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Beyond Growth: Substrate-Dependent Variations in the Proximate, Phytochemical, and Mineral Composition of White Oyster (*Pleurotus ostreatus*)

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ABSTRACT
This study assessed the impact of three readily available substrate materials, namely sawdust, maize leaves, and banana leaves, on the constituents of *Pleurotus ostreatus*. The mushroom was cultivated under the same conditions on the substrates independently, harvested, and analysed for proximate, mineral, and phytochemicals in line with standard protocols. Crude protein and crude fat content differed significantly across the three substrates, while significant differences in crude fibre and ash were observed between selected substrates ($p < 0.05$). The mushroom grown on sawdust had the highest protein content, while those cultivated on maize leaves recorded higher levels of crude fat, crude fibre, and ash. Some phytochemicals (oxalates, phytates, phenols, and saponins), and all the mineral elements analysed, were significantly influenced by the substrate type. Banana leaves supported Mn and K accumulation, while maize leaves favored Fe, Zn, and Mg in the grown mushrooms. Both banana leaves and maize leaves yielded statistically equivalent high K values. These results show that the choice of substrate for the cultivation of mushrooms can affect their compositional characteristics. No single substrate wholly produced mushrooms with the highest levels of all the measured constituents, but each substrate was linked to particular nutritional and mineral contents. This study highlights the potential of readily available agricultural residues as substrates for cultivating *P. ostreatus* with differing nutritional profiles and provides useful information for selecting substrates according to desired mushroom quality.

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INTRODUCTION

Edible mushrooms are increasingly recognised as valuable food resources because they provide protein, dietary fibre, minerals and a variety of biologically active compounds. Among cultivated species, *Pleurotus ostreatus* (oyster mushroom) is especially popular because of its nutritional value, ability to adapt to different growing conditions, and utilize different lignocellulosic wastes (Lesa *et al.*, 2022). The nutritional composition of *P. ostreatus* includes protein, carbohydrate, fibre, ash, and fat, with their levels in the mushroom varying based on environmental and cultivation conditions (Ekute, 2018; Elkanah *et al*., 2022). Being a saprophytic fungus, *P. ostreatus* can grow on agricultural and agro-industrial residues by degrading cellulose, hemicellulose, and lignin through extracellular enzymes (Doroski *et al*., 2022; Karmani *et al.,* 2022). The use of such biomass residues offers twofold benefits. These include the provision of relatively inexpensive materials for mushroom production along with creating an avenue for the productive utilisation of agricultural wastes.

Sawdust is one of the commonly used substrates for oyster mushroom cultivation because of its lignocellulosic nature and availability. However, increasing emphasis on sustainable utilization of forest resources has sparked interest in alternative agricultural residues. They are cheap, renewable, and readily available. Some authors have investigated crop residues such as maize residues, banana leaves, rice husks, and oil-palm wastes for mushroom cultivation (Obinna-Echem and Chukunda, 2018; Adebayo *et al.*, 2021; Costa *et al*., 2023).

Banana leaves are of special interest because they are readily available agricultural residues in many tropical regions such as Nigeria, and have demonstrated potential as a substrate for *P. ostreatus*. Aguchem *et al.* (2022) reported significant differences in several nutritional and antinutritional parameters between banana-leaf-grown mushrooms and those grown on a rice-bran/sawdust substrate. Such findings suggest that banana leaves can provide a suitable growing environment while producing mushrooms with a distinct chemical composition.

Maize leaves are a potential substrate for mushroom cultivation because it is available in large quantities wherever maize is cultivated and processed. Their ability to support *P. ostreatus* cultivation has been demonstrated. Adjapong *et al.* (2015) showed that maize husk could support oyster mushroom production, while subsequent studies have continued to explore agricultural residues as alternative substrates for improving mushroom production and quality. These findings demonstrate the potential of maize residues as alternative substrates for *P. ostreatus* cultivation.

Substrate composition can impact the nutrients available to the fungus during colonization and fruit-body formation. This may subsequently affect the nutritional characteristics of the harvested mushrooms. Earlier studies reported variations in nutritional, mineral, and bioactive contents of *P. ostreatus* cultivated on different agricultural wastes (Kunjadia *et al.,* 2014; Onyeka *et al*., 2018; Elkanah *et al*., 2022; Jimoh *et* *al*.,2023; Muhammed e*t al*., 2023). Similarly, Aguchem *et al.* (2022) reported that mushrooms cultivated on banana leaves and sawdust differed significantly in nutrient, vitamin, mineral, and antinutrient composition. This shows that substrate selection can modify the nutritional characteristics of the harvested fruiting bodies.

