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Oyster Mushroom (*Pleurotus ostreatus*) Cultivation Using Different Combinations of Agricultural By-Products as Substrates

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Abstract

This study examined the effects of different agricultural substrate combinations on the growth performance, yield, and economic efficiency of oyster mushroom *(Pleurotus ostreatus*). Anchored on sustainable agriculture and circular economy principles, the research aimed to identify optimal substrate materials for improved productivity and resource utilization. An experimental research design using a single-factor Completely Randomized Design (CRD) with seven treatments and four replications was employed, involving 560 fruiting bags. Substrates included sawdust, rice straw, corn cobs, corn husk, banana leaves, mungbean pod husk, and coconut husk, supplemented with rice bran. Data were collected through structured observation of growth parameters, yield, health conditions, and cost-benefit analysis, and analyzed using Analysis of Variance (ANOVA) and Tukey's Honestly Significant Difference (HSD) test. Results revealed significant variation in growth and yield across treatments, with sawdust producing the highest yield (2,179.72 g), largest and heaviest mushrooms, and greatest profitability (₱1,252.72 net income; 135.14% ROI), followed by corn cobs as a viable alternative. Substrates such as rice straw, banana leaves, and coconut husk showed lower productivity and economic returns. Minimal disease incidence and appropriate environmental conditions supported successful cultivation, while social findings indicated widespread adoption but limited use of diversified substrates and growth enhancers, with lack of knowledge identified as a primary challenge. The study concludes that substrate composition is a critical factor in optimizing biological efficiency and profitability, recommending sawdust as the primary substrate and corn cobs as an alternative, alongside improved training and support for farmers. The study supports Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production), by promoting efficient food production and agricultural waste utilization. It contributes to environmental and socio-economic sustainability by enhancing resource efficiency, reducing agricultural waste, and improving livelihood opportunities in local farming communities.

Keywords: Agricultural substrates; Economic efficiency; Oyster mushroom; Pleurotus ostreatus; Sustainable agriculture; Waste utilization; Yield performance

1. Introduction

Oyster mushroom *(Pleurotus ostreatus)* cultivation is widely recognized for its nutritional value, economic potential, and environmental benefits. Its ability to grow on diverse agricultural by-products makes it a viable solution for sustainable food production and waste management. However, variations in substrate combinations significantly influence growth performance, yield, and efficiency. This study examines different agricultural substrate combinations to determine the most effective and sustainable options for oyster mushroom production while contributing to broader socio-economic and environmental goals.

1.1 Background of Oyster Mushroom *(Pleurotus ostreatus)* Cultivation Using Agricultural Substrate Combinations

Oyster mushrooms (Pleurotus ostreatus) are widely cultivated edible fungi known for their nutritional properties, adaptability, and rapid growth on various substrates (Dhakal et al., 2020). They are rich in proteins, vitamins, minerals, and antioxidants, contributing to improved immune response and overall health. Their cultivation supports food security and provides income opportunities, particularly in resource-limited communities. Mushrooms have long been valued as food due to their nutritional and medicinal properties. Their composition varies depending on species, substrate, and environmental conditions. Growth-promoting bacteria further enhance mushroom productivity through mechanisms such as hormone secretion and nutrient solubilization (Zarenejad et al., 2012). As a result, oyster mushroom cultivation has emerged as an efficient and sustainable agricultural practice.

1.2 Themes on Agricultural Substrate Combinations Affecting Growth Performance, Yield, and Efficiency of Pleurotus ostreatus

Literature consistently emphasizes the role of agricultural substrates in determining mushroom growth and productivity. Oyster mushrooms efficiently utilize lignocellulosic materials such as rice straw, sawdust, and corn cobs, converting agricultural waste into valuable food products (Sanchez, 2010; Gebru et al., 2024). Substrate selection significantly affects mycelial growth, fruiting time, and yield (Pedroso et al., 2025). Studies show that various agricultural residues, including banana leaves, rice straw, and sawdust, support mushroom growth and offer cost-effective and sustainable alternatives (Tejada et al., 2023; Varghese et al., 2020). Several researchers identified banana leaves as particularly effective for improving yield and biological efficiency (Tirkey et al., 2017; Ticman, 2023; Neupane et al., 2018). Other substrates such as cotton seed hull, barley straw, and paper waste also demonstrate varying levels of productivity (Tekeste et al., 2020; Girmay et al., 2016). Mixed substrates and supplementation further enhance productivity. Combining agricultural materials improves colonization rate, yield, and biological efficiency (Muswati et al., 2021; Muslimin et al., 2021). Substrate composition and nutrient supplementation significantly influence mushroom quality and yield (Carrasco et al., 2018). Additionally, environmental factors such as temperature, humidity, pH, and management practices play critical roles in successful cultivation (Dhakal et al., 2020; Hu et al., 2023; Saputra et al., 2024; Preston and Pardo-Giménez, 2018).

