

Bioconversion of lignocellulosic waste through the cultivation of *Pleurotus eryngii* and its potential as organic fertilizer

Bioconversión de residuos lignocelulósicos mediante el cultivo de *Pleurotus eryngii* y su potencial como abono orgánico

Carol Daniela Coello-Loor¹
Orly Fernando Cevallos-Falquez²
Juan Humberto Avellaneda-Cevallos³
Aurelio David Zapatier-Santillan⁴

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Correspondence author

ccoello@uteq.edu.ec

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Quevedo State Technical University, Faculty of Industrial and Production Sciences. Quevedo, Ecuador. ccoello@uteq.edu.ec ; <https://orcid.org/0000-0002-2810-6208>

² Quevedo State Technical University, Faculty of Animal and Biological Sciences. Quevedo, Ecuador. fcevallos@uteq.edu.ec ; <https://orcid.org/0000-0002-4137-7133>

³ Quevedo State Technical University, Faculty of Animal and Biological Sciences. Quevedo, Ecuador. javellaneda@uteq.edu.ec ; <https://orcid.org/0000-0002-1805-4803>

⁴ Quevedo State Technical University, Faculty of Animal and Biological Sciences. Quevedo, Ecuador. aurelio.zapatier@uteq.edu.ec ; <https://orcid.org/0000-0003-3290-8016>

Abstract: The evaluation in this study demonstrated the bioconversion capacity of the fungus *Pleurotus eryngii* on three lignocellulosic residues (corn stover, rice straw, and peanut shells) and its potential use as organic fertilizer. A completely randomized design was used with four treatments, four replicates, and two units per replicate, totaling 32 experimental units. The treatments were: T1 (100% corn stover + *P. eryngii*), T2 (100% rice straw + *P. eryngii*), T3 (100% peanut shells + *P. eryngii*), and T4 (a mixture of 33.33% of each residue + *P. eryngii*). The FMS process was carried out over 45 days. The variables evaluated were biodegradation rate, nitrogen, phosphorus, and potassium (NPK) content, organic matter, and initial and final pH. The statistical analysis was performed using ANOVA and Tukey's test ($p \leq 0.05$). The results reveal that T1 exhibits the highest biodegradation rate (45.25%) and the highest nitrogen (0.50%), phosphorus (0.10%), and potassium (0.75%) contents. In contrast, the N and P values did not reach the minimum levels established for high-quality organic fertilizers (1% N and 0.15% P), due to the fact that the bioconversion time was 45 days. T3 recorded the highest organic matter content (39%). The final pH ranged from 6.51 to 7.31, within the optimal range for agricultural application. It is concluded that *P. eryngii* is effective for biodegrading agricultural waste, although a longer solid-state fermentation time or supplementation with other wastes is required to obtain an optimal biofertilizer.

Keywords: FMS, NPK, biodegradation, organic matter, depleted substrate

Resumen: La evaluación del presente estudio demostró la capacidad de bioconversión del hongo *Pleurotus eryngii* sobre tres residuos lignocelulósicos (panca de maíz, paja de arroz y cáscara de maní) y su potencial uso como de abono orgánico. Se empleó un diseño completamente al azar con cuatro tratamientos, cuatro repeticiones y 2 unidades por repetición, totalizando 32 unidades experimentales. Los tratamientos fueron: T1 (100% panca de maíz + *P. eryngii*), T2 (100% paja de arroz + *P. eryngii*), T3 (100% cáscara de maní + *P. eryngii*) y T4 (mezcla 33,33% de cada residuo + *P. eryngii*). El proceso de FMS se realizó durante 45 días. Se evaluaron las variables tasa de biodegradación, contenido de nitrógeno, fósforo y potasio (NPK), materia orgánica y pH inicial y final. El estudio estadístico se realizó mediante ANOVA y prueba de Tukey ($p \leq 0,05$). Los resultados revelan que el T1 presenta la mayor tasa de biodegradación (45,25%) y los contenidos más altos de nitrógeno (0,50%), fósforo (0,10%) y potasio (0,75%). Por el contrario, los valores de N y P no alcanzaron los mínimos establecidos para abonos orgánicos de calidad (1% N y 0,15% P), esto debido a que el tiempo de bioconversión fue de 45 días. El T3 registró el mayor contenido de materia orgánica (39%). El pH final osciló entre 6,51 y 7,31, dentro del rango óptimo para aplicación agrícola. Se concluye que *P. eryngii* es efectivo para biodegradar residuos agrícolas, aunque se requiere mayor tiempo de Fermentación en medio sólido o complementación con otros residuos para obtener un biofertilizante óptimo.