Although some studies have established that cultivation substrates influence mushroom chemical/nutritional quality, most have assessed selected nutritional parameters or compared only a limited number of substrates. Comparative assessments that integrate proximate composition, phytochemical constituents, and mineral profiles of *P. ostreatus* cultivated on sawdust, banana leaves, and maize leaves under the same growing conditions remain relatively scarce. Such all-encompassing research is valuable because it provides a basis for selecting locally available substrates based on the desired nutritional constituents of the cultivated mushrooms rather than fruiting body yield alone.

Therefore, this study aims to assess the effects of sawdust, banana leaves, and maize leaves as growth substrates on the proximate composition, phytochemical constituents, and mineral composition of *Pleurotus ostreatus*. The findings contribute to the growing body of knowledge on sustainable utilization of agricultural residues and provide useful information for optimizing substrate selection to improve the nutritional quality of cultivated oyster mushrooms.

MATERIALS AND METHODS

Collection of Mushroom Spawn and Substrates

Pleurotus ostreatus sorghum-grain spawn was purchased from a commercial mushroom farmer in Abuja, Nigeria. Fresh sawdust, banana leaves, and maize leaves were collected from local sources within Abuja.

Preparation of Cultivation Substrates

The banana leaves and maize leaves were cleaned to remove dirt, air-dried, and chopped into smaller pieces, while the sawdust was sieved to remove coarse particles and unwanted materials. The resulting substrate particle sizes were not quantitatively measured. The cleaned substrates were lightly sprayed with distilled water before being transferred into cultivation bags. The amount of water applied was not quantified. We weighed approximately 500 g of each substrate into separate ice-block polyethylene bags, and prepared 15 bags for each substrate treatment. Raw substrate characterization was not performed.

The substrate bags were pasteurized by steam generated from boiling water in a tightly covered metal drum (see Figure 1). The bags were placed on a raised platform above the boiling water, ensuring that they were not in direct contact with the water, and were exposed to steam for twenty-four (24) hours. Following pasteurization, the substrate bags were allowed to cool to room temperature before inoculation.

Inoculation, Incubation and Harvesting

As described by Tarko and Sirna (2018), each substrate bag was inoculated with *Pleurotus ostreatus* spawn at a spawn rate of 5% (w/w) under sterile conditions in a Still Air Box.

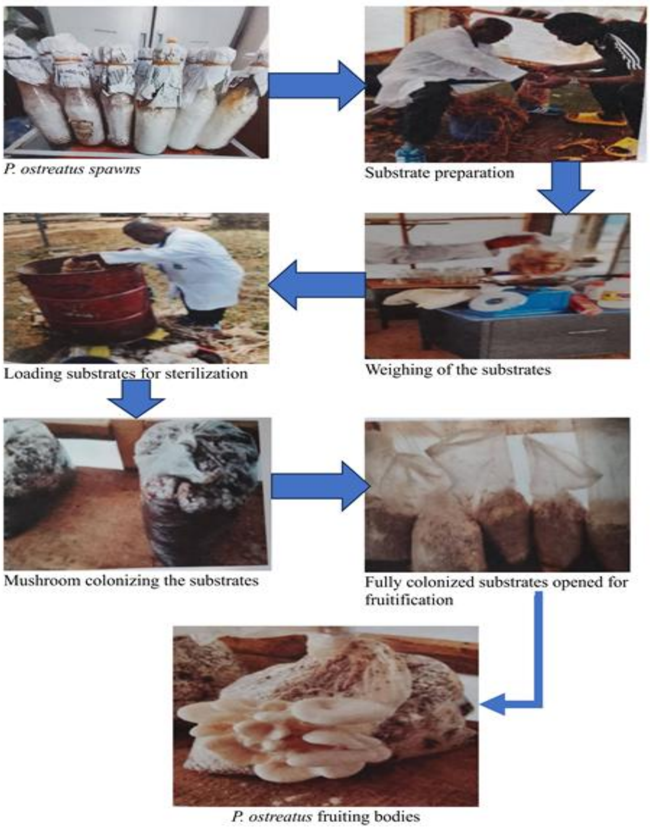

Figure 1: Stages in the Cultivation of *Pleurotus ostreatus* on the Substrates

The inoculated bags were incubated in a dark room until complete mycelial colonization and subsequent fruiting. Mature fruiting bodies were harvested manually from each cultivation bag. For each substrate treatment, the harvested mushrooms from the fifteen (15) bags were pooled to form a composite sample, which was subsequently prepared for chemical analysis. Each chemical analysis was performed in triplicate using the respective composite samples.

Sample Preparation

The harvested mushrooms were cleaned to remove substrate particles, oven-dried to constant weight at 60 ºC, and milled into fine powder using a laboratory grinder. The powdered samples were stored in airtight containers until further analyses.