1.3 Local, National, and Global Context of Agricultural Waste Utilization for Oyster Mushroom Production

Globally, food insecurity and environmental degradation highlight the need for sustainable agricultural practices. Oyster mushroom cultivation addresses these challenges by utilizing agricultural residues that are often underutilized or burned, contributing to pollution and greenhouse gas emissions. Locally and nationally, agricultural wastes such as rice straw, corn husks, and sawdust are abundant but inefficiently managed, presenting an opportunity for resource optimization. Mushroom cultivation provides a low-cost, high-value enterprise that supports rural livelihoods and promotes sustainable farming systems. By transforming waste into nutritious food, it contributes to both economic development and environmental conservation.

1.4 Conceptual Basis on the Effects of Substrate Combinations on Growth, Yield, and Efficiency of Pleurotus ostreatus

This study is grounded in sustainable agriculture and circular economy principles, where agricultural waste is converted into productive resources. Oyster mushrooms function as decomposers of lignocellulosic materials, making substrate composition a key determinant of growth and yield. The relationship between substrate composition, environmental conditions, and mushroom productivity reflects biological efficiency and resource utilization theories. Proper substrate selection and supplementation enhance nutrient availability, improve mycelial growth, and optimize yield performance (Preston and Pardo-Giménez, 2018). Environmental control factors such as humidity and temperature further influence growth dynamics (Dhakal et al., 2020; Hu et al., 2023).

1.5 Research Gap on Optimal Agricultural Substrate Combinations for Pleurotus ostreatus Production

Although numerous studies have explored oyster mushroom cultivation using agricultural residues, most focus on single substrates rather than combinations. Limited comparative research exists on the performance of different substrate mixtures, particularly using locally available materials. There is a lack of comprehensive data on how substrate combinations affect growth performance, yield, and production efficiency. This gap limits farmers' ability to make informed decisions regarding cost-effective and sustainable substrate use. Therefore, this study aims to evaluate different combinations of agricultural by-products to identify optimal substrates for oyster mushroom production while enhancing sustainability and productivity.

1.6 Alignment with Sustainable Development Goals on Agricultural Waste Utilization and Oyster Mushroom Production

This study aligns with several Sustainable Development Goals. It supports SDG 2 (Zero Hunger) by promoting a nutritious and accessible food source. It contributes to SDG 8 (Decent Work and Economic Growth) by providing income-generating opportunities through low-cost mushroom farming. The study also supports SDG 12 (Responsible Consumption and Production) by utilizing agricultural waste as substrates, reducing waste and encouraging resource efficiency. Additionally, it contributes to SDG 13 (Climate Action) by minimizing open-field burning of residues and reducing greenhouse gas emissions. Finally, it aligns with SDG 15 (Life on Land) by promoting sustainable land use and reducing environmental degradation.

1.7 Multidisciplinary Sustainability Importance of Agricultural Substrate Optimization in Oyster Mushroom Cultivation

This study contributes to socio-economic sustainability by improving farmers' livelihoods and supporting rural development through cost-efficient agricultural practices. It promotes environmental sustainability by reducing agricultural waste and encouraging recycling of organic materials. It also supports food and nutritional sustainability by providing an alternative protein source that enhances food security. Furthermore, the study contributes to agricultural and technological sustainability by optimizing resource utilization and improving cultivation practices. Overall, it integrates economic, environmental, and social dimensions of sustainability through sustainable mushroom production systems.

