Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 9, S. 176-181, 3, 2025

Araştırma Makalesi

IJANSER

https://as-proceeding.com/index.php/ijanser
ISSN:2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 9, pp. 176-181, 3, 2025

Research Article

Mycelium-Based Biocomposites: Sustainable Material Design with *Lentinula edodes* and *Pleurotus ostreatus* for the Construction Industry

Sinan AKTAŞ[1*], Yağmur YILDIZ [2]

[1] *Department of Biology/ Faculty of Science, Selçuk University, Türkiye*
(ORCID: 0000-0003-1657-5901)

[2] *Department of Biology/ Institute of Science, Selçuk University, Türkiye*
(ORCID: 0009-0005-1184-7244)

[*]*(saktas@selcuk.edu.tr)*

(Received: 04 March 2025, Accepted: 07 March 2025)

(4th International Conference on Recent Academic Studies ICRAS 2025, March 04-05, 2025)

ATIF/REFERENCE: Aktaş, S. & Yıldız, Y. (2025). Mycelium-Based Biocomposites: Sustainable Material Design with Lentinula edodes and Pleurotus ostreatus for the Construction Industry. *International Journal of Advanced Natural Sciences and Engineering Researches*, 9(3), 176-181.

Abstract – Global climate change, depletion of natural resources, and waste management challenges have heightened the need for eco-friendly materials in the construction sector. Mycelium (the filamentous structure of fungi), which binds agricultural or industrial waste, offers the potential to produce lightweight, highly insulative, and biologically degradable composite products. In this study, we examine the production stages, physical and mechanical properties, and prospective applications—primarily in construction but also in fields such as insulation, decorative elements, and temporary structures—of mycelium-based biocomposites derived from *Lentinula edodes* and *Pleurotus ostreatus*. The findings reveal several advantages rooted in high porosity, including effective thermal and acoustic insulation, a low carbon footprint, and light weight, accompanied by certain limitations such as water sensitivity and somewhat restricted mechanical strength. Nevertheless, it is understood that with suitable surface coatings, flame-retardant additives, and automation-assisted production processes, these challenges can be significantly overcome, indicating that mycelium-based composites may provide critical contributions to the quest for sustainable materials.

Keywords – Mycelium, Lentinula Edodes, Pleurotus Ostreatus, Biocomposite, Sustainability, Construction Material.

I. INTRODUCTION

Today, the construction sector stands among the greatest obstacles to environmental sustainability goals, given its substantial share in energy consumption, resource usage, and waste generation [1,2]. The production of conventional materials—such as cement, steel, EPS (expanded polystyrene), and polyurethane foam—relies heavily on fossil fuel consumption and generates considerable carbon emissions, thereby accelerating global warming and intensifying the depletion of natural resources [3,4]. Additionally, most of these materials pose significant challenges in waste management at the end of their service life, as recycling them can be both complex and energy-intensive.

In this context, there is increasing interest in developing materials derived from renewable resources, which are capable of biodegrading at the end of their lifespan and which exhibit a minimized carbon footprint [1,5]. In pursuit of these aims, researchers have turned to biocomposites generated through mycelium (the vegetative part of fungi) [2,6]. Mycelium forms a fibrous network (hyphae) that naturally binds lignocellulosic substrates—such as wheat straw, rice husk, or sawdust—thereby producing lightweight, highly porous, and largely biodegradable composites [7,8].

Within the literature, Lentinula edodes (commonly known as Shiitake) and Pleurotus ostreatus (oyster mushroom) are frequently highlighted, due to their rapid colonization rates, broad tolerance ranges in temperature and humidity, and robust enzymatic activity [3,9]. Composites derived from these species exhibit low density (0.05–0.30 g/cm^3), low thermal conductivity (around 0.03–0.05 W/mK), moderate sound absorption (absorption coefficients of 0.3–0.6 in the 500–2000 Hz range), and partially sufficient mechanical properties (e.g., compressive strengths around 0.1–1 MPa) [4,10,11]. Together, these characteristics have garnered interest in fields such as indoor insulation, acoustic management, and decorative components for the construction sector.