Palabras clave: FMS, NPK, biodegradación, materia orgánica, sustrato agotado

Introduction

The generation of agricultural waste constitutes one of the main environmental challenges of the 21st century, particularly in countries with economies based on the primary sector. In Ecuador, agricultural production generates approximately 15 million tons of crop residues annually. Their final disposal through *on-site* burning (at the source) or accumulation in landfills results in nutrient losses of 98 to 100% of nitrogen and 20 to 40% of phosphorus and potassium. This poor practice contributes to greenhouse gas emissions and the deterioration of air quality (Galazka, Ibarra-Rondón, & Grupa, 2025). This challenging situation has spurred the search for sustainable alternatives that integrate the principles of the bioeconomy and the circular economy, where waste is revalued as a resource for new production processes and its high organic value is harnessed instead of being burned. (Zotti, Cecchi, Canonica, & Di Piazza, 2025).

Within this framework and given the circumstances, white-rot basidiomycete fungi of the genus *Pleurotus* have emerged as biotechnological tools with high potential for the biodegradation of lignocellulosic substrates. These microorganisms possess an enzymatic complex capable of depolymerizing cellulose, hemicellulose, and lignin through the production of laccases, manganese peroxidase, lignin peroxidase, and cellulases, among other extracellular enzymes (Galazka et al., 2025). In particular, *Pleurotus eryngii*, commercially known as the king oyster mushroom, stands out for

its metabolic adaptability; it has development potential on various lignocellulosic substrates and produces fruiting bodies with high nutritional and medicinal value (Zotti et al., 2025).

The biodegradation of agricultural waste using *P. eryngii* represents an opportunity with a dual benefit: on the one hand, it reduces the environmental burden resulting from improper waste disposal, and on the other, it generates a byproduct rich in organic matter and mineral nutrients that can be used as a biofertilizer or organic/mineral soil amendment. Recent research has shown that *P. eryngii* can achieve a biological conversion rate exceeding 60% in alternative substrates such as lavender waste and poplar sawdust, with protein contents in the fruiting bodies ranging from 200 to 260 g/kg (Zotti et al., 2025). Likewise, comparative proteomics studies have revealed that *P. eryngii* secretes distinct enzymatic profiles depending on substrate composition, with a predominance of laccases and manganese peroxidase in residues with high lignin content, which explains its adaptive capacity to degrade various lignocellulosic materials (Zhang, Li, Wang, & Chen, 2025).

Corn stalks (*Zea mays L.*), rice straw (*Oryza sativa L.*), and peanut shells (*Arachis hypogaea L.*) are three of the most abundant agricultural residues in the Ecuadorian coastal region. These materials have a variable lignocellulosic composition, with cellulose contents ranging from 23–45%, hemicellulose from 23–30%, and lignin from 5–33%, making them potentially suitable substrates for the growth of lignin-degrading fungi (Treviño, Hernández, & Caballero, 2025). However, biodegradation efficiency depends on factors such as the carbon-to-nitrogen ratio, particle size, substrate moisture content, and incubation conditions.

Despite growing interest in the biotechnology of *Pleurotus* spp., there are limitations in the scientific literature regarding the systematic evaluation of different tropical lignocellulosic wastes as substrates for *P. eryngii*, as well as in the nutritional characterization of the resulting biodegraded material for its use as a biofertilizer. Most studies have focused on the cultivation of *P. eryngii* under humid tropical conditions using residues characteristic of the Neotropical region.

For the reasons mentioned above, the present study aimed to evaluate the bioconversion capacity of *Pleurotus eryngii* on three crop residues (corn stalks, rice straw, and peanut shells) and their mixture, for the production of organic fertilizers in the Mocache area, Los Ríos, Ecuador. Specifically, the levels of primary macronutrients (NPK), the biodegradation rate, the organic matter content, and the pH of the biodegraded substrate were determined to establish the technical feasibility of this alternative for the sustainable management of agricultural waste in humid tropical environments and its potential use as organic fertilizer.