Proximate Analysis

Moisture, crude protein, crude fat, crude fibre and ash contents of the mushroom samples were determined according to standard AOAC methods of analysis (AOAC, 2005 (a -d); Thiex, 2009). Total carbohydrate content was spectrophotometrically determined using the anthrone method as described by Yemm and Willis (1954). Each parameter was determined in triplicate, and the results were expressed on a percentage basis.

Phytochemical Analysis: Qualitative

The mushroom samples were extracted using distilled water and ethanol as described by Khan *et al*. (2023). The extracts were then evaluated for the presence of the phytochemicals, namely saponins, tannins, phenols, flavonoids, steroids, alkaloids, oxalates, phytates, phytosterols, terpenoids, quinones, fixed oil and fats, carboxylic acids, anthraquinones, glycosides, xanthoproteins, polyphenols, anthocyanins, resins and phlobatannins, according to the standard methods described by Ekute (2019), Effiong *et al*. (2024), and Lokman *et al.* (2025).

Phytochemical Analysis: Quantitative

Of the ten (10) phytochemicals detected, six (6) were subsequently quantified based on the availability and completeness of the required analytical reagents at the time of the study. The remaining four (4) phytochemicals could not be quantitatively determined because the necessary reagents were either incomplete or not available. The concentrations of the phytochemicals, alkaloids, total phenols, saponins, oxalates, phytates, and terpenoids, were determined using standard analytical procedures described by Ekute *et al.* (2025). All analyses were carried out in triplicate and expressed as mg g^{-1}.

Mineral Analysis

The powdered mushroom samples were digested using a standard wet digestion procedure before mineral determination (Ekute *et al.*, 2025). Sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), potassium (K), and magnesium (Mg) contents were determined using an atomic absorption spectrophotometer. Mineral concentrations were expressed as mg kg^{-1}. Each determination was performed in triplicate.

Statistical Analysis

Results were expressed as mean ± standard deviation of triplicate determinations. Statistical analysis was performed using one-way analysis of variance (ANOVA) to evaluate the effect of cultivation substrate on the measured parameters. Differences among treatment means were separated using post hoc Tukey's (HSD) test at a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

Cultivation Substrate Impact on Proximate Composition of *Pleurotus ostreatus*

The proximate composition of *Pleurotus ostreatus* grown on different substrates namely sawdust, banana leaves, and maize leaves, is given in Table 1, with an indication of post hoc

Table 1: Proximate Composition of *Pleurotus ostreatus* Grown on Different Substrates

Parameter (%)	Sawdust	Banana leaves	Maize leaves
Crude Protein	7.97±0.087^{a}	7.54±0.136^{b}	5.68±0.045^{c}
Crude Fat	4.06±0.051^{b}	3.61±0.128^{c}	4.88±0.055^{a}
Crude Fibre	12.76±0.252^{b}	14.46±0.522^{a}	14.87±0.126^{a}
Moisture	5.25±0.296^{a}	5.25±0.217^{a}	5.10±0.080^{a}
Ash	8.88±0.092^{b}	9.15±0.165^{ab}	9.56±0.225^{a}
Carbohydrates	61.43±0.638^{a}	60.13±0.834^{a}	60.536±0.875^{a}

Values are Presented as Mean ± Standard deviation (n = 3). Means Within the Same row Bearing Different Superscript Letters are Significantly different ($p < 0.05$), While Means Sharing a Common Superscript Letter are not Significantly Different Based on the Post Hoc Tukey Test.

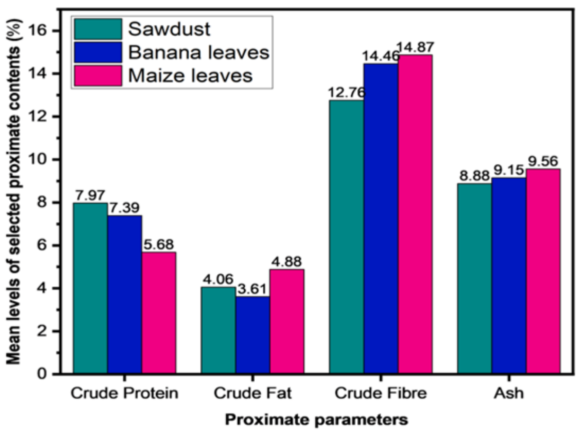

Figure 2: Effect of Cultivation Substrate on Selected Proximate Constituents of *Pleurotus ostreatus*