However, mycelium-based composites also encounter limitations, including sensitivity to moisture, somewhat low mechanical strength for load-bearing systems, and a lack of standardized production protocols [6,12]. In response, the use of surface coatings (based on natural resins, borates, or waxes), flame-retardant additives, and robotic or automated production approaches have been proposed as promising remedies [8,9]. Against this backdrop, this paper explores the material properties, manufacturing processes, and construction applications of composites produced from the mycelium of L. edodes and P. ostreatus, assessing how significant an option they represent in the pursuit of sustainable building materials. We consolidate academic findings and case studies from real-world applications to highlight prospective future research directions and the standardization requirements needed to advance the field.

II. MATERIALS AND METHOD

This research synthesizes numerous studies in the literature (see [1–12]), centering on L. edodes and P. ostreatus. We compare various experimental results, focusing on production protocols, testing methods, and final material properties reported for mycelium-based composites.

2.1. Mycelium Composite Production Process

Mycelium-based composite production generally involves the following stages [2,4,7]:

Substrate Preparation

Selection: Wheat straw, rice husk, sawdust, or coffee grounds are common lignocellulosic inputs.

Cleaning & Shredding: Foreign materials are removed, and the substrate is cut into lengths of about 5–20 mm.

Sterilization/Pasteurization: To reduce contamination, materials may be autoclaved at 121 °C for 15–30 minutes or soaked in hot water at 80–90 °C for 10–60 minutes [9,10].

Moisture & pH Adjustment: Moisture content is regulated to ~60–70%, with pH maintained at around 5–6 via additives like $CaSO_4$ or lime [1,8].

Inoculation

The sterilized substrate is homogeneously mixed with fungal spawn (grain carrying live mycelium) at approximately 5–10%. This mixture is then placed into containers or molds under sterile conditions [3,11].

Incubation (Colonization)

Kept in darkness or low light at 20–28 °C and 60–90% relative humidity for 7–20 days, during which the fungus colonizes and binds the substrate [2,4].

Some studies integrate robotic processes or 3D-printing technologies for shaping [3,8].

Drying & Heat Treatment

After colonization, items are typically heated at 60–80 °C, deactivating the mycelium and reducing moisture to stabilize the product [6,10].

Optional Surface Treatments: Water-repellent or flame-retardant finishes (e.g., borate or natural resin) can be applied [4,9].

2.2. Testing and Characterization

Physical Measurements

Density (g/cm^3): Calculated via mass/volume. Lower density translates to lighter weight [5,6].

Porosity: Some research employs mercury porosimetry or micro-CT scanning [1].

Mechanical Strength

Compression and Flexural Tests: Universal testing machines measure the composite's ultimate strength and modulus [7,10].

Water Absorption and Thickness Swelling: Samples are soaked for 24 hours. Weight gain and thickness change reveal dimensional stability under moisture [11,12].

Thermal and Acoustic Properties

Thermal Conductivity (W/mK): Techniques include guarded hot plate or hot-wire methods [4,9].

Sound Absorption: Impedance tube or reverberation chamber tests determine absorption coefficients across mid- to high-frequency bands [5,8].

Flammability and Flame Retardance

Single Flame Source, Cone Calorimeter: Measures ignition time, flame spread, and heat release rate [3,10].

III. RESULTS

This section consolidates findings on physical, mechanical, thermal, and acoustic properties from various references, while also presenting application examples from the construction industry.

3.1. Physical and Mechanical Performance

Density (0.05–0.30 g/cm^3): This lightness eases transportation and assembly, although pressing or compaction and substrate particle size strongly influence density [1,2].

Compressive Strength (0.1–1 MPa): These values generally suit semi-structural or infill usage. P. ostreatus composites may reach around 0.8–1 MPa, whereas L. edodes typically falls in the 0.4–0.7 MPa range [4,8].