Methodology

The study was conducted at the Microbiology Laboratory on the “La María” campus of the Quevedo State Technical University (UTEQ).

Biological Material.

The *Pleurotus eryngii* strain (K15) from the FOCICYT-UTEQ-PFOC6-47-2018 Project, obtained from the Microbiology Laboratory of the Quevedo State Technical University (UTEQ), was used. The strain was maintained in

PDA (Potato Dextrose Agar) culture medium, composed of potato extract (200 g/L), dextrose (20 g/L), and agar (15 g/L), pH 6.0, and incubated at a temperature of 25°C. In addition, subcultures were performed every 7 days to maintain the viability and purity of the inoculum.

Lignocellulosic Substrates.

Three types of crop residues were analyzed: corn stalks (*Zea mays L.*), rice straw (*Oryza sativa L.*), and peanut shells (*Arachis hypoganea L.*). The residues were collected in the catchment area of the Mocache canton. Subsequently, they were washed with potable water to remove any impurities and left to dry at room temperature.

Once dry, the residues were mechanically crushed into fragments of approximately 3 to 5 cm in size to increase the contact area and promote fungal colonization, following the methodology proposed by (Patil, 2024) . The substrate moisture content was adjusted to 70% by adding sterile distilled water.

Preparation of the Inoculum (Corn Seed).

Corn kernels (*Zea mays L.*) were used as the inoculation substrate for propagating the inoculum. The kernels were washed with running water and then soaked in distilled water for 24 hours. They were then drained and distributed into polypropylene bags (250 g per bag).

The material was sterilized in an autoclave at 121°C for 30 minutes. After cooling, inoculation was performed with *Pleurotus eryngii* K15 mycelium, obtained from Petri dishes containing PDA medium, placing approximately 6 pieces of 3-cm mycelium per bag. Subsequently, the bags were incubated at a temperature of 25°C for a period of 10 to 15 days, until complete colonization of the grain was achieved (Wagner V., 2025) .

Experimental Design and Treatment Distribution.

“A completely randomized design (CRD) consisting of four treatments and four replicates was implemented, resulting in a total of 32 experimental units” (Steel & Torrie, 1985) . Each experimental unit consisted of a 23 x 35 cm polyethylene bag containing 1000 g of dry substrate. The treatments evaluated were as follows:

T1: 100% corn cobs + *P. eryngii*

T2: 100% rice straw + *P. eryngii*

T3: 100% peanut shells + *P. eryngii*

T4: Mixture of 33.33% corn stalks + 33.33% rice straw + 33.33% peanut shells + *P. eryngii*

Inoculation was carried out by adding 50 g of corn seed colonized by *Pleurotus eryngii* per kilogram of dry substrate. Subsequently, the bags were sealed, properly labeled, and placed in incubation at a temperature of 25°C in the dark during the colonization phase, which lasted 25 days.

Once the mycelium had completely colonized the substrate, fruiting was induced by exposure to artificial light under a photoperiod of 12 hours of light and 12 hours of darkness, while maintaining the ambient temperature. The total cultivation cycle lasted 45 days, after which the biodegraded substrate was harvested for subsequent analysis.

Table1 . *Distribution of treatments and experimental units.*

Treatments	Replicates	No. of samples/replication	No. of samples/treatment
T1 (100% corn silage + <i>Pleurotus eryngii</i>)	4	2	8
T2 (100% rice straw + <i>Pleurotus eryngii</i>)	4	2	8
T3 (100% peanut shells + <i>Pleurotus eryngii</i>)	4	2	8
T4 (33.33% peanut shells + 33.33% rice straw + 33.33% corn cobs + <i>Pleurotus eryngii</i>)	4	2	8
Total			32

1.1. Evaluated Variables.

1.1.1. Biodegradation Rate (BR).

It was determined using the following formula:

$$BR = \frac{\text{Peso seco inicial} - \text{Peso seco final}}{\text{Peso seco inicial}} \times 100$$

Where:

Initial dry weight: corresponds to the weight of the substrate prior to inoculation (1000 g)

Final dry weight: corresponds to the weight of the substrate after 45 days of biodegradation, determined after drying in an oven at 60°C until a constant weight is reached.

