio composite solution among these substitutes is mycelium-based packaging made from fungal biomass, specifically *Pleurotus ostreatus* and

other basidiomycetes. According to Jones et al. (2020), mycelium, a network of fungi that resembles roots, can colonize lignocellulosic agricultural wastes like wood chips, sawdust, and wheat straw and link the particles into a long-lasting substance that has cushioning and insulating qualities. In addition to keeping agricultural waste out of landfills, this method provides a low-energy, biodegradable substance that breaks down organically without leaving behind

microplastic residues (Haneef et al., 2017). According to studies, mycelium composites can replace Styrofoam in insulation and packaging applications since they have adequate mechanical strength and heat resistance (Islam et al., 2017; Appels et al., 2018).

Additionally, through fungal solid-state fermentation, agricultural residues—generally regarded as low-value biomass—can be effectively transformed into high-performance materials, providing advantages for the environment and the economy (Elsacker et al., 2019). These materials' biodegradability guarantees a small environmental impact and supports the objectives of the circular economy. Under normal circumstances, mycelium packaging breaks down in a matter of weeks, as opposed to traditional plastics that linger in the environment for centuries (Jones et al., 2020). This technique is a viable and sustainable solution for the worldwide eco-friendly packaging industry due to its scalability and the availability of local agricultural waste. Therefore, the development of biodegradable packaging from agricultural waste and fungal mycelium represents a significant step toward reducing plastic dependency and promoting environmental stewardship.

II. MATERIAL AND METHOD

Pleurotus ostreatus was the type of fungus used in this investigation. In sterile circumstances, pure cultures were kept on potato dextrose agar (PDA) plates and incubated for 7–10 days at $25 \pm 2^\circ\text{C}$ until dense mycelial growth was seen.

Sterilized wheat grains were used in the spawn preparation process. To get the best softness while keeping the grains whole, they were soaked in water for 12 hours and then boiled for 15 to 20 minutes. The grains were air-dried after the extra water was drained, bringing the moisture level down to about 60–65%. Gypsum (CaSO_4) and calcium carbonate (CaCO_3) were added at 1% and 2%, respectively, to correct pH and avoid clumping. After that, the grains were placed

in polypropylene bags, autoclaved for 30 to 45 minutes at 121°C , and injected with mycelial discs from PDA cultures that were actively growing. The spawn was prepared for substrate inoculation when the infected bags were cultured for 15–20 days at 25°C in a dark, sterile environment until full colonization of the grains was seen.

The selection and processing of agricultural leftovers, such as rice and wheat straw, which were the main substrates, marked the beginning of the packaging material production process. To get rid of microbiological pollutants, these residues were cut into 2–3 cm lengths, carefully cleaned, and pasteurized in hot water at $70\text{--}80^\circ\text{C}$ for an hour. To promote fungal development, the substrates were drained and cooled before being treated with several nutrient enhancers, such as coco peat (10%), wheat bran (10%), or wheat flour (7%). After that, the prepared spawn was added to the moistened substrates in a 3:1 substrate-to-spawn ratio, and everything was well combined.

The inoculation mixtures were placed in polypropylene grow bags or sterilized molds and kept at a steady $25\text{--}28^\circ\text{C}$ in a dark, humid environment with 75–85% relative humidity. Maintaining proper aeration helped avoid CO_2 build-up, which can impede mycelial growth. Mycelium colonized the whole matrix in ten to fifteen days, cementing the substrate into a dense, foam-like composite. To lower moisture content and stop additional fungal activity, the previous biomaterials were taken out of the molds after complete colonization and dried for 24 to 48 hours at 60°C . The physical properties and applicability of the finished dried mycelium-based composite as a biodegradable packaging material were next assessed.

III. RESULT AND DISCUSSION

Table 1: Table showing moist and dry weight of packaging materials.

Experiment no.	Substrate + spawn	Supplement	Moist weight	Dry weight	Images
1.	Wheat straw+ spawn	No supplement	168 g	66.1g	
2.	Wheat straw +spawn	Wheat bran (10%)	151.5 g	70.2g	

3.	Wheat straw +spawn	Wheat bran (10%) (unboil)	178.5g	83.9g	
4.	Rice straw + spawn	No supplement	119.2g	72.6g	
5.	Rice straw +spawn	7% wheat flour	152.9g	83.8g	
6.	Wheat straw + spawn	Coco peat (10%)	grow bag Contami nated	Grow bag Contami nated	-
7.	Rice straw +spawn	Coco peat (10%)	No results	No results	-
8.	Rice straw +spawn	Wheat bran (10%)	180.2g	92.3g	
9.	Wheat straw +spawn	7% wheat flour	167.7g	84.6g	
10.	Rice Straw +spawn	Wheat bran (10%)	206.7g	68.2g	
11.	Rice straw +spawn	Wheat bran (10%) unboil	117.0g	76.2g	

When utilizing *Pleurotus ostreatus* mycelium and agricultural waste to create biodegradable packaging materials, the maximum biomass yield is not the only factor that determines the final material's quality. Instead, the mycelial composite's structure, density, and porosity are crucial factors in evaluating whether or not it is suitable for use as a packaging material. It's interesting to note that this study found that the lowest dry biomass (66.1 g) produced by Experiment 1 with wheat straw and no supplement produced a solid, lightweight substance that is perfect for packaging applications.