2. Materials and methods

2.1 Research Design

The study utilized an experimental research design using a single-factor Completely Randomized Design (CRD) with seven treatments and four replications. Each experimental unit consisted of 20 fruiting bags, resulting in a total of 560 fruiting bags. The treatments consisted of different agricultural substrate combinations combined with rice bran in a 70% to 30% ratio. The control treatment used sawdust with rice bran, while other treatments included rice straw, corn cobs, corn husk, banana leaves, mungbean pod husk, and coconut husk. Data collected were subjected to statistical analysis using Analysis of Variance (ANOVA), and significant differences among means were further analyzed using Tukey's Honestly Significant Difference (HSD) test.

2.2 Locale of the Study

The experimental component of the study was conducted at the residence of Mr. Efren Bala located at Barangay District No. 4, San Manuel, Isabela. The social research component involved farmer-participants from Barangay Malalinta, San Manuel, Isabela.

2.3 Respondents of the Study

The respondents of the study consisted of farmer-participants who were engaged in mushroom cultivation and were members of the local community. These participants were involved in the Urban Agriculture Program of the Department of Agriculture–Agricultural Training Institute (DA-ATI). They were selected based on their willingness to participate, ability to follow mushroom production procedures, access to agricultural substrates, and capacity to understand the local dialect. Participants who were unwilling to adopt new technologies, lacked access to substrates, or had allergies related to mushrooms were excluded.

2.4 Sample and Sampling Procedure

Participants were selected from the local farming community using defined inclusion and exclusion criteria to ensure relevance to the study. The experimental component involved 560 fruiting bags distributed across seven treatments with four replications. Each treatment represented a specific agricultural substrate combination. The sampling approach ensured representation of locally available agricultural by-products and practical applicability within the community setting.

2.5 Research Instrument

Data were collected using structured observation and measurement procedures for growth, yield, health, and economic parameters. Growth parameters included rate of colonization, time to first fruiting, number of fruiting bodies, and cap and stem dimensions. Yield measurements included fresh weight, total yield per unit area, and number of yields. Health and disease incidence were monitored throughout the study period. Economic data were gathered through recording production costs and gross income to determine cost-benefit analysis and return on investment. For the social component, a researcher-developed questionnaire was used and reviewed by experts. The instrument was administered in the local dialect and validated through interviews and focus group discussions to ensure accuracy and reliability of responses.

2.6 Data Gathering Procedure

Agricultural by-products such as rice straw, corn husk, corn cobs, banana leaves, coconut husk, mungbean pod husk, and sawdust were collected, dried, and processed into substrates. Materials were chopped, soaked when necessary, and pre-composted for seven days. Substrates were mixed with rice bran, agricultural lime, sugar, and water to achieve appropriate moisture and pH levels before being packed into polypropylene bags. The fruiting bags were sterilized at 100 °C for eight hours and inoculated aseptically with mushroom spawn. After inoculation, the bags were incubated for approximately 30 days until full mycelial colonization was achieved. The bags were then transferred to a mushroom house where environmental conditions such as temperature and humidity were maintained using regular watering and monitoring equipment. Mushrooms were harvested when caps were fully developed, cleaned, and stored properly to maintain quality. Data on growth, yield, and environmental conditions were recorded throughout the production cycle. For the social research component, community participation was integrated through engagement, training, and monitoring activities. Participants were involved in training programs, feedback sessions, and evaluation processes. Questionnaires and interviews were conducted after obtaining informed consent. Safety protocols, including the use of personal protective equipment, health monitoring, and proper waste handling procedures, were implemented throughout the study.

2.7 Data Analysis Techniques

Descriptive statistics, including mean, median, and standard deviation, were used to summarize growth and yield data. Inferential statistical analysis was conducted using Analysis of Variance (ANOVA) to determine significant differences among treatments. Tukey's Honestly Significant Difference (HSD) test was applied for mean comparison. Economic analysis was performed through cost-benefit analysis and return on investment calculations to evaluate the profitability of each treatment.

3. Results and Discussion

3.1 Growth and Yield Performance of Oyster Mushroom under Different Substrate Treatments

3.1.1 Health Condition and Disease Incidence

Most fruiting bodies exhibited healthy characteristics, including firm texture, well-formed caps, and vigorous mycelial growth that fully colonized the substrate before pinhead formation. Only a small proportion of fruiting bags (approximately 5–10%) showed symptoms of bacterial blotch, characterized by water-soaked lesions on caps, and some contamination from green mold caused by Trichoderma species. No significant insect infestations were observed. These findings indicate that proper substrate preparation, sterilization, and environmental control contributed to overall healthy mushroom development. The minimal disease incidence suggests effective hygiene practices, while the presence of bacterial blotch and green mold highlights the importance of moisture control and proper sterilization to prevent contamination.