Flexural Strength (1–4 MPa): The porous structure usually yields 1–2 MPa, though special pressing can push it to 4 MPa [5,7].

3.2. Thermal and Acoustic Properties

Thermal Conductivity (0.03–0.05 W/mK): This is comparable to conventional insulation (glass wool, EPS). Such low conductivity indicates strong potential for energy-saving insulation [3,9].

Sound Absorption ($\alpha \sim 0.3$–0.6): In the 500–2000 Hz range, these composites show medium-high absorption, which may be beneficial for interior acoustic solutions [2,5].

3.3. Moisture Behavior

Water Absorption (≥200%): Owing to high porosity, miselyum-based composites tend to absorb large amounts of water, restricting outdoor or humid applications [1,10].

Thickness Swelling (2–5%): Upon water contact, the material partly loses dimensional stability, suggesting the need for either surface coatings or multi-layered protective systems [8,11].

3.4. Flammability and Fire Retardancy

Ignition Time (~60–70 seconds): Tests demonstrate a delay in ignition relative to synthetic foams, with a comparatively slower spread of flames [3,10].

Retardant Additives: Borates, clay, or other chemical coatings can lengthen ignition time and reduce flame spread rates [4,9].

3.5. Construction Industry Applications

Interior Insulation Panels: Provide both thermal and acoustic insulation, particularly effective in partition walls or ceiling panels [6,12].

Decorative Uses: Natural texture and light weight make them suitable for trade show stands, lampshades, or modular furniture [7,8].

Temporary Structures: Rapid assembly, disassembly, and biodegradability offer advantages for festivals or exhibition venues [2,5].

IV. DISCUSSION

This study explores the production methods, mechanical and physical attributes, moisture and fire responses, and potential construction applications of mycelium-based composites—especially those derived from Lentinula edodes and Pleurotus ostreatus. The data point to promising characteristics that can meet sustainability demands in materials science, while also revealing remaining hurdles for widespread implementation.

4.1. Sustainability and Circular Economy

Low Carbon Footprint: Unlike petroleum-derived insulation or building materials, mycelium composites predominantly use agricultural and industrial by-products, consuming significantly less energy [1,3]. The relatively mild temperatures during growth (incubation at ~20–28 °C and drying at 60–80 °C) minimize CO_2 emissions.

Waste Management and Biodegradability: Whereas synthetic foams may take centuries to degrade, mycelium-based composites readily decompose, aligning well with circular economy principles [5,7]. Post-use, such materials can function as compost, thus returning nutrients to agricultural systems.

4.2. Mechanical Strength vs. Insulating Performance

Mechanical Constraints: Compressive strength typically around 0.1–1 MPa and flexural strength of 1–4 MPa are inadequate for full load-bearing structures [6,8]. Instead, these materials suit semi-structural or infill roles. Current research investigates improvements via pressed densification, fiber reinforcement (e.g., flax), or polymer modifications [3,10,12].

Thermal and Acoustic Advantages: High porosity yields thermal conductivity in the 0.03–0.05 W/mK range and moderate-high sound absorption in the 500–2000 Hz band [2,4]. This synergy benefits energy conservation and acoustic comfort. On the downside, pressing to enhance mechanical strength reduces porosity, slightly diminishing insulation performance [9]. An optimal balance must be identified for each application.

4.3. Tackling Water and Humidity Sensitivity

High Water Uptake: Values exceeding 200% reflect the highly porous internal structure, posing a major impediment for damp or external use [1,10].

Proposed Solutions: Studies highlight the success of natural resins (e.g., lignin modification), waxes, boron compounds, and chitosan coatings in boosting water resistance [8,11]. Multi-layer configurations (a water-repellent external layer plus a mycelium core) are also being tested.

