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Sustainable Cultivation and Nutritional Analysis of Pleurotus ostreatus Grown on Lignocellulosic Aquatic Waste Substrate.

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Abstract

Sustainable management of agricultural waste remains a critical global issue, which requires innovative biotechnological solutions. These help to enhance resource efficiency and support a circular bioeconomy. This study assesses the efficacy of water hyacinth as substrate for *Pleurotus ostreatus* cultivation, investigating the biological efficiency, growth parameters, and proximate analysis of *P. ostreatus* cultivated on water hyacinth and paddy straw, addressing the potential for these underutilized resources to enhance mushroom production. Also compared total yields over multiple harvests were also compared, and nutritional content was analyzed according to AOAC and IS standards. The results show that paddy straw substrate produces mushrooms with higher nutritional value and better yield. Indicating that water hyacinth, an invasive aquatic weed, is an effective protein- rich alternative to traditional agricultural residues for sustainable mushroom cultivation.

INTRODUCTION

The cultivation of oyster mushrooms on agro- industrial by products represents promising biotechnological approach for waste variolisation and food production (Doroški et al., 2022; Miśkiewicz et al., 2025). *P. ostreatus* are capable to convert agro- industrial food cellulosic wastes into nutritious fruiting body (Panagiota et al., 2023; Sganzerla et al., 2022). Their enzymatic machinery facilitates the degradation of complex lignocellulostic structure into simple compounds (Ahmed et al., 2023). The efficiency of this degradation, growth of fungal biomass and nutritional profile is influenced by substrate composition (Panagiota et al., 2023). So for the cultivation of mushrooms substartes like rice straw, sugarcane bagasse, spent coffee grounds, wheat straw and corn cobs are used (Akter et al., 2022; Fayssal et al., 2021; Kumawat et al., 2025). The use of underutilized agricultural substrates like *Pontederia crassipes* (water hyacinth) can enhance the economic viability and production of mushrooms (Ahmed et al., 2023). By using water hyacinth as a substrate for mushroom production it helps to use its economic feasibility, weed suppression and waste water phytoremediation (Ejigu et al., 2022; Mukhopadhyay, 2020; Subedi et al., 2023).

Mushrooms are well established for their nutritional characters and therapeutic properties, and because of the ease of cultivation, increased consumer interest mushroom cultivation become common (Aditya et al., 2024). Among them *Pleurotus sp.* are great for their nutritional characters and also in their taste and aroma which make them a commercially available edible food (Miśkiewicz et al., 2025). So, Oyster mushrooms are the second most commonly grown mushroom in world. As white rot fungus oyster mushrooms possess variable bioactive compounds and biological impact (Aditya et al., 2024). Bioactive compounds containing in mushrooms has immunomodulatory, antibacterial, antiviral, haematological, antitumour, hypocholoesterolemic, and blood glucose regulatory effects (Azzam et al., 2025). It contain high content of crude protein carbohydrate dietary fibre amino acids, minerals and vitamins (Azzam et al., 2025; Doroški et al., 2022). Oyster mushrooms species has the capacity to grow rapidly over wide temperature (10–30℃) and pH (6.0–8.0) and can be seen in temperate, tropical, subtropical regions (Aditya et al., 2024; Azzam et al., 2025). And these mushrooms while utilizing lignocellulosic waste the

resulting fruiting body has high protein and valorising the waste materials (Azzam et al., 2025). Fungi produces laccase peroxidase like lignocellulolytic enzymes, which help in the breakdown of lignocellulosic materials (Zárate-Salazar et al., 2020). Analysis of these enzymatic activity helps to understand the efficiency of *Pleurotus ostreatus* in deconstructing the novel substrates (Wiesnerová et al., 2023). Such biochemical analysis would complement the macroscopic observations of yield and nutritional content, offering a more holistic understanding of substrate suitability (Luque et al., 2021). Optimising the nitrogen-to-carbon ratio of nitrogen rich supplements to carbon rich agricultural wastes is crucial for maximising fungal growth and reproductive output (Subedi et al., 2023). For this purpose integration of nutrient rich additives like legume-based flours can be added which significantly enhance biological efficiency and increase the protein and sugar percentage in the final yield (Sharma et al., 2025).

In this study we aimed the valorisation of invasive aquatic weed water hyacinth for the cultivation of *Pleurotus ostreatus.* And compare the nutritional profile of mushrooms with the conventional substrate rice straw.

MATERIALS AND METHOD

Mushroom Strain and Substrates

Pleurotus ostreatus species was procured from Tamil Nadu Agricultural University, Coimbatore, India are used for cultivation. The spawns are maintained in potato Dextrose Agar. Rice straw (RS) and sundried water hyacinth (WH) were used as substrates for mushroom cultivation. Both are collected locally from the agricultural field and ponds in Coimbatore, India. The roots of sundried substrates were discarded because it is reported that they can absorb heavy metals.