Tukey analysis and analysis of variance (ANOVA, $p < 0.05$), indicating a significant or insignificant difference in values obtained per proximate component across the three substrates. Figure 2 correspondingly shows the substrate-dependent variations in composition. The results showed that the three substrates produced *P. ostreatus* mushrooms having crude protein, crude fat, crude fibre, ash, moisture, and carbohydrates. However, the substrate type affected the levels of some of the nutritional constituents (crude fat, crude protein, crude fibre, and ash) in the mushrooms, as revealed by significant differences at $p < 0.05$ (Table 1). Carbohydrate was the highest available nutrient in the mushrooms (60.13 ± 0.834 to 61.43 ± 0.638 %), followed by crude fibre (12.76 ± 0.252 to 14.87 ± 0.126%), ash (8.88 ± 0.092 to 9.56 ± 0.225 %), crude protein (5.68 ± 0.045 to 7.97 ± 0.087 %), moisture (5.10 ± 0.080 to 5.25 ± 0.296 %) and crude fat (3.61 ± 0.128 to 4.88 ± 0.055 %). The moisture content recorded in this study falls within the range of 3–13% documented by Lysakowska *et al*. (2023) for dried mushrooms. Looking at the effect of the substrates on the proximate levels, the order of values for the significantly different parameters was sawdust > banana leaves > maize leaves for crude protein, maize leaves > sawdust > banana leaves for crude fat, maize leaves > banana (though not significantly different from that of maize leaves) > sawdust for crude fibre, and maize leaves > banana leaves > sawdust for ash content. The observed higher protein content in sawdust-grown mushrooms than in the other two substrates could be related to differences in substrate nutrient availability and its carbon-to-nitrogen balance (Belletini *et al*., 2016). *P. ostreatus* requires carbon for energy and nitrogen for the synthesis of protein and some other nitrogen-containing cellular constituents, thus validating the role of a balance in the C-to-N ratio in the growth substrate. Disesa *et al*. (2024) noted a similar observation in their study, which demonstrated that substrate formulation with respect to C, N, and C-to-N characteristics produces significant differences in protein content of the studied mushrooms. Another study by Gardelli et al. (2024) further affirmed that substrate and mushroom strain affected the quality of protein in *P. ostreatus*.

Also related to substrate carbon resource availability and its assimilation by the growing mushroom is the fat content. Fat accumulation is closely linked with fungal carbon metabolism, and variation in growth substrate composition can influence the amount and composition of fats formed in the edible fungus fruiting bodies (Suwannarach *et al*., 2022), hence the observed variations. Diamantopoulou *et al.* (2023) observed substrate-related differences in *P. ostreatus* cultivated on different agro-industrial substrates. However, in this case, maize leaves-grown *P. ostreatus* had the highest fat content but the lowest protein content. The lower content observed in the maize leaves-grown mushrooms may be related to differences in the nutrients available to the fungus during the development of the fruiting bodies. Similarly, the higher fat content suggests that the fungus may have assimilated nutrients differently when grown on maize leaves. This is in agreement with the observation that the composition of *P. ostreatus* could vary based on the substrate used for cultivation (Hoa *et al*., 2015; Elkanah *et al*., 2022). Though this study did not determine the chemical composition of the substrates before cultivation and, as such, the specific component responsible for the differences in observation cannot be identified, the findings nevertheless imply that each substrate is nutrient-specific, not necessarily favoring all other food nutrients.

Similarly, maize leaves-grown mushrooms gave the highest numerical value of crude fibre, though the Tukey grouping showed they were not uniformly significant across the three substrate types. This observation may also be related to differences in structural carbohydrate composition of the substrates and the capability of *P. ostreatus* to degrade and utilize the cellulose and other lignocellulosic components of the substrate. Hu *et al*. (2024) noted that substrate composition influences the biochemical properties of the resulting mushroom grown on it.

Ash content, which gives an estimate of the inorganic left over after combustion, indirectly reflecting the total mineral portion of food materials (Ekute *et al*., 2025), was observed to be higher in maize leaves-derived *P. ostreatus*. The authors Diamantopoulou *et al*. (2023) and Disesa *et al*. (2024) reported significant differences in ash content of *P. ostreatus* grown on different substrates. Maize-leaves-grown mushrooms having the highest ash content may suggest greater mineral accumulation from the growth substrate.

Phytochemical Qualitative Evaluation of the Cultivated Mushrooms

Twenty-one (21) phytochemicals were tested for their presence in *P. ostreatus* cultivated on the three substrates, as presented in Table 2. The mushrooms from the substrates were found to contain phenols, steroids, alkaloids, oxalates, phytates, phytosterols, terpenoids, fixed oil and fats, resins, and saponins, though saponins were not found in the banana leaves-grown *P. ostreatus,* while the eleven (11) others gave negative indications, inferring their absence in the mushrooms. This observation indicates possible substrate impact on the mushroom constituents.