3.1.2 Environmental Conditions during Cultivation

Temperature during incubation ranged from 30.40–33.70°C, while humidity ranged from 62.33–79.00%, supporting effective mycelial colonization. During fruiting, temperature was maintained between 25–32°C, and relative humidity ranged from 85–99%, which promoted proper fruit body development. Higher humidity levels were associated with larger and plumper mushrooms, while slight temperature fluctuations were observed due to environmental factors. These results demonstrate that stable environmental conditions are critical for successful oyster mushroom cultivation. Proper control of temperature and humidity enhances colonization, fruiting, and yield, while inconsistencies in microclimate indicate the need for improved ventilation and uniform environmental management.

3.1.3 Rate of Colonization

The fastest colonization was observed in corn cobs, completing in 32 days, followed by sawdust at 34 days. Rice straw and mungbean pod husk required 36 days, while coconut husk and banana leaves required 38 and 40 days, respectively. Corn husk showed the slowest colonization at 42 days. These results indicate that substrate characteristics such as porosity, aeration, and nutrient availability influence colonization rate. Corn cobs provided a more favorable structure for rapid mycelial spread, while tougher or less moisture-retentive substrates slowed colonization.

3.1.4 Time to First Fruiting

Coconut husk recorded the earliest fruiting at 50 days, followed by sawdust and corn cobs at 51 days. Corn husk and mungbean pod husk produced fruiting at 52 days, while rice straw and banana leaves had the longest fruiting time at 55 days. This suggests that substrate texture and moisture retention affect the transition from colonization to fruiting. Substrates with better aeration and moisture balance promote earlier fruiting, while softer or rapidly decomposing materials may delay primordia formation.

3.1.5 Morphological Characteristics of Mushrooms

Sawdust produced the longest mushrooms at 12.54 cm, while corn husk produced the shortest at 10.94 cm. Other treatments showed intermediate values with minimal differences. Mushroom height showed no significant variation across treatments, with values ranging from 10.23 cm to 11.56 cm. These findings indicate that substrate composition has limited influence on mushroom height but can affect length to some extent. Structural and nutritional properties of substrates contribute to physical characteristics, although differences are generally small.

3.1.6 Fruiting Bag Weight

Sawdust produced the highest fruiting bag weight at 517.98 g, followed by corn cobs at 497.47 g. Moderate weights were observed in corn husk, coconut husk, and rice straw, while banana leaves and mungbean pod husk recorded the lowest weights. This shows that substrates with better moisture retention, aeration, and nutrient composition contribute to higher fruiting bag weight. Sawdust remains the most effective substrate, while corn cobs serve as a strong alternative.

3.1.7 Number of Fruiting Bodies

Sawdust produced the highest number of fruiting bodies at 19.5, while banana leaves and coconut husk produced the lowest at 16.5. Other treatments showed intermediate values. These results suggest that substrate structure and nutrient availability significantly influence the number of fruiting bodies. Substrates with stable structure and balanced nutrients promote higher productivity.

3.1.8 Yield per Unit Area

Sawdust yielded the highest production at 71.25 pieces, followed by corn cobs at 64 pieces. Moderate yields were observed in mungbean pod husk, rice straw, and coconut husk, while corn husk and banana leaves produced the lowest yields. This confirms that substrate composition strongly affects yield. Substrates with optimal physical and nutritional properties enhance overall productivity, with sawdust remaining the most effective.

3.1.9 Weight of Individual Mushrooms

Sawdust produced the heaviest mushrooms at 30.59 g, followed by corn husk at 28.65 g. The lightest mushrooms were produced from rice straw, banana leaves, and coconut husk. These findings highlight that substrate quality, particularly aeration and nutrient availability, influences mushroom weight. High-performing substrates support better development of individual fruiting bodies.

3.1.10 Total Yield per Treatment

Sawdust produced the highest total yield at 2,179.72 g, followed by corn cobs at 1,637.60 g. Moderate yields were observed in corn husk and mungbean pod husk, while rice straw, coconut husk, and banana leaves produced the lowest yields. These results emphasize that substrate selection is a critical factor in maximizing production. Sawdust consistently outperformed other substrates, while corn cobs emerged as a viable alternative.