Preparation of Substrates

The collected substrates were cleaned to remove debris and impurities. The stems of water hyacinth were cut into suitable sizes and dried under sunlight in a well-ventilated area until optimal moisture reduction was achieved. Proper substrate conditioning enhances mycelial colonisation and reduces contamination risks. The dried WH stems were immersed completely in clean water and allowed to soak for approximately 3 hours to ensure proper hydration. Adequate moisture content is critical for enzymatic activity and efficient substrate colonisation. The soaked substrates were pasteurised by immersion in hot water maintained at 60–70°C to eliminate competing microorganisms. Pasteurisation is a crucial step in oyster mushroom cultivation, as it selectively reduces harmful microbes while preserving beneficial ones.

Inoculation and Bag preparation

The bed preparation was carried out using the layer spawning technique. Transparent polythene bags (60 × 30 cm) were disinfected using 70% ethanol. The bottom ends of the bags were tied, and small perforations were made to facilitate drainage. Approximately 2 kg of prepared substrate was filled into each bag in layers, and a handful of *Pleurotus ostreatus* spawn was added between each layer. The prepared spawn bags were transferred to a controlled spawn running room and arranged in rows. Environmental conditions were maintained at 22–24°C temperature and 85–90% relative humidity. The room was disinfected periodically using 0.5% formaldehyde solution, and the spawn bags were monitored daily for contamination and colonisation.

Cultivation

The cultivation of mushrooms was carried out at the mushroom cultivation unit of Nehru Arts and Science College. The cultivation room was designed to provide optimal environmental conditions for the growth and development of oyster mushrooms.

A layer of sand approximately 5–6 cm thick was spread over the ground and covered with coconut leaves to prevent direct exposure to sunlight. Humidity and temperature were maintained. To maintain this humidity, regular water spraying was carried out in the cropping room. Adequate ventilation was maintained throughout the cultivation process. Light intensity of approximately 500 lux for 8–12 hours per day was provided. Water used for spraying was at a neutral pH, avoiding excessive acidity or alkalinity, and was free from harmful salts (Chen et al., 1984; Hu et al., 2022). After 2 weeks, the first flush of mushrooms started to develop. Harvesting was performed before water spraying to maintain quality. The harvesting stage was determined based on the size and shape of the fruiting bodies. After harvesting, the lower portion of the stalk containing adhering debris was trimmed using a sterile knife. Fresh mushrooms were packed in perforated polythene bags.

Assessing Nutritional Quality of Mushrooms

Harvested mushroom fruiting bodies were collected and analysed from both substrates. The samples used for chemical analysis were oven-dried at 45°C for 72 hours, ground to powders and kept in airtight bags. They were subjected to nutritional analysis. The analysis relied on the Association of Official Analytical Chemists (AOAC) protocol for moisture, ash, fat, and carbohydrates. Protein analysis was performed using the IS 7219:2015 standard, and energy content was determined using the ALT/SOP protocol.

Statistical Analysis of Experimental Data

All the experiments and analyses were done in such a way that at least three replicates were used for each experiment and analysis. Results are expressed as mean value± standard error.

RESULT

Yield of Mushrooms

Pleurotus ostreatus grows well in the studied substrate. About 2460 g of mushrooms were harvested from WH, but only about 1860 g of mushrooms were obtained from PS. So, there is a significant growth increase is seen in mushrooms grown in WH. Also, there is a significant decline in yield of mushrooms from PS after the first harvest. Meanwhile, WH shows sustained productivity across the fourth harvest (as shown in Fig. 1).

Assessing Nutritional Quality of Mushrooms

The nutritional analysis of mushrooms from each source was done (as shown in Table 1). There is a significant difference was found in moisture content in mushrooms from both substrates. The results show that mushrooms from WH have more moisture content than from PS. The protein content is also higher in mushrooms from WH, at about 14% of dry weight. It is noticeable that there is a detectable limit of carbohydrate found in mushrooms from WH. So, the nutritional profiles show that WH has more protein and moisture, while PS has more fat, ash, and carbohydrates.