Phytochemical Estimation

Of the identified phytocompounds, phenols, phytates, oxalates, saponins, alkaloids, and terpenoids were quantified. The phytochemical composition of the harvested mushrooms from the different substrates is presented in Table 3. An estimation of the selected phytochemical constituents revealed a selective response of the mushroom to the cultivation substrates. The phenols, phytates, and oxalates showed significant substrate-related differences, while alkaloids, saponins, and terpenoids did not show any significant differences ($p < 0.05$), thus indicating that the various cultivation substrates did not produce a uniform increase or decline in all the quantified phytochemical constituents. A lack of significant difference in the alkaloid contents across the three substrates suggests relatively

Table 2: Phytochemical Screening of *Pleurotus ostreatus* Grown on Different Substrates

PARAMETER	POML	POSD	POBN
Saponins	++	++	-
Tannins	-	-	-
Phenols	+	+	+
Flavonoids	-	-	-
Steroids	+	+	+
Alkaloids	+	+	+

PARAMETER	POML	POSD	POBN
Oxalates	+	+	+
Phytates	+	+	+
Phytosterols	+	+	+
Terpenoids	+	+	+
Quinones	-	-	-
Fixed oil and fats	+	+	+
Carboxylic acids	-	-	-
Anthraquinones	-	-	-
Glycosides	-	-	-
Cardiac glycosides	-	+	-
Xanthoproteins	-	-	-
Polyphenols	-	-	-
Anthocyanins	-	-	-
Resins	+	+	+
Phlobatannins	-	-	-

NOTE: + Signifies Present, ++ Signifies Moderately Present, - Signifies Not Present.
POSD: *Pleurotus ostreatus* Grown on Sawdust; **POML**: *Pleurotus ostreatus* Grown on Maize Leaves; and **POBN:** *Pleurotus ostreatus* Grown on Banana Leaves

Table 3: Quantified Phytochemical Constituents of *Pleurotus ostreatus* Grown on Different Substrates

Parameter (mg/g)	Sawdust	Banana leaves	Maize leaves
Alkaloids	0.125±0.005[a]	0.125±0.002[a]	0.124±0.005[a]
Phenols	3.314±0.079[a]	3.320±0.023[a]	3.113±0.091[b]
Saponins	0.142±0.006[a]	-	0.134±0.005[a]
Oxalates	0.294±0.128[b]	0.383±0.006[a]	0.353±0.006[ab]
Phytates	2.450±0.135[a]	2.177±0.136[ab]	1.943±0.146[b]
Terpenoids	0.223±0.006[a]	0.220±0.009[a]	0.234±0.007[a]

Values are presented as mean ± standard deviation (n = 3). Means within the same row bearing different superscript letters are significantly different ($p < 0.05$), while means sharing a common superscript letter are not significantly different based on the post hoc Tukey test.

stable alkaloid accumulation under the same conditions. This does not mean that substrate composition cannot affect alkaloids and alkaloid-related metabolites, but rather has a non-detectable impact in relation to the substrates used in this study. In fact, Effiong *et al*. (2024) confirmed the presence of alkaloids in *P. ostreatus* while noting that phytochemical levels could differ based on extraction conditions.

Phenolic content, which differed significantly across the three substrates, was higher in the banana leaves substrate-grown mushroom (3.320 ± 0.023 mg/g) than in those grown on sawdust (though only slightly) and maize leaves. This could imply that the chemical environment generated by the banana leaves influenced phenolic accumulation sufficiently more than that of the maize leaves. This finding concurs with the observations of Diamantopoulou *et al*. (2023) and Effiong *et al*. (2024). An insignificant substrate impact on saponin levels was recorded in this study and could infer a relatively stable saponin fraction across the three cultivation environments. A similar observation was made for terpenoids. Considering phytate levels across the three substrates, there was a significant difference between the mushrooms grown on sawdust (2.450 ± 0.135 mg/g) and maize leaves (2.177 ± 0.136 mg/g), while banana leaves (1.943 ± 0.146 mg/g) was not significantly different from sawdust and maize leaves. This suggests different phytate accumulation substrate-type influences. The oxalate content differed significantly between sawdust and banana leaves-grown mushrooms, while that of maize leaves was not significantly different from both substrates. This is possible due to the fact that the chemical constituents available to the macro-fungus and the metabolic pathways through which these constituents are transformed could differ among different growth residues. Nwaji *et al*. (2024), for instance, reported substrate-related differences in phytochemical constituents of another *Pleurotus* species (*P. pulmonarius*) grown on sawdust, corn cob, and palm bunch. The oxalate content (0.294 ± 0.128 to 0.383 ± 0.006 mg/g) observed is relatively low compared with values reported for *P. ostreatus* (0.425 ± 0.035 and 0.789 ± 0.015 mg/g) grown on different substrates by Aguchem *et al*., 2022. The phytate levels, however, were present at higher values when compared with values (0.1341 ± 0.005 mg/g) reported by Khan *et al*., 2025. The presence of phytates and oxalates in a food could inhibit maximal utilization of nutrients such as minerals, vitamins, and proteins depending on their concentrations (Gemede *et al*., 2016). These phytochemicals minimize the bioavailability of minerals as they form insoluble salts of the minerals, such as calcium oxalate. However, considering the levels of oxalates and phytates in relation to the mineral levels in the mushrooms, this may suggest their limited impact on the bioavailability of minerals such as Zn and Fe (Rahman and Shaheen, 2022). Hence, no health risk may be associated with the consumption of these mushrooms, irrespective of the growth substrates.