3.1.11 Economic Performance (Cost-Benefit Analysis)

Sawdust generated the highest net income of ₱1,252.72 with an ROI of 135.14%, followed by corn cobs with ₱750.60 and an ROI of 84.62%. Moderate returns were observed in corn husk and mungbean pod husk, while rice straw, banana leaves, and coconut husk recorded the lowest returns. This indicates that profitability is strongly influenced by yield performance. High-yielding substrates provide better economic returns, highlighting the importance of selecting efficient and cost-effective materials.

3.2 Community Participation and Adoption Practices

3.2.1 Socio-Demographic Characteristics

All respondents were from the same community, with most being middle-aged and predominantly female. The majority had at least high school education and managed small to medium land areas with diversified farming systems. These findings suggest that oyster mushroom production is accessible to a wide range of individuals, particularly those with basic education and existing agricultural experience. Female participation also highlights its suitability as a livelihood activity.

3.2.2 Adoption of Oyster Mushroom Production Practices

All respondents were aware of and engaged in oyster mushroom production, with oyster mushroom as the dominant species. However, most did not use different substrate combinations and relied on traditional materials such as sawdust, rice straw, and banana leaves. This indicates that while adoption is widespread, innovation in substrate diversification remains limited. Farmers tend to rely on familiar and locally available materials rather than experimenting with alternative combinations.

3.2.3 Use of Growth Enhancers

Only a minority of respondents used growth enhancers, primarily low-cost materials such as rice wash and Yakult, with most having used them for only a short period. This suggests that adoption of improved inputs is still emerging, with farmers preferring accessible and affordable options over commercial products.

3.3 Benefits, Challenges, and Future Directions

3.3.1 Benefits and Motivation

The primary motivation for mushroom production was increased income, with most respondents identifying it as the main benefit. Other benefits such as increased production and environmental concerns were less emphasized. This indicates that economic gain is the main driver of adoption, with farmers prioritizing profitability over other potential advantages.

3.3.2 Challenges in Adoption

The major challenge identified was lack of knowledge, followed by insufficient government support and low market demand. Other factors such as substrate availability and market linkage were minimal concerns. These results highlight the need for capacity-building programs and institutional support to improve adoption and productivity in mushroom cultivation.

3.3.3 Information Sources and Trust

Respondents primarily relied on online resources and agricultural extension services for information, with extension services being the most trusted source. This demonstrates the importance of extension systems in disseminating knowledge and influencing adoption of improved agricultural practices.

3.3.4 Future Plans and Recommendations

All respondents expressed willingness to continue mushroom production, recommend it to others, and share their knowledge. While many were satisfied with current practices, some suggested the need for additional training and government support. These findings indicate strong sustainability and potential for expansion of oyster mushroom production, provided that training and institutional support are strengthened.

4. Conclusion & Recommendations

The study demonstrated that substrate composition significantly influences the growth performance, yield, and economic returns of oyster mushroom (Pleurotus ostreatus). Among the seven treatments, sawdust consistently produced the best results, including the tallest and heaviest mushrooms, highest total yield, and greatest profitability, while corn cobs also showed strong performance as a viable alternative. In contrast, rice straw, corn husk, banana leaves, mungbean pod husk, and coconut husk exhibited lower productivity and economic returns. Overall, the findings confirm that selecting appropriate substrates with balanced nutrient composition, moisture retention, and structural properties is essential for maximizing both biological efficiency and profitability in oyster mushroom cultivation.

Based on the findings, sawdust is recommended as the primary substrate for oyster mushroom production due to its superior yield and profitability, while corn cobs may be used as an alternative when sawdust is less available or more costly. Substrates such as rice straw, corn husk, banana leaves, mungbean pod husk, and coconut husk are not recommended for large-scale production due to their lower performance. Further research is suggested to explore improved substrate combinations, supplementation, nutrient composition, and performance under varying environmental conditions, while maintaining proper cultivation practices such as optimal humidity, temperature, cleanliness, and cost monitoring to ensure sustained productivity and profitability.

