RESEARCH PAPER

Comparative Evaluation of Lignocellulosic Substrates on Growth, Yield, Nutritional Quality, and Economic Efficiency of Oyster Mushroom (*Pleurotus ostreatus*)

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ABSTRACT

Oyster mushroom (*Pleurotus ostreatus*) cultivation is an efficient and sustainable method for converting lignocellulosic agro-wastes into nutritionally valuable food. The present study was conducted during 2025 - 2026 to evaluate the influence of different substrates on growth, yield, biological efficiency, quality parameters, and economic returns of oyster mushroom. The experiment was laid out in a Completely Randomized Design (CRD) with five treatments paddy straw, banana sheath, sugarcane bagasse, coir pith, and sawdust each replicated three times. Significant differences were observed among substrates for all parameters studied. Banana sheath exhibited superior performance, recording the shortest spawn run (14 days), earliest pinhead initiation (17 days), and minimum time to first harvest (21 days). It also produced better morphological traits, including higher stipe length (5.8 cm), larger pileus diameter (8.2 cm), greater number of fruiting bodies (21), and higher individual weight (25 g). The highest total yield (1160 g) was recorded in banana sheath, followed by paddy straw (1050 g), whereas sawdust produced the lowest yield (840 g). Biological efficiency was maximum in banana sheath (116%), indicating efficient substrate utilization. Nutritional analysis revealed higher protein (27%), carbohydrate (47%), and ash content (9%) in mushrooms grown on banana sheath. Economic analysis showed the highest net return (₹218) and benefit - cost ratio (2.67) for banana sheath. The study concludes that banana sheath is an effective, economical, and sustainable alternative substrate for oyster mushroom cultivation.

Keywords: Oyster mushroom; *Pleurotus ostreatus*; Lignocellulosic substrates; Banana sheath; Biological efficiency; Sustainable cultivation

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INTRODUCTION

Oyster mushroom (*Pleurotus ostreatus*) is one of the most extensively cultivated edible fungi worldwide due to its rapid growth, high biological efficiency, and ability to utilize a wide range of lignocellulosic substrates. It belongs to the class Basidiomycetes and is well known for its adaptability to diverse climatic conditions and simple cultivation technology. In recent years, oyster mushroom cultivation has gained considerable importance as a sustainable agricultural practice that contributes to food security, waste recycling, and rural income generation (Miśkiewicz *et al*., 2025). A distinctive feature of Pleurotus species is their ability to degrade complex lignocellulosic materials through the production of extracellular enzymes such as lignin peroxidase, manganese peroxidase, and laccase. These enzymes enable efficient breakdown of cellulose, hemicellulose, and lignin, allowing the fungus to grow on various agricultural residues including paddy straw, banana sheath, sugarcane bagasse, coir pith, and sawdust (Akcay *et al*., 2023). This biodegradation capability makes oyster mushroom an important component of sustainable waste management and circular bioeconomy systems. Nutritionally, oyster mushrooms are considered a functional food due to their high protein content, essential amino acids, dietary fibre, vitamins (B-complex), and minerals such as potassium, phosphorus, and iron. In addition, they contain bioactive compounds including polysaccharides, phenolics, and antioxidants that exhibit medicinal properties such as immunomodulatory, antitumor, and hypocholesterolaemia effects (Karthikeyan & Selvakumar, 2024). The nutritional composition of mushrooms is influenced by the type of substrate used, highlighting the importance of substrate selection in improving both yield and quality. The choice of substrate plays a crucial role in determining the growth, yield, and biological efficiency of oyster mushroom. Substrates serve as both physical support and nutrient source, and their chemical composition particularly the cellulose, hemicellulose, lignin content, and carbon-to-nitrogen ratio directly affects mycelial colonization and fruiting body development. Paddy straw is traditionally used as a standard substrate due to its favourable structure and nutrient balance; however, its availability and cost fluctuations necessitate the exploration of alternative substrates (Patil, 2024). Various agro-industrial wastes such as banana sheath, sugarcane bagasse, coir pith, and sawdust have been evaluated as potential substrates for oyster mushroom cultivation. These materials differ in their physicochemical properties, which significantly influence parameters such as spawn run duration, pinhead initiation, yield, and morphological characteristics (Manjari & Chandra, 2022). Faster spawn run and early fruiting are desirable traits that enhance productivity and reduce the cultivation cycle. Yield and biological efficiency (BE) are critical indicators of substrate performance in mushroom cultivation. Biological efficiency, defined as the ratio of fresh mushroom yield to dry substrate weight, reflects the efficiency of substrate utilization. Previous studies have demonstrated that appropriate substrate selection and supplementation can significantly enhance yield and BE (Tran & Lee, 2022; Berglund *et al*., 2021). Moreover, substrate composition also affects the nutritional quality and market acceptability of the mushrooms. In the context of increasing environmental concerns and the need for sustainable agricultural practices, the utilization of agro-wastes for mushroom cultivation offers a viable solution for waste management and value addition. Comparative evaluation of different substrates is therefore essential to identify efficient, cost-effective, and environmentally sustainable options for oyster mushroom production (Miśkiewicz *et al*., 2025). Based on these considerations, the present investigation was undertaken to evaluate the effect of different substrates paddy straw, banana sheath, sugarcane bagasse, coir pith, and sawdust on growth parameters, yield, biological efficiency, nutritional quality, and economic returns of oyster mushroom (*Pleurotus ostreatus*).