Table 1
Nutritional assessment of Oyster Mushroom

Table 1: Nutritional assessment of Oyster Mushroom	**Test Protocol**	**Result (WH)**	**Result (PS)**
Moisture (% of fresh weight)	AOAC 22nd Edition 925.10:2023	84.96 ± 9.4	45.26 ± 10.5
Total Ash (% DWB)	AOAC 22nd Edition 923.03:2023	1.17 ± 0.6	2.71 ± 1.5
Total Fat (% DWB)	AOAC 22nd Edition 920.85:2023	0.09 ± 0.01	1.0 ± 0.05
Total Protein (% DWB)	IS 7219:2015	14.16 ± 1.2	2.85 ± 2.6
Carbohydrate (% DWB)	AOAC 22nd Edition 986.25 E: 2023	BDL*	4.5 ± 1.9
Energy (Kcal/100g)	ALT/SOP/03/01:2016	56.84 ± 1.9	43.25 ± 1.2
*BDL= Below Detectable Limit			
DWB- Dry weight biomass of mushroom.			
Results are mean ± standard deviation			
FIGURE			
Graph			

DISCUSSION

The comparative evaluation of *Pleurotus ostreatus* cultivation on water hyacinth (*Eichhornia crassipes*) and PS demonstrates that water hyacinth is not only a viable alternative but also a superior substrate in terms of biological productivity and nutritional density. The growth of mushrooms in lignocellulosic material indicates that by using biotechnology, we can turn invasive aquatic biomass into something useful that helps with both food security and environmental management (Ejigu et al., 2022). The total yield from water hyacinth was approximately 31.6% higher than that of paddy straw. A notable observation in this study was the sustained productivity of water hyacinth across four flushes, especially the unexpected increase in the fourth harvest compared to the third. In contrast, paddy straw followed a typical exhaustion curve, with the first flush yielding 949g and then declining steadily. This consistent productivity indicates that the lignocellulosic materials of *E. crassipes* may facilitate a more gradual nutrient release or potentially a greater reservoir of accessible hemicellulose that persists beyond initial flushes (Mahmoud, 2006). Previous studies show that using water hyacinth biomass as the main substrate often leads to better biological efficiency than using straws that are high in carbon but low in nutrients (Ejigu et al., 2022). The mycelium's ability to maintain high-yield production into a fourth flush

highlights the commercial potential of this substrate to extend the lifecycle of cultivation bags. The most significant finding of this study is the drastic difference in protein content. Mushrooms harvested from water hyacinth substrates contain nearly five times the amount found in those grown on paddy straw. This shows that the nitrogen-to-carbon (N: C) ratio in water hyacinth is much higher, which is responsible for the formation of the fungal proteins (Ejigu et al., 2022). The biochemical makeup of the substrate is the main thing that decides how healthy the fruit bodies will be (Jmg and Escober, 2025). The high protein density and higher energy value make mushrooms grown in water hyacinth a very good food source for people who are protein-energy malnourished. Also, the fact that the water hyacinth group had carbohydrates below the detectable limit suggests that the mushrooms were able to turn available sugars into biomass and protein, which is a good thing for low-glycemic dietary supplements. The moisture content of mushrooms cultivated on water hyacinth aligned with the established physiological standards for the Pleurotus genus. But the fact that paddy straw mushrooms have a lot less moisture could mean that the substrate is stressed for water during the fruiting phase. Water hyacinth is known for being able to hold a lot of water even after it has been dried and processed. This probably helps the developing mycelium stay hydrated better (Mukhopadhyay, 2020). Conversely, the higher ash content in paddy straw mushrooms aligns with established literature regarding the high mineral and silica content inherent to rice residues (Bhattacharjya et al., 2015). While ash content reflects mineral availability, the lower moisture content in paddy straw could lead to a tougher texture and reduced shelf life in fresh markets compared to more hydrated water hyacinth harvests(Subedi et al., 2023). Using water hyacinth as a growing medium is a smart way to solve the "weed problem" in aquatic ecosystems. This model exemplifies a circular bioeconomy by turning an invasive species into a high-protein food source (Kumawat et al., 2025; Mukhopadhyay, 2020). The higher yields and protein profiles obtained in this study indicate that switching from paddy straw, which is often used as livestock feed, to water hyacinth can maximise the economic benefits for both small-scale and large-scale growers (Ahmed et al., 2023) .

CONCLUSION

Water hyacinth serves as an effective and sustainable substrate for the cultivation of oyster mushrooms. Using it as an alternative substrate for growing mushrooms can help mushrooms grow more efficiently, reduce their impact on the environment, and make mushroom farming more profitable. Using it as a different substrate for growing mushrooms can make better use of resources, have less of an effect on the environment, and make mushroom farming more profitable. Future research can investigate the optimal harvesting times for water hyacinth to increase the yield and desired nutritional profiles of mushrooms. Additional research may investigate the effectiveness of these materials as substrates for applications, including mushroom cultivation, and assess the quality and yield of the resultant product. Could look into how well these materials work as substrates for certain uses, like growing mushrooms, and check the quality and yield of the finished product. Investigate the effectiveness of these materials as substrates for particular applications, including mushroom cultivation, and assess the quality and yield of the final product. Assessing the economic viability and environmental impact of using these biomasses is also important for making them work in real life. In conclusion, the data show that

Eichhornia crassipes is a high-quality substrate that improves the nutritional and economic aspects of *P. ostreatus* cultivation. Future studies should explore the optimisation of water hyacinth by supplementing it with other agricultural wastes to further maximise biological efficiency and nutrient bioavailability.