Primary Macroelements (NPK).

From each experimental unit, 200 g of biodegraded substrate were collected per treatment; subsequently, the samples were homogenized to obtain a composite sample of 1000 g per treatment. The content of total nitrogen (N), available phosphorus (P), and exchangeable potassium (K) was analyzed at the Soil Laboratory of the National Institute of Agricultural Research (INIAP),

following the methods described by (Faik Ceylan, 2025) . The results obtained were expressed as percentages (%).

Organic Matter (OM).

Organic matter was determined using the loss-on-ignition method, employing a 10-g sample of dry substrate, at 550 °C for 4 hours in a muffle furnace . The final value was expressed as a percentage.

pH

To determine the pH, a 1:5 (w/v) suspension was prepared by mixing 10 g of dry substrate with 50 mL of distilled water and stirring the mixture for 30 minutes. The measurement was performed using a digital potentiometer previously calibrated with pH 4.0 and 7.0 standard solutions (Faik Ceylan, 2025) . Both the initial pH (before inoculation) and the final pH (day 45) were recorded.

Statistical Analysis.

The data obtained were subjected to an analysis of variance (ANOVA) corresponding to a completely randomized design. When significant differences were detected ($p \leq 0.05$), Tukey's multiple range test was applied. Statistical processing was performed using the software InfoStat version 2020 (Di Rienzo, et al., 2020) . Results are presented as means \pm standard error.

Ethical and Biosafety Considerations.

During the research involving the *P. eryngii* strain, biosafety standards corresponding to Level 1 (BSL-1) were applied. These measures included the mandatory use of lab coats, latex gloves, and face masks, as well as the handling of cultures within a laminar flow hood. Furthermore, all waste generated in the laboratory was autoclaved prior to final disposal.

Results

Biodegradation Rate

Statistical analysis of the data revealed significant differences among the treatments analyzed ($p \leq 0.05$). Treatment T1, consisting solely of corn stalks inoculated with *Pleurotus eryngii*, exhibited the highest level of biodegradation, with a value of 45.25%. In contrast, treatment T3, corresponding to peanut shells, recorded the lowest percentage, at 33.65%. Meanwhile, treatments T2 (rice straw) and T4 (waste mixture) achieved intermediate values of 40.20% and 38.64%, respectively (Table 1). The experimental variation was very low, reflected in a coefficient of variation of only 0.46%.

Table2 . Analysis of variance for the biodegradation rate.

Source of variation	GL	SC	CM	F	p
Treatment	3	274.22	91.41	10.50	0.0001
Error	12	0.04	0.003		
Total	15	274.27			

CV = 0.46%. DF: degrees of freedom; SS: sum of squares; MS: mean square.

Table3 . Tukey's significance test for the biodegradation rate.

Treatment	Mean (%)	Group
T1	45.25	to
Q2	40.20	b
T3	38.64	c
T4	33.65	d

CV: 0.46%. Means with different letters indicate significant differences (Tukey, $p \leq 0.05$).

These values were lower than those reported in recent studies with other *Pleurotus* species. Romero-Carcía et al. (2023) achieved biological efficiencies exceeding 60% in wheat straw substrates with *P. eryngii*, attributing the variability to differences in the substrate's lignocellulosic composition and the strain's specific enzymatic activity.

The lower biodegradability of peanut shells (T3) may be associated with their higher lignin content (27–33%), which hinders the action of the oxidative enzymes secreted by the fungus (Kunapuli, 2025) .

Organic Matter Content.

Statistical analysis revealed significant heterogeneity in organic matter concentration among the tested formulations ($p \leq 0.05$). Contrary to what was observed in the biodegradation rate, treatment T3 (peanut shells) recorded the highest organic matter content (39.00%), while treatment T1 (corn cobs) had the lowest value (35.00%). Treatments T2 (rice straw) and T4 (mixture) showed intermediate values of 37.00% and 38.00%, respectively (Table 5). Data dispersion was minimal (CV = 2.19%).

Table4 . Percentage of organic matter by treatment. Tukey's test ($p \leq 0.05$).