MATERIALS AND METHODS

Experimental Site and Duration

The experiment on oyster mushroom (*Pleurotus ostreatus*) cultivation was conducted during 2025–2026 in a controlled mushroom production unit of the Department of Agriculture. The cropping room was maintained under optimal environmental conditions, with temperature ranging from 20–30°C and relative humidity of 70–90%, which are considered favorable for mycelial growth and fructification of Pleurotus species (Akcay *et al*., 2023).

Experimental Design and Treatments

The study was laid out in a Completely Randomized Design (CRD) with five substrate treatments and three replications. Each experimental unit consisted of 1 kg (dry weight basis) of substrate filled in polyethylene bags.

Treatments:

T_1 - Paddy straw
T_2 - Banana sheath
T_3 - Sugarcane bagasse
T_4 - Coir pith
T_5 - Sawdust

All treatments were subjected to uniform cultural practices to minimize experimental error.

Culture Maintenance and Spawn Preparation

A pure culture of *Pleurotus ostreatus* was obtained from a recognized laboratory and maintained on Potato

Dextrose Agar (PDA) medium under aseptic conditions at 25 ± 2°C. Grain spawn was prepared using healthy sorghum grains. The grains were washed thoroughly and soaked in water for 12 hours, followed by boiling for 20–30 minutes until softened. Excess moisture was drained, and grains were mixed with calcium carbonate ($CaCO_3$) (2%) and gypsum ($CaSO_4$) (4%) on a weight basis to maintain pH (6.5–7.0) and prevent clumping. The prepared grains were filled into polypropylene bags, sterilized at 121°C (15 psi) for 1–2 hours, and inoculated with pure culture under aseptic conditions. The inoculated bags were incubated at 25–28°C for 12–15 days until complete mycelial colonization was achieved (Tran and Lee, 2022).

Substrate Collection and Preparation

Locally available lignocellulosic substrates, namely paddy straw, banana sheath, sugarcane bagasse, coir pith, and sawdust, were collected. Paddy straw and banana sheath were chopped into small pieces (3 - 5 cm) to enhance surface area and facilitate uniform colonization. All substrates were soaked in clean water for 24 - 48 hours to achieve adequate hydration. Excess water was drained to maintain a moisture content of approximately 60 - 70%, which is optimal for enzymatic activity and mycelial growth (Akcay *et al.*, 2023).

Substrate Pasteurization

The substrates were pasteurized using hot water treatment at 60–70°C for 1–2 hours to eliminate competing microorganisms. After pasteurization, the substrates were drained and allowed to cool to room temperature under hygienic conditions. Proper pasteurization improves substrate selectivity and enhances mushroom yield (Berglund *et al.*, 2021).

Spawning and Bag Filling

Spawning was carried out at a rate of 3–5% of substrate dry weight. The layer spawning method was adopted; wherein alternate layers of substrate and spawn were arranged inside perforated polyethylene bags (30 × 40 cm). Each bag was tightly packed, tied, and perforated uniformly to facilitate aeration. The prepared bags were labeled according to treatments and replications.