4.4. Fire Safety and Flame Retardants

Ignition Behavior: Although ignition times of 60–70 s are slower than many synthetic foams, certain applications still require alignment with international fire standards, possibly necessitating additional retardant additives or layered designs [3,4,10].

Bio-Film and Chemical Agents: Some fungal strains may produce a surface film with flame-retardant effects, while bor or mineral fillers also slow ignition spread [7,9].

4.5. Production Scalability and Standardization

Complex Parameter Interplay: Fungal species, substrate makeup, particle size, and incubation conditions all influence properties [12]. Precise process control is crucial for consistent quality.

Automation and 3D Printing: Incorporating robots, digital controls, or advanced climate monitoring can enhance batch consistency and enable complex mold geometries. Such steps could increase acceptance among industry and designers [2,6].

Absence of Specific Standards: Despite the possibility of adapting existing ASTM, EN, or ISO protocols, no dedicated standard fully addresses mycelium composites [4]. Establishing recognized guidelines is vital for widespread market integration [3,8].

4.6. Multi-Industry Prospects

Packaging and Protective Foam: Mycelium foams can safeguard fragile goods, offering lower environmental and cost burdens [1,11].

Furniture and Decor: The natural texture, lightness, and moldability suit furnishings, lampshades, and acoustic wall coverings.

Biomedical Explorations: The porous, bio-compatible qualities of mycelium have sparked interest in wound dressing or tissue engineering scaffolds. Far more rigorous testing is needed in this domain [9,12].

4.7. Overall Assessment

Given their potential for reducing carbon emissions and resource consumption, mycelium-based composites could become a linchpin in sustainable building concepts [6]. Current constraints—water sensitivity, moderate mechanical strength, and an evolving production infrastructure—limit their immediate application scope to interior insulation, temporary structures, and decorative elements [4,5]. Over time, improvements in robotics, chemical and biological modifications, life-cycle analyses (LCAs), and cost-benefit models will likely foster broader adoption [2,7].

Ultimately, these composites also offer solutions beyond construction, innovating in waste management, renewability, and minimal energy demand. If recognized standards and industrial-scale production are successfully established, mycelium-based composites could feasibly replace or reduce the use of many conventional materials.

V. CONCLUSION

This study has examined the potential of mycelium-based biocomposites—particularly those produced from Lentinula edodes (Shiitake) and Pleurotus ostreatus (oyster mushroom)—with a focus on their relevance in the construction sector. Drawing on literature surveys and real-world observations, the primary outcomes and findings can be summarized as follows:

Eco-Friendliness and Low Carbon Footprint

Mycelium's ability to process agricultural or industrial waste under mild temperature conditions (20–28 °C for incubation and 60–80 °C for drying) reduces energy consumption and CO_2 emissions significantly, promoting both waste minimization and energy efficiency. Moreover, complete biodegradability post-use sharply lowers end-of-life disposal issues.

Lightweight Materials with Thermal and Acoustic Benefits

With conductivity between 0.03 and 0.05 W/mK and a sound absorption coefficient of about 0.3–0.6 in the 500–2000 Hz frequency range, the porous structure provides high insulation performance for heat and noise. Densities of 0.05–0.30 g/cm^3 further translate to shipping and assembly advantages.

Mechanical Strength and Application Boundaries

Typical compressive strengths of 0.1–1 MPa and flexural strengths of 1–4 MPa limit full load-bearing capabilities. Nonetheless, in semi-structural, infill, and interior design uses, the material is sufficiently robust. For heavier loads, further improvements—possibly via pressing, fiber reinforcement, or composite designs—are necessary.

Moisture Sensitivity

High water absorption (≥200%) restricts application in moist or outdoor settings. Nevertheless, surface treatments based on waxes, resins, or borates can notably enhance water repellence. Multi-layer designs likewise mitigate dimensional swelling and material damage in humid environments.

Fire Retardancy and Safety Compliance

Mycelium composites generally ignite later (around 60–70 seconds) than synthetic foams and exhibit lower flame spread. Some operational contexts, however, demand compliance with international fire codes, often requiring layered compositions or flame-retardant additives.