Treatment	Organic matter (%)	Group
T3 (Peanut shells)	39.00	to
T4 (Mixture)	38.00	ab
T2 (Rice Straw)	37.00	b

T1 (Corn stalks) 35.00 c

CV: 2.19%. Means with different letters indicate significant differences (Tukey, $p \leq 0.05$).

This result, which appears to contradict the biodegradation rate, can be explained by the fact that peanut shells have a higher initial content of lignin and recalcitrant compounds that are partially degraded but not completely mineralized, thereby maintaining their organic structure (García, A., & Bermúdez, R., 2021). The values obtained far exceed the 30% threshold recommended for organic amendments, positioning all treatments as suitable materials for improving soil physical properties.

pH

Analysis of variance applied to the pH values revealed statistically significant differences among the four experimental treatments ($p \leq 0.05$). The multiple comparison of means using Tukey's test is presented in Table 6.

Table 5. Initial and final pH values by treatment. Tukey's test ($p \leq 0.05$).

Treatment	Initial pH	Final pH
T1 (Corn silage)	6.94 ± b	6.83 ± b
T2	7.40 ± c	7.24 ± c
T3 (Peanut shells)	6.63 ± a	6.51 ± a
T4 (Mixture)	7.48 ± d	7.31 ± d
C.V. (%)	0.28	0.13

The maximum alkalinity, recorded at both the beginning and end of the experiment, corresponded to treatment 4 (7.48 and 7.31, respectively). In contrast, the most pronounced acidity was observed in treatment 1, with readings of 6.94 (initial) and 6.83 (final).

These measurements fall within the range reported by various authors. Bejarano (2018), in his research, quantified a pH of 5.86 in lignocellulosic sugarcane residues subjected to biodegradation for three months. For their part, García et al. (2014) determined an alkalinity of 7.15 in compost formulated with mushroom production waste. Fontalvo et al. (2013) note that relative neutrality (pH 6.0–8.0) constitutes a favorable condition for the mobilization of mineral nitrogen and the expansion of the root system, while acidic (<5.5) or basic (>8.5) extremes generate nutritional deficiencies due to the insolubilization of essential elements.

Primary Macroelements (NPK).

Analysis of the primary macronutrients revealed statistically significant differences between treatments ($p \leq 0.05$). Total nitrogen content showed significant variation, with values ranging from 0.30% in T2 to 0.50% in T1. Available phosphorus showed a similar pattern, with minimum concentrations in T2 (0.08%) and maximum concentrations in T1 (0.10%). For exchangeable

potassium, treatment T1 had 0.75%, while T3 recorded the lowest value (0.62).

Table 6 . Tukey's significance test for primary macronutrients (NPK).

Treatments	Nitrogen (N)		Phosphorus (P)		Potassium (K)	
T1	0.50	to	0.10	a	0.75	to
Q2	0.30	b	0.08	b	0.66	c
T3	0.40	Aab	0.09	ab	0.62	d
T4	0.40	aab	0.09	ab	0.70	b
C.V (%)	14.51		9.42		1.58	

The content of primary macronutrients (NPK) showed significant variation among treatments. The highest values were recorded in treatment T1 (corn silage), with 0.50% nitrogen, 0.10% phosphorus, and 0.75% potassium. In contrast, treatment T2 (rice straw) had the lowest concentrations of nitrogen (0.30%) and phosphorus (0.08%). Regarding potassium, treatment T3 (peanut shells) had the lowest value (0.62%).

These results were lower than those reported in previous studies using other types of waste and *Pleurotus* species. García et al. (2014) obtained higher values in compost made from spent mushroom substrate (1.05% N, 0.85% P, 1.35% K), while Bermúdez et al. (2019) found 3.39% nitrogen, 0.16% phosphorus, and 1.74% potassium in coffee pulp biodegraded by *P. ostreatus*. This difference can be explained by the biodegradation time, as recent studies indicate that nutrient mineralization is influenced by microbial activity, moisture content, ambient temperature, and the chemical nature of the materials used (Kunapuli, 2025). Therefore, the values obtained in the present study did not meet the minimum standards established for quality compost, which, according to Soto and Meléndez (2004), must contain at least 1% nitrogen and 0.15% phosphorus.

However, the potassium content (0.62–0.75%) is competitive with values reported in recent literature. (found that spent *P. ostreatus* substrate applied at rates of 12.5–25 t/ha improved the yield of baby leaf lettuce, despite having moderate NPK contents, attributing this effect to improved soil structure and the gradual release of nutrients.