Incubation (Spawn Run)

The spawned bags were incubated in a dark room maintained at 25 ± 2°C and relative humidity of 70 - 80%. Observations were recorded daily for mycelial growth. The number of days required for complete colonization of the substrate was recorded as the spawn run period. Rapid colonization is an indicator of substrate suitability and nutrient availability.

Fruiting Conditions and Crop Management

After complete colonization, the bags were transferred to the cropping room. Environmental conditions were maintained at 20 - 28°C temperature, 80 - 90% relative humidity, adequate ventilation, and diffused light. Small openings were made in the bags to facilitate fruiting body emergence. Water was sprayed 2 - 3 times daily to maintain humidity. Proper environmental control is essential for pinhead initiation and development of healthy fruiting bodies (Akcay *et al.*, 2023).

Observations, Quality and Economic Analysis

Growth parameters of oyster mushroom were recorded by noting the number of days required for complete spawn run, pinhead initiation, and first harvest, along with the total crop duration for each treatment. Morphological characteristics were evaluated by measuring stipe length (cm), pileus diameter (cm), number of fruiting bodies per bag, and individual fruit weight (g). Yield performance was assessed by recording the yield of each flush (first, second, and third) separately and expressing it in grams per bag, after which the total yield per treatment was calculated by summing all flushes. For quality analysis, mushroom samples were subjected to biochemical evaluation to determine protein, carbohydrate, crude fiber, and ash content using standard laboratory procedures. Protein content was estimated by the Kjeldahl method, carbohydrate content by the Anthrone method, crude fiber as per AOAC procedures, and ash content using the muffle furnace method. Economic analysis was carried out by calculating the total cost of production, including substrate and other input expenses, and estimating gross income based on the prevailing market price of fresh mushrooms. Net return was computed as the difference between gross income and cost of production, while the benefit–cost ratio was determined to evaluate the economic feasibility of different substrate treatments.

Biological Efficiency (BE)

Biological efficiency was calculated using the following formula:

"BE (%)"="Fresh weight of mushrooms (g)" /"Dry weight of substrate (g)" ×100

It is a standard index for evaluating substrate utilization efficiency (Berglund *et al.*, 2021).

Statistical Analysis

The experimental data were statistically analyzed using Analysis of Variance (ANOVA) appropriate for CRD. The significance of treatment effects was tested at the 5% probability level. Standard deviation (SD) and Critical Difference (CD) were calculated to compare treatment means. Statistical analysis was performed using standard statistical procedures as described for agricultural experiments.

RESULTS AND DISCUSSION

Effect of Substrates on Spawn Run and Early Development

The results presented in Table 1 revealed significant variation among different substrates with respect to spawn run, pinhead initiation, first harvest, and total crop duration. Among the treatments, T_2 (banana sheath) recorded the shortest spawn run (14 days), earliest pinhead initiation (17 days), and minimum days to first harvest (21 days), followed by T_1 (paddy straw). In contrast, T_5 (sawdust) and T_4 (coir pith) exhibited delayed colonization and fruiting, requiring 19–22 days for spawn run and up to 26 days for first harvest. The superior performance of banana sheath may be attributed to its balanced lignocellulosic composition, higher cellulose and hemicellulose fractions, and better moisture retention capacity, which Favor rapid enzymatic degradation and mycelial proliferation. *Pleurotus ostreatus* produces ligninolytic enzymes such as laccase and peroxidases that efficiently degrade cellulose-rich substrates, thereby accelerating colonization (Akcay *et al.*, 2023). Similar observations were reported by Patil (2024), who noted faster spawn run in substrates with favourable aeration and nutrient availability. The delayed growth observed in sawdust and coir pith could be due to their high lignin content and compact structure, which restrict aeration and slow enzymatic breakdown. Berglund *et al.* (2021) also reported that substrates with higher lignin proportions require longer colonization periods due to reduced accessibility of cellulose. The findings are in agreement with Manjari and Chandra (2022), who reported significant differences in spawn run duration among different substrates. Early pinhead initiation in banana sheath indicates a shorter cropping cycle, which is advantageous for commercial production.