Need for Standardization and Production Scale

Diverse factors (mushroom species, substrate composition, etc.) can alter performance, complicating consistent production. Moving toward industrial-scale manufacturing will likely call for advanced automation, tight process monitoring, and recognized test standards.

Future in Construction and Beyond

Presently, mycelium composites show the most promise in interior insulation panels, decorative and acoustic elements, modular furniture, and temporary installations. Over the longer term, consistent large-scale production, improved mechanical and moisture resistance, and official regulatory frameworks could greatly expand their role, replacing some conventional materials and aligning construction practice with sustainable development objectives.

In summary, mycelium-based biocomposites offer an alternative that meets modern sustainability requirements—low carbon footprint, minimized waste, and relatively low energy processes—while contributing notably to both environmental conservation and design innovation. Continued research, particularly on mechanical reinforcement, moisture resilience, and standardized methodologies, will be key to unlocking their full potential for construction and other industries.

REFERENCES

[1] Alaneme, K.K. et al. (2023). Mycelium based composites: A review of their bio-fabrication procedures, material properties and potential for green building and construction applications. *Alexandria Engineering Journal*, 83, 234–250.

[2] Zhang, X., Hu, J., Fan, X. & Yu, X. (2022). Naturally grown mycelium-composite as sustainable building insulation materials. *Journal of Cleaner Production*, 342, 130784.

[3] Elsacker, E., Søndergaard, A., Vandelook, S., Brancart, J., Peeters, E. & De Laet, L. (2021). Applications and growth of fungal mycelium-based materials in architecture and design. *Frontiers in Materials*, 8, 1–24.

[4] Kırdök, O., Toker, S.K., Kıvrak, O., Altun, T.D. & Hameş, E.E. (2024). Comparative Analysis of Mycelium Biocomposites as Potential Next-Generation Green Building Materials. *Mantar Dergisi*, 15(Special issue), 7–17.

[5] Walter, N. & Gürsoy, B. (2022). A study on the sound absorption properties of mycelium-based composites cultivated on waste paper-based substrates. *Biomimetics*, 7(3), 100.

[6] Sarıay, E., Cörüt, A. & Büyükakıncı, B.Y. (2023). Miselyum kompozitlerinin sürdürülebilir yapı malzemesi olarak kullanımı. *Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 14(1), 196–207.

[7] Mertoglu, Ş., Karaca, C. & Karaca, G. (2023). Use of fungi in sustainable product design. [Conference presentation].

[8] Alemu, D., Tafesse, M. & Deressa, Y.G. (2022). Production of Mycoblock from the Mycelium of the Fungus *Pleurotus ostreatus* for Use as Sustainable Construction Materials. *Advances in Materials Science and Engineering*, 2876643, 1–12.

[9] Bıyık, H.H. & Özgür, A. (2024). Bazı mantar miselyumlarından yalıtım malzemesi üretimi üzerine bir araştırma. *Mantar Dergisi*, 15(Özel sayı), 73–82.

[10] Kutbay, N.H., Yavuzcan, H.G. & Aktaş, S. (2022). Mantarın bağlayıcı olarak kullanıldığı bir kompozit malzemenin üretilmesi ve tutuşma süresi ile su alma özelliklerinin tespiti. *Politeknik Dergisi*, 25(4), 1701–1711.

[11] Appels, F.V.W., Camere, S., Montalti, M., Karana, E., Jansen, K.M.B., Dijksterhuis, J., Krijgsheld, P. & Wösten, H.A.B. (2019). Fabrication factors influencing mechanical, moisture and fire properties of mycelium-based composites. *Materials and Design*, 161, 64–71.

[12] Islam, M.R., Tudryn, G., Bucinell, R., Schadler, L. & Picu, R.C. (2017). Mechanical and thermal characterization of mycelium-based bio-composites. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, 231(2), 446–455.