Biodegradation Rate.

The results obtained in this study reveal that the treatment with corn husks (dry or fresh leaves surrounding the corn cob) + *P. eryngii* achieved the highest biodegradation rate (45.25%), followed by rice straw (40.20%), the

waste mixture (38.64%), and finally the peanut husk (33.65%). Although these values differ significantly from one another, they are lower than those reported in recent studies involving other species of the genus *Pleurotus* and different lignocellulosic substrates.

Romero et al. (2018) reported a biodegradation rate of 70% in wheat straw with *P. ostreatus*, while Romero-Arenas et al. (2010) achieved 60.56% in corn residues with the same species. This difference can be attributed to several factors: (1) the species used (*P. eryngii* vs. *P. ostreatus*), since different white rot fungus species possess distinct enzymatic capabilities for degrading lignocellulose (Shivam Singh, 2026); (2) the biodegradation time (45 days in my study vs. complete fruiting cycles in other studies); and (3) the specific composition of the waste, particularly the initial C:N ratio.

Recent research has shown that the biodegradation efficiency of white rot fungi is closely related to the activity of ligninolytic enzymes (laccases, manganese peroxidase, and lignin peroxidase), whose production varies depending on the fungal species and substrate conditions (Shivam Singh, 2026). *P. eryngii*, known as the “thistle mushroom” or “king oyster,” has a moderate lignin-degrading capacity compared to *P. ostreatus*, which would explain the relatively lower rates observed in this study.

The lower biodegradation value in peanut shells (33.65%) can be explained by their high lignin content (27–33%) and their more compact physical structure, which hinders mycelial colonization and enzymatic access to the cellulosic components. This is consistent with the findings of Kunapuli et al. (2025), who note that highly lignified substrates require longer processing times or physicochemical pretreatments to optimize fungal degradation.

Macronutrient Content (NPK)

The NPK analysis revealed that the corn stover treatment had the highest values: 0.50% N, 0.10% P, 0.75% K. However, these values do not meet the minimum standards established for high-quality organic fertilizers, which, according to Soto & Meléndez (2004) and reaffirmed by current research, must contain >1% N and >0.15% P (Kunapuli, 2025).

This nutritional limitation is consistent with recent findings. For example, a 2025 study on spent substrates from *Pleurotus spp.* reported total nitrogen contents of just 0.7% in cotton hull substrate, a value similar to that obtained in the results (Bonis et al., 2025). Likewise, Kunapuli et al. (2025) found that spent *Pleurotus spp.* substrate derived from cotton hulls had nitrogen contents ranging from 6.72 to 8.47 g/kg (0.67–0.85%), with a C:N (carbon-to-nitrogen) ratio of 35–40. These values are comparable to the results obtained, and it is suggested that the low nitrogen content is an intrinsic characteristic of *Pleurotus* cultivation residues when they are not enriched with additional nitrogen sources.

The potassium content (0.75%) is competitive with values reported in recent literature. For example, the spent *P. ostreatus* substrate analyzed by (Bonis et al., 2025) contained 2.59 g/kg K (0.26%), a lower value than that obtained in our findings. This suggests that corn stover is an excellent natural source of potassium that remains available after the fungal biodegradation process.

Nutrient mineralization during biodegradation is controlled by microbial abundance, moisture, the quality of the incorporated materials, and, fundamentally, the composting time (Kunapuli, 2025). Studies confirm that, as the degradation time increases, mineralization tends to increase exponentially (Kunapuli, 2025). Therefore, the 45-day period used in the research, although sufficient for mycelial colonization and fruiting, is insufficient to achieve the chemical maturity required for high-quality organic fertilizers; however, it does allow us to consider its potential use as fertilizer once the solid-medium fermentation process is complete, approximately 75 days later.

Organic Matter pH.

The organic matter content varied significantly among treatments, with peanut shells having the highest value (39.005%), followed by the mixture (38.00%), rice straw (37.00%), and corn stover (35.00%). These values far exceed the 30% threshold recommended by Herrera-Gamboa, J. (2018), positioning all treatments as suitable materials for use as organic amendments.