Effect of Substrates on Morphological Characters

Significant differences were observed in morphological parameters among treatments. T_2 (banana sheath) recorded the highest stipe length (5.8 cm), pileus diameter (8.2 cm), number of fruiting bodies (21), and individual fruit weight (25 g), followed by T_1 (paddy straw). The lowest values were recorded in T_5 (sawdust). The improved morphological development in banana sheath may be attributed to its superior nutrient profile and better substrate structure, which enhance mycelial density and efficient translocation of nutrients to fruiting bodies. Substrate composition directly influences cell expansion and differentiation processes in mushrooms, thereby affecting size and weight (Karthikeyan & Selvakumar, 2024). Larger pileus diameter and higher fruit weight are desirable traits for market acceptability. In contrast, reduced morphological traits in sawdust may be due to limited nutrient availability and slower degradation of lignin, which restricts nutrient uptake. Similar findings were reported by Manjari and Chandra (2022), who observed reduced fruit body size in substrates with poor nutrient composition. These results indicate that substrate quality plays a crucial role in determining morphological characteristics and market value of oyster mushrooms.

Effect of Substrates on Yield Parameters

Yield performance varied significantly among treatments. T_2 (banana sheath) recorded the highest yield in all flushes, with a total yield of 1160 g, followed by T_1 (paddy straw) with 1050 g. The lowest yield was observed in T_5 (sawdust) with 840 g. A declining trend in yield was observed from first to third flush in all treatments, which is a typical phenomenon due to progressive depletion of nutrients in the substrate. The higher yield obtained in banana sheath may be attributed to efficient nutrient utilization, improved aeration, and favourable physical properties of the substrate, which support sustained mycelial activity and fruiting. According to Milkias *et al.* (2024), substrate composition significantly affects yield through its influence on enzymatic degradation and nutrient availability. Escober (2025) also reported that substrates rich in cellulose and hemicellulose produce higher yields compared to lignin-rich substrates. The gradual reduction in yield across flushes is associated with nutrient exhaustion and accumulation of metabolic wastes, which limit further fruiting. Similar patterns have been documented by Tran and Lee (2022), indicating that substrate supplementation may be required to sustain productivity over multiple flushes.

Effect of Substrates on Biological Efficiency

Biological efficiency (BE) showed significant variation among substrates, with T_2 (banana sheath) recording the highest BE (116%), followed by T_1 (paddy straw) (105%), while T_5 (sawdust) recorded the lowest BE (84%). Higher BE values indicate efficient conversion of substrate into mushroom biomass. The superior BE in banana sheath suggests better substrate degradability and efficient enzymatic activity, leading to improved nutrient conversion. Cellulose-rich substrates enhance fungal metabolism and biomass production, resulting in higher BE (Berglund *et al.*, 2021). Tran and Lee (2022) also reported that substrate structure and composition significantly influence biological efficiency. Lower BE in sawdust may be attributed to its high lignin content and resistance to enzymatic breakdown, resulting in poor substrate utilization. These findings highlight the importance of selecting substrates with balanced lignocellulosic composition to maximize productivity.

Effect of Substrates on Quality Parameters

Significant variation was observed in nutritional composition among treatments. T_2 (banana sheath) recorded the highest protein (27%), carbohydrate (47%), and ash content (9%), whereas T_5 (sawdust) recorded the lowest values. Fiber content was relatively higher in coir pith and sawdust-based substrates. The improved nutritional quality in banana sheath may be attributed to higher nutrient availability and efficient assimilation of nitrogen and minerals by the fungus. Substrate composition influences metabolic pathways involved in protein synthesis and accumulation of bioactive compounds (Karthikeyan & Selvakumar, 2024). Mushrooms grown on nutrient-rich substrates tend to have higher protein and mineral content, enhancing their functional food value. Higher fiber content in coir pith and sawdust may be due to incomplete degradation of lignocellulosic components, resulting in higher residual fiber. These results are consistent with previous findings indicating that substrate type significantly affects the nutritional profile of oyster mushrooms.

Effect of Substrates on Economic Analysis

Economic analysis revealed that T_2 (banana sheath) recorded the highest gross income (₹348), net return (₹218), and benefit–cost ratio (2.67), followed by T_1 (paddy straw). The lowest economic returns were observed in T_5 (sawdust). The higher profitability of banana sheath is primarily due to its superior yield, shorter cropping duration, and relatively low cost of substrate. Efficient substrate utilization reduces production costs while increasing output, thereby improving economic returns. Miśkiewicz *et al.* (2025) emphasized that selection of appropriate agro-waste substrates plays a crucial role in enhancing profitability and sustainability of mushroom cultivation systems. Lower economic returns in sawdust are associated with reduced yield and longer crop duration, which increase production costs. These findings indicate that substrate selection is a key determinant of economic viability in oyster mushroom production.