Mineral Composition of *P. ostreatus*: Cultivation Substrate-Type Impact

The mineral composition of *P. ostreatus* cultivated on the three substrates is presented in Table 4, while the pattern of substrate-dependent variation of the mineral constituents of the **v**alues are presented as mean ± standard deviation (n = 3). Means within the same row bearing different superscript letters are significantly different ($p < 0.05$), while means sharing a common superscript letter are not significantly different based on the post hoc Tukey test.

Table 4: Mineral Composition of *Pleurotus ostreatus* Grown on Different Substrates (mg/Kg)

Mineral	Sawdust	Banana leaves	Maize leaves
Na	233.20±4.36[a]	155.91±4.19[b]	120.40±7.72[c]
Fe	355.49±8.55[b]	290.94±11.63[c]	439.85±23.49[a]
Zn	42.14±0.53[c]	48.70±0.53[b]	60.03±0.35[a]
Mn	12.90±1.89[b]	20.34±2.31[a]	14.61±1.91[b]
K	2284.95±24.08[b]	2454.64±60.22[a]	2454.82±13.03[a]
Mg	1241.77±15.14[c]	1507.40±2.02[b]	1534.75±6.73[a]

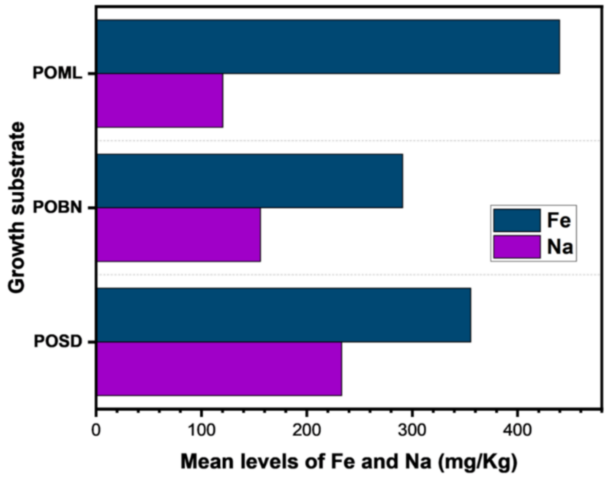

Figure 3: Growth Substrate Impact on Fe and Na Levels in *Pleurotus ostreatus*

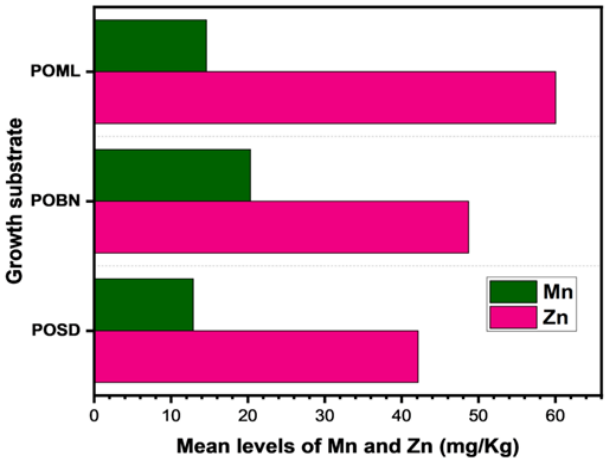

Figure 4: Growth Substrate Impact on Mn and Zn Levels in *Pleurotus ostreatus*

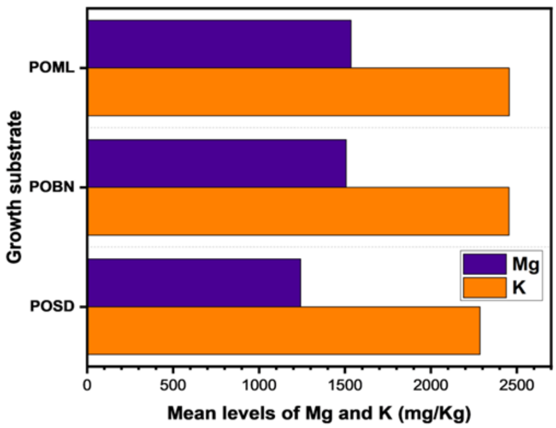

Figure 5: Growth Substrate Impact on Mg and K Levels in *Pleurotus ostreatus*

Corresponding *P. ostreatus* mushrooms is presented in Figures 3, 4, and 5, respectively. The same evidence of substrate-dependent variations was observed for all the minerals analyzed. Unlike proximate and phytochemical composition, in which certain constituents exhibited relatively small variations, all the minerals showed notable and significantly different values among the three substrates, though the mineral levels did not follow the same trend in the substrates. This suggests selective and element-specific accumulation of minerals in *P. ostreatus*. This is in agreement with observations of some authors who reported significant substrate-dependent differences in Mg, K, Na, Fe, and Zn concentrations (Desisa *et al*., 2024). Overall, the mineral composition was in the order of K > Mg > Fe > Na > Zn > Mn, with maize leaves grown on mushrooms having the highest values of Mg (1534.75±6.73 mg/Kg), Zn (60.03±0.35 mg/Kg), and Fe (439.85±23.49 mg/Kg) and the same mean value for K as that grown on banana leaves (Table 4), while that on sawdust substrate had the highest sodium levels (233.20±4.36 mg/Kg). The observed higher levels of most of the analyzed minerals in maize leaves align with the highest ash content recorded for the same mushroom in this study. Banana leaves-based *P. ostreatus* also had higher mineral levels than its sawdust counterpart except for sodium. The similarity between the *P. ostreatus* grown on banana leaves and maize leaves indicates that both substrates likely provided comparable conditions for mineral accumulation, while sawdust produced significantly lower accumulation. Some authors made similar observations, affirming the effect of substrates on the mineral composition of the respective produced mushrooms (Desisa *et al*. 2024; Effiong *et al*. 2024).