However, the decrease in organic matter observed in the corn cob treatment (35%)—paradoxically, the highest rate of biodegradation—can be explained by the fungus's higher metabolic activity in this substrate. García & Bermúdez (2021) note that the substrate biodegradation process results in a slight decrease in organic matter content due to the fungus's growth and fruiting, as well as the release of CO₂ during the decomposition of cellulosic components via exoenzymes.

Regarding pH, the values obtained (6.51–7.48) fall within the optimal range for most agricultural crops (6.0–8.0), as reported by Fontalvo et al. (2013) and confirmed by Kunapuli et al. (2025). Treatment with corn stover showed the lowest initial and final pH values (6.94 and 6.83), which is favorable since values close to neutrality promote nitrogen mineralization and nutrient availability for plants (Bonis et al., 2025).

Bejarano (2018) obtained similar values (pH 5.86–5.91) in sugarcane bagasse substrate biodegraded by *P. ostreatus* at 90 days, demonstrating that the pH tends to acidify slightly during the fungal process.

Practical Implications and Outlook.

The results obtained have important implications for the sustainable management of agricultural waste in the Mocache area, Los Ríos, Ecuador. Although the NPK values do not meet the standards of commercial organic fertilizers, the biodegraded substrate exhibits valuable physical and microbiological characteristics: high organic matter content (>35%), favorable pH, and an improved structure that promotes moisture retention and soil aeration (Shuai Wang, 2024).

Studies have shown that spent *Pleurotus spp.* substrate, even with moderate NPK content, significantly improves plant growth when used in soil mixtures. For example, the study by (Bonis et al., 2025) showed that spent *P. ostreatus* substrate applied at 12.5–25 t/ha improved baby leaf lettuce yield and soil fertility, despite requiring nitrogen supplementation for short growing cycles. Similarly, Kunapuli et al. (2025) reported that mixtures of 75% spent substrate + 25% soil promoted greater growth of *Centella asiatica*, attributing this effect to improved soil structure and the gradual release of nutrients.

The carbon-to-nitrogen ratio of the biodegraded substrates in the study (approximately 35–40, estimated based on organic matter and nitrogen content) is higher than the optimal range for mature compost (15–20), indicating that the material has not yet reached its full potential as a fertilizer. Co-composting of spent *P. ostreatus* substrate with pig manure demonstrated that the addition of nitrogen sources accelerates maturation and significantly improves total nutrient content, meeting quality standards for organic fertilizers (Shuai Wang, 2024) .

Conclusions

The cultivation of the *Pleurotus eryngii* mushroom demonstrated a significant impact on the biodegradation of crop residues, with corn stover being the substrate with the highest biodegradation rate (45.25%), followed by rice straw (40.20%), the waste mixture (38.64%), and peanut shells (33.65%). Despite this, these values are lower than those reported for other *Pleurotus* species and different substrates, suggesting that *P. eryngii* has a lower degradation capacity compared to the more extensively studied strains of *P. ostreatus*.

The incorporation of primary macronutrients (NPK) into the biodegraded substrates did not reach the minimum levels established for quality organic fertilizers (1% N and 0.15% P), with maximum values of 0.50% N, 0.10% P, and 0.75% K recorded in the corn stalk treatment. These results indicate that the 45-day period is insufficient to achieve the chemical maturity required for organic fertilizers, considering that the nitrogen and phosphorus values obtained did not meet the minimum standards established for quality fertilizers.

The organic matter analysis showed that all evaluated treatments exceeded the 30% threshold recommended for organic amendments. Among them, peanut shells had the highest content (39.00%) despite their lower biodegradability. This result indicates that residues with high lignification content retain their organic structure even when fungal degradation is limited, making them potentially useful materials for improving soil physical properties.

Regarding pH, the values obtained ranged from 6.51 to 7.48, falling within the optimal range for nutrient availability and root development (6.0–8.0), with corn stalks exhibiting values closest to neutrality (6.83–6.94), which presents favorable conditions for nitrogen mineralization processes.

This research proposes a viable alternative for the sustainable management of agricultural residues in the Mocache area, Los Ríos, Ecuador; however, it is recommended to extend the biodegradation period, evaluate the impact of the degraded substrate on crops under field conditions, and consider nitrogen supplementation to improve the nutritional quality of the final product.

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