The study was limited to selected agricultural substrates and specific experimental conditions, which may affect the generalizability of the results to other environments or production systems. The findings were based on short-term observations and controlled conditions, and did not include broader variations in substrate combinations, environmental factors, or large-scale commercial applications.

Compliance with ethical standards

The author acknowledges the participation of farmer-respondents from Barangay Malalinta, San Manuel, Isabela, and their involvement in the Urban Agriculture Program of the Department of Agriculture–Agricultural Training Institute (DA-ATI), which contributed to the successful conduct of this study.

REFERENCES

Akcay, C., Ceylan, F., & Arslan, R. (2023). Production of oyster mushroom (Pleurotus ostreatus) from some waste lignocellulosic materials and FTIR characterization of structural changes. Scientific Reports, 13, 12897. https://doi.org/10.1038/s41598-023-40200-x

Carrasco, J., Zied, D. C., Pardo, J. E., Preston, G. M., & Pardo-Giménez, A. (2018). Supplementation in mushroom crops and its impact on yield and quality. AMB Express, 8, 146. https://doi.org/10.1186/s13568-018-0678-0

Conde, C. (2023). Development of IoT-based temperature, humidity, and substrate pH level control system for oyster mushroom (Pleurotus spp.) cultivation. Rivista Italiana di Filosofia Analitica Junior, 14(2).

Dhakal, P., Pokhrel, A., Bista, A., Shah, K., Acharya, B., & Shrestha, J. (2020). Growth and yield performance of oyster mushroom (Pleurotus ostreatus) on different substrates. Agriways, 8(1), 1–8.

Dollison, M. D. (2023). Performance of edible mushroom varieties under different agricultural substrates. International Journal of Multidisciplinary: Applied Business and Education Research, 4(5), 1612–1617. https://doi.org/10.11594/ijmaber.04.05.22

Dubey, D., Dhakal, B., Dhami, K., Sapkota, P., Rana, M., Poudel, N. S., & Aryal, L. (2019). Comparative study on the effect of different substrates on yield performance of oyster mushroom. Global Journal of Biology, Agriculture and Health Sciences, 7, 7.

Gebru, H., Belete, T., & Faye, G. (2024). Growth and yield performance of Pleurotus ostreatus cultivated on agricultural residues. Mycobiology, 52(6), 388–397. https://doi.org/10.1080/12298093.2024.2399353

Girmay, Z., Gorems, W., Birhanu, G., & Zewdie, S. (2016). Growth and yield performance of Pleurotus ostreatus (Jacq. Fr.) Kumm (oyster mushroom) on different substrates. AMB Express, 6, 87. https://doi.org/10.1186/s13568-016-0265-1

Hoa, H. T., Wang, C. L., & Wang, C. H. (2015). The effects of different substrates on the growth, yield, and nutritional composition of two oyster mushrooms (Pleurotus ostreatus and Pleurotus cystidiosus). Mycobiology, 43(4), 423–434. https://doi.org/10.5941/MYCO.2015.43.4.423

Hu, Y., Xue, F., Chen, Y., Qi, Y., Zhu, W., Wang, F., Wen, Q., & Shen, J. (2023). Effects of mycelial culture temperature on the growth and development of Pleurotus ostreatus. Horticulturae.

Mangilog, K., Mendez, J. F., & Soriano, R. (2024). Growth and yield response of oyster mushroom (Pleurotus ostreatus) on different ratios of rice husk and corncob substrates. Aka Student Research Journal, 3(1), 9–18. https://journal.omsc.edu.ph/index.php/aka-journal/article/view/54

Mohamed, M. F., Refaei, E. F. S., Abdalla, M. M. A., & El-Kattan, M. H. (2016). Fruiting bodies yield of oyster mushroom (Pleurotus columbinus) as affected by different portions of compost in the substrate. International Journal of Recycling of Organic Waste in Agriculture, 5, 281–288. https://doi.org/10.1007/s40093-016-0138-2

Muslimin, R., et al. (2021). The effect of different substrates on oyster mushroom (Pleurotus ostreatus) spawn growth. IOP Conference Series: Earth and Environmental Science, 911, 012044.