CONCLUSION

Our findings show that the type of substrate employed to grow *Pleurotus ostreatus* could make an evident difference in the composition and quality of the mushroom. Maize leaves produced a mushroom with higher crude fat, ash, Fe, Mg, and Zn, while sawdust produced a mushroom with the highest protein content. Banana leaves, on the other hand, favoured accumulation of Mn in the mushroom. The substrates also influenced the levels of phytate and phenols. An outstanding observation from this study is that no single substrate gave the best value for every quantified parameter. Rather, the three substrates impacted different nutritional and mineral profiles in the same mushroom species. This thus suggests that these readily available materials used in this study could be chosen not just as a cultivation substrate but also on the basis of the desired nutritional composition of the resulting mushrooms. These findings add to the existing knowledge on the use of agricultural wastes or materials as alternative substrates for growing *P. ostreatus* and the possible development of substrates for specific nutritional purposes.

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CONFLICT OF INTEREST

We, the authors, declare no conflict of interest.

REFERENCES

Adebayo, E. A., Elkanah, F. A., Afolabi, F. J., Ogundun, O. S., Alabi, T. F. and Oduoye, O. T. (2021). Molecular characterization of most cultivated *Pleurotus* species in sub-western region Nigeria with development of cost effective protocol on palm oil waste. *Heliyon*, 7(2): e06215. https://doi.org/10.1016/j.heliyon.2021.e06215.

Adjapong, A. O., Ansah, K. D., Angfaarabung, F. and Sintim, H. O. (2015). Maize residue as a viable substrate for farm scale cultivation of oyster mushroom (*Pleurotus ostreatus*). *Advances in Agriculture*, 213251: 1–6. https://doi.org/10.1155/2015/213251.

Aguchem, R. N., Chibuogwu, C. C., Okolo, B. O., Oyeagu, U., Etim, V. E., Anaele, E. N. and Njoku, O. U. (2022). Nutrient and antinutrient composition of *Pleurotus ostreatus* grown on different substrates. *Biology and Life Sciences Forum*, 11(1): 69. https://doi.org/10.3390/IECPS2021-11955.

AOAC (2005a). AOAC Official Method 2001.11: Determination of protein (crude) in animal feed, forage (plant tissue), grain, and oilseeds: Block digestion with a copper catalyst and steam distillation into boric acid: Collaborative study. In *Official Methods of Analysis of AOAC International* (18th ed.). AOAC International.

AOAC (2005b). AOAC Official Method 2003.05: Crude fat in feeds, cereal grains, and forages. In *Official Methods of Analysis of AOAC International* (18th ed., pp. 40–42). AOAC International.

AOAC (2005c). AOAC Official Method 942.05: Ash of animal feed. In *Official Methods of Analysis of AOAC International* (18th ed., p. 8). AOAC International.

AOAC (2005d). AOAC Official Method 978.10: Fiber (crude) in animal feed and pet food. In *Official Methods of Analysis of AOAC International* (18th ed., pp. 46–47). AOAC International.