In this case, lower biomass means that the mycelium successfully colonized and bound the substrate without expanding too much, which is essential for creating a robust, lightweight, and moldable composite. As seen in higher biomass treatments such as Experiments 8 and 9, a dense or excessively thick mycelial mat may result in increased brittleness, poor air-drying properties, or increased moisture retention—factors that potentially jeopardize the packaging material's mechanical integrity and shelf

stability. Conversely, the Experiment 1 sample demonstrated superior textural homogeneity, reduced weight, and enough rigidity, rendering it more appropriate for substituting materials such as Styrofoam in protective packaging.

Furthermore, this formulation's lack of supplements decreases production costs, streamlines the manufacturing process, and lessens the chance of contamination. Reducing the nutritional load in the substrate by using only wheat straw and spawn promotes slow, even colonization and creates a homogenous composite, which are desirable qualities in environmentally friendly packaging materials. Thus, Experiment 1 is regarded as very favorable for the creation of biodegradable packaging even if it has the lowest dry biomass. It backs the idea that when developing sustainable packaging, substrate formulation should be guided by ideal material qualities rather than solely biomass output. This emphasizes how crucial it is to create bio-based materials with a balance between biological efficiency and functional performance.

IV. CONCLUSION

The study emphasizes the possibility of creating sustainable, biodegradable packaging materials by combining *Pleurotus ostreatus* mycelium with agricultural waste like rice and wheat straw. The formulation consisting of wheat straw without any supplements (Experiment 1) produced the lowest dry biomass (66.1 g) of the several substrate and supplement combinations examined, but it showed outstanding structural qualities appropriate for packaging applications. This research highlights that stronger mycelial binding combined with reduced biomass produces lightweight, moldable, and long-lasting composites that are perfect for replacing petroleum-based packaging like Styrofoam. Higher biomass does not always equate to better material quality.

The use of unsupplemented wheat straw is also economically and environmentally feasible due to its many benefits, which include simpler processing, lower manufacturing costs, and a decreased danger of contamination. However, even though they produced more biomass, combinations with additional nutrients like wheat bran or wheat flour tended to produce denser materials, which could impair packaging performance because of their increased weight or brittleness.

Experiment 1, which strikes a balance between sustainability, usefulness, and scalability, is clearly the most effective and useful formulation. This strategy promotes the development of environmentally friendly packaging technology, which is consistent with the ideas of the circular economy and aids in the worldwide endeavor to lessen plastic pollution. To further confirm the economic potential of such mycelium-based biocomposites, further research may concentrate on mechanical testing, water resistance, and product lifespan evaluation.

REFERENCES

- [1] Jones, M., Bhat, T., Kandare, E., Thomas, A., Joseph, P., & Dekiwadia, C. et al. (2020). Thermal degradation and fire properties of fungal mycelium and mycelium–biomass composites. *Scientific Reports*, 10(1), 1–13.
- [2] Haneef, M., Ceseracciu, L., Canale, C., Bayer, I. S., Heredia-Guerrero, J. A., & Athanassiou, A. (2017). *Advanced Materials From Fungal Mycelium: Fabrication and Tuning of Physical Properties*. *Scientific Reports*, 7(1), 41292.
- [3] Islam, M. R., Tudryn, G., Bucinell, R., Schadler, L., & Picu, R. C. (2017). Morphology and mechanics of fungal mycelium. *Scientific Reports*, 7(1), 13070.
- [4] Appels, F. V. W., Camere, S., Montalti, M., Karana, E., Jansen, K. M. B., Dijksterhuis, J., & Wösten, H. A. B. (2018). Fabrication factors influencing mechanical, moisture- and water-related properties of mycelium-based composites. *Materials & Design*, 161, 64–71.
- [5] Elsacker, E., Vandeloock, S., Brancart, J., Peeters, E., & De Laet, L. (2019). Mechanical, physical and chemical characterisation of mycelium-based composites with different types of lignocellulosic substrates. *PLOS ONE*, 14(7), e0213954.