Declarations

AUTHOR CONTRIBUTIONS

T.M is responsible for conceptualisation. S.A.S responsible for data collection. S.A.S and T.M contributed to the methodology, formal analysis, investigation, writing original draft, editing, and validation. Both authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING DECLARATION

No funding was received for conducting this study.

DATA AVAILABILITY

The nutritional analysis profiles and cultivation datasets generated and analysed during the current study are available from the corresponding author, upon reasonable request.

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Figures

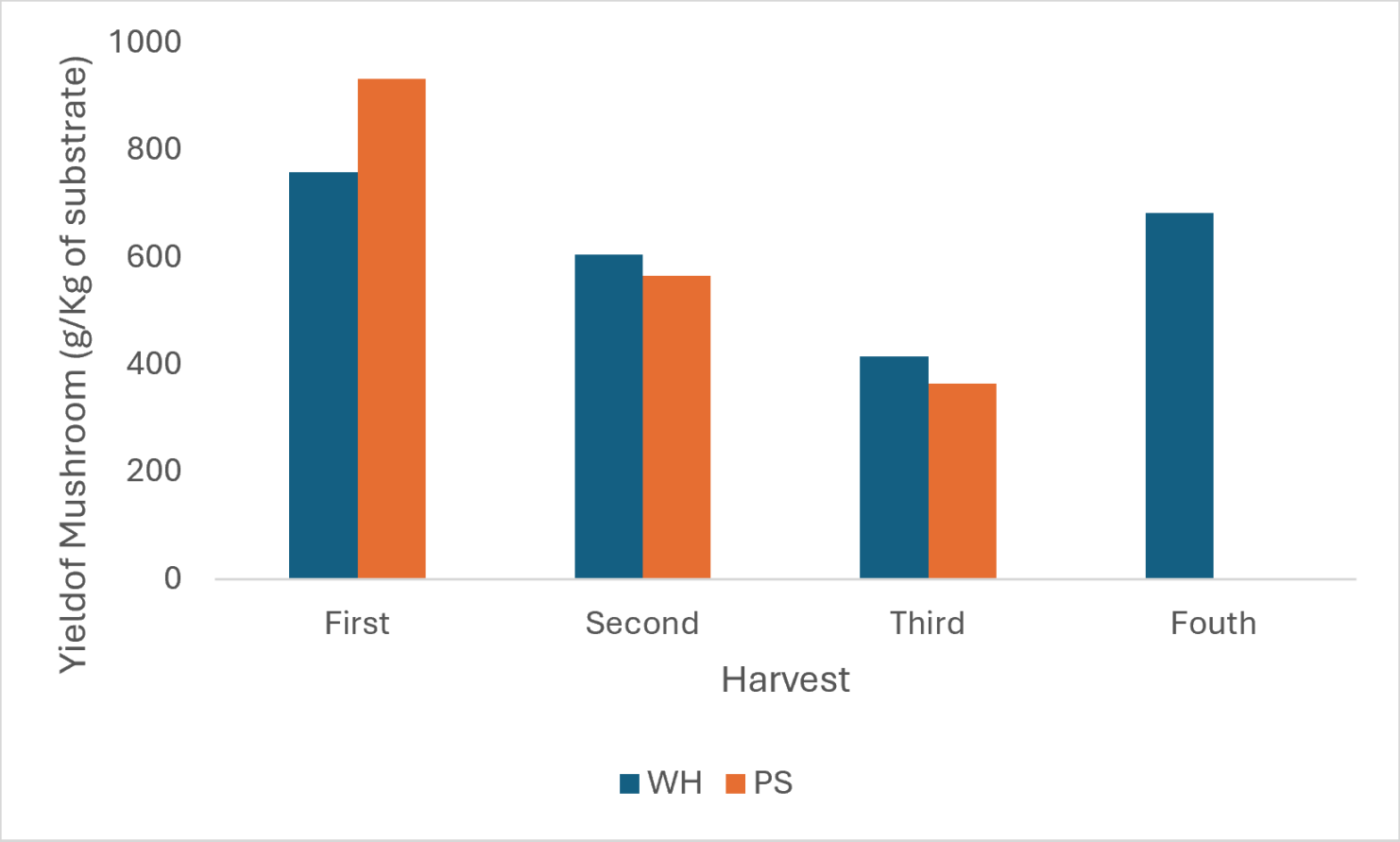


Figure 1

Biological yield of *P. ostreatus*after four flushes on two substrates.