Belletini, M. B., Fiorda, F. A., Maieves, H. A., Teixeira, G. L., Avila, S., Hornung, P. S., Junior, A. M. and Ribani, R. H. (2016). Factors affecting mushroom *Pleurotus* spp. *Saudi Journal of Biological Sciences*, 26: 633–646. https://doi.org/10.1016/j.sjbs.2016.12.005.

Costa, A. F. P., Steffen, G. P. K., Steffen, R. B., Portela, V. O., Santana, N. A., Richards, N. S. P. d.-S. and Jacques, R. J. S. (2023). The use of rice husk in the substrate composition increases *Pleurotus ostreatus* mushroom production and quality. *Scientia Horticulturae*, 321: 112372. https://doi.org/10.1016/j.scienta.2023.112372.

Desisa, B., Muleta, D., Dejene, T., Mulissa, J., Goshu, A., Negi, T. and Martin-Pinto, P. (2024). Utilization of local agro-industrial by-products based substrates to enhance production and dietary value of mushroom (*P. ostreatus*) in Ethiopia. *World Journal of Microbiology and Biotechnology*, 40: 277. https://doi.org/10.1007/s11274-024-04062-3.

Diamantopoulou, P., Fourtaka, K., Melanouri, E. M., Dedousi, M., Diamantis, I., Gardeli, C. and Papanikolaou, S. (2023). Examining the impact of substrate composition on the biochemical properties and antioxidant activity of *Pleurotus* and *Agaricus* mushrooms. *Fermentation*, 9(7): 689. https://doi.org/10.3390/fermentation9070689.

Doroški, A., Klaus, A., Režek Jambrak, A. and Djekic, I. (2022). Food waste originated material as an alternative substrate used for the cultivation of oyster mushroom

(*Pleurotus ostreatus*): A review. *Sustainability*, 14(19): 12509. https://doi.org/10.3390/su141912509.

Effiong, M. E., Umeokwochi, C. P., Afolabi, I. S. and Chinedu, S. N. (2024). Comparative antioxidant activity and phytochemical content of five extracts of *Pleurotus ostreatus* (oyster mushroom). *Scientific Reports*, 14: 3794. https://doi.org/10.1038/s41598-024-54201-x.

Ekute, B. O. (2018). Nutritional profile of two Nigerian edible mushrooms: *Pleurotus ostreatus* and *Pleurotus pulmonarius*. *Journal of Applied Sciences and Environmental Management*, 22(11): 1745–1747. https://doi.org/10.4314/jasem.v22i11.6.

Ekute, B. O. (2019). Screening and quantitative determination of phytochemical constituents of *Pleurotus ostreatus* and *Pleurotus pulmonarius* commonly grown in South-western Nigeria. *Sokoto Journal of Medical Laboratory Science*, 4(2): 132–136.

Ekute, B. O., Khan, M. E., Pam, A. A. and Emurotu, J. E. (2025). Assessment of the nutritional and phytochemical composition of selected mushroom species grown in Southern Nigeria. *Journal of the Nigerian Society of Physical Sciences*, 7(4): 2978. https://doi.org/10.46481/jnsps.2025.2978.

Elkanah, F. A., Oke, M. A. and Adebayo, E. A. (2022). Substrate composition effect on the nutritional quality of *Pleurotus ostreatus* (MK751847) fruiting body. *Heliyon*, 8(11): e11841. https://doi.org/10.1016/j.heliyon.2022.e11841.

Gardeli, C., Mela, N., Dedousi, M., Kandyliari, A., Kaparakou, E., Diamantopoulou, P., Pappas, C. and Mallouchos, A. (2024). The influence of substrate and strain on protein quality of *Pleurotus ostreatus*. *Applied Sciences*, 14(10): 4040. https://doi.org/10.3390/app14104040.

Gemede, H. F., Haki, G. D., Beyene, F., Woldegiorgis, A. Z. and Rakshit, S. K. (2016). Proximate, mineral, and antinutrient compositions of indigenous okra (*Abelmoschus esculentus*) pod accessions: Implications for mineral bioavailability. *Food Science and Nutrition*, 4(2): 223–233. https://doi.org/10.1002/fsn3.282

Hoa, H. T., Wang, C.-L. and 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., Dong, H., Chen, H., Shen, X., Li, H., Wen, Q., Wang, F., Qi, Y. and Shen, J. (2024). PoSnf1 affects cellulose utilization through interaction with cellobiose transporter in *Pleurotus ostreatus*. *International Journal of Biological Macromolecules*, 275: 133503. https://doi.org/10.1016/j.ijbiomac.2024.133503.

Jimoh, M. A., Akinyemi, S. A., Olatunji, O. A., Olowolaju, E. D. and Okunlola, G. O. (2023). Cultivation of *Pleurotus ostreatus* on agricultural wastes and effects on nutritional composition of the fruiting body. *International Journal of Vegetable Science*, 29(