Muswati, C., Simango, K., Tapfumaneyi, L., Mutetwa, M., & Ngezimana, W. (2021). The effects of different substrate combinations on growth and yield of oyster mushroom (Pleurotus ostreatus). International Journal of Agronomy, 2021, Article 9962285. https://doi.org/10.1155/2021/9962285

Neupane, S., Thakur, V., Bhatta, B., Pathak, P., Gautam, B. B., & Aryal, L. (2018). Performance of different substrates on the production of oyster mushroom (Pleurotus florida) at Gokuleshwor, Darchula. International Journal of Scientific and Research Publications, 8(6), 231–240.

Ogbuji, N. G., & Mbeke-Gomba, E. S. (2025). Oyster mushroom [Pleurotus ostreatus (Jacq. ex Fr.) P. Kumm.] cultivation using agricultural wastes. Ethiopian Journal of Agricultural Sciences, 34(4), 112–122. https://www.ajol.info/index.php/ejas/article/view/289528

Paudel, S., & Dhakal, D. (2020). Yield performance of oyster mushroom (Pleurotus ostreatus) on different substrate. Archives of Agriculture and Environmental Science, 5(2), 190–195. https://doi.org/10.26832/24566632.2020.0502016

Pedroso, M. L., Alagos, A. L. C., Esgrina, F. J. O., Habibun, J. F., Maun, J. N., & Rodriguez, R. M. M. (2025). Maximizing Pleurotus ostreatus yield with sustainable agricultural waste substrates. Nusantara Bioscience.

Preston, G. M., & Pardo-Giménez, A. (2018). Supplementation in mushroom crops and its impact on yield and quality. AMB Express, 8, 146.

Roy, S., Sinha, A., Kumari, A., & Mishra, P. K. (2023). Effect of organic supplement on oyster mushroom spawn production. Journal of Advanced Scientific Research.

Royse, D. J. (2014). A global perspective on the high five: Agaricus, Pleurotus, Lentinula, Auricularia, and Flammulina. In Proceedings of the 8th International Conference on Mushroom Biology and Mushroom Products (pp. 1–6).

Sánchez, C. (2010). Cultivation of Pleurotus ostreatus and other edible mushrooms. Applied Microbiology and Biotechnology, 85(5), 1321–1337.

Saputra, E. A., Rahman, Y. A., Santoso, R., & Tegar, R. (2024). Application of temperature and humidity control technology in oyster mushroom cultivation.

Tejada, R., Clemente, R., Gaerlan, R., Libunao, J., Mapuyan, C., Rivera, D., & Valderama, J. (2023). Performance and yield of oyster mushroom (Pleurotus ostreatus) with banana leaves, rice straw and sawdust as substrates. Southeast Asian Journal of Agriculture and Allied Sciences.

Tekeste, N., Dessie, K., Taddesse, K., & Ebrahim, A. (2020). Evaluation of different substrates for yield and yield attributes of oyster mushroom (Pleurotus ostreatus) in crop–livestock farming system of Northern Ethiopia. Open Agriculture Journal, 14, 30–36. http://dx.doi.org/10.2174/1874331502014010030

Tesfaw, A., Tadesse, A., & Kiros, G. (2015). Optimization of oyster (Pleurotus ostreatus) mushroom cultivation using locally available substrates and materials in Debre Berhan, Ethiopia. Journal of Applied Biology and Biotechnology, 3(1), 1–2.

Ticman, C. M., Jr. (2023). Performance of oyster mushroom (Pleurotus sp.) using different sources of substrates. International Journal of Molecular Microbiology, 16(2), 1–5. https://innspub.net/performance-of-oyster-mushroom-pleurotus-sp-using-different-sources-of-substrates/

Tirkey, V. J., Simon, S., & Lal, A. A. (2017). Efficacy of different substrates on the growth, yield, and nutritional composition of oyster mushroom—Pleurotus florida (Mont.) Singer. Journal of Pharmacognosy and Phytochemistry, 6(4), 1097–1100.

Varghese, B. P., & Amritkumar, P. (2020). Comparative study on cultivation of oyster mushrooms using nutrition-enhancing substrates. International Journal of Scientific Research in Biological Sciences, 7(2), 105–111. https://ijsrbs.isroset.org/index.php/j/article/view/346

Zarenejad, F., Yakhchali, B., & Rasooli, I. (2012). Evaluation of indigenous potent mushroom growth-promoting bacteria (MGPB) on Agaricus bisporus production. World Journal of Microbiology and Biotechnology, 28, 99–104.