CONCLUSION

The study demonstrates that substrate composition significantly influences growth, yield, biological efficiency, nutritional quality, and economic returns of oyster mushroom (*Pleurotus ostreatus*). Among the substrates tested, banana sheath showed superior performance, with faster colonization, early fruiting, higher yield, and maximum biological efficiency, indicating efficient substrate utilization. Enhanced morphological traits and improved nutritional composition in mushrooms grown on banana sheath further highlight its suitability. In contrast, sawdust and coir pith exhibited lower performance due to higher lignin content and reduced degradability. The banana sheath is identified as a highly efficient, economical, and sustainable substrate for oyster mushroom cultivation, supporting improved productivity and agro-waste utilization.

Table 1. Effect of different substrates on spawn run and early development of *Pleurotus ostreatus*

Treatment	Substrate	Spawn run (days)	Pinhead initiation (days)	First harvest (days)	Crop duration (days)
T_1	Paddy straw	15	18	22	45
T_2	Banana sheath	14	17	21	43
T_3	Sugarcane bagasse	16	19	23	47
T_4	Coir pith	18	21	25	50
T_5	Sawdust	19	22	26	52
	SD (±)	0.82	0.75	0.90	1.20
	CD (5%)	1.80	1.65	2.00	2.60

Table 2. Effect of different substrates on morphological characters of *Pleurotus ostreatus*

Treatment	Substrate	Stipe length (cm)	Pileus diameter (cm)	No. of fruiting bodies	Individual weight (g)
T_1	Paddy straw	5.2	7.5	18	22
T_2	Banana sheath	5.8	8.2	21	25
T_3	Sugarcane bagasse	4.8	7.0	16	20
T_4	Coir pith	4.3	6.6	14	18
T_5	Sawdust	4.0	6.3	13	17
	SD (±)	0.35	0.45	1.30	1.60
	CD (5%)	0.75	0.95	2.70	3.30

Table 3. Effect of different substrates on yield of *Pleurotus ostreatus*

Treatment	Substrate	First flush (g)	Second flush (g)	Third flush (g)	Total yield (g)
T_1	Paddy straw	450	350	250	1050
T_2	Banana sheath	500	380	280	1160
T_3	Sugarcane bagasse	420	330	230	980
T_4	Coir pith	390	300	210	900
T_5	Sawdust	360	280	200	840
	SD (±)	22	20	16	35
	CD (5%)	48	44	36	70

Table 4. Effect of different substrates on biological efficiency of *Pleurotus ostreatus*

Treatment	Substrate	Dry substrate (kg)	Fresh yield (kg)	Biological efficiency (%)
T_1	Paddy straw	1.0	1.05	105
T_2	Banana sheath	1.0	1.16	116
T_3	Sugarcane bagasse	1.0	0.98	98
T_4	Coir pith	1.0	0.90	90
T_5	Sawdust	1.0	0.84	84
	SD (±)	0.06	0.07	3.8
	CD (5%)	0.13	0.15	8.2

Table 5. Effect of different substrates on quality parameters of *Pleurotus ostreatus*

Treatment	Substrate	Protein (%)	Carbohydrate (%)	Fiber (%)	Ash (%)
T_1	Paddy straw	25.0	45.0	12.0	8.5
T_2	Banana sheath	27.0	47.0	11.2	9.0
T_3	Sugarcane bagasse	24.0	44.0	12.5	8.2
T_4	Coir pith	23.0	43.0	13.2	8.0
T_5	Sawdust	21.5	41.5	13.8	7.7
	SD (±)	1.3	1.6	0.9	0.6
	CD (5%)	2.8	3.4	1.9	1.2

Table 6. Effect of different substrates on economic returns of *Pleurotus ostreatus*

Treatment	Substrate	Cost (₹)	Gross income (₹)	Net return (₹)	B:C ratio
T_1	Paddy straw	120	315	195	2.62
T_2	Banana sheath	130	348	218	2.67
T_3	Sugarcane bagasse	115	294	179	2.55
T_4	Coir pith	110	270	160	2.45
T_5	Sawdust	105	252	147	2.40
	SD (±)	6	14	11	0.18
	CD (5%)	13	30	24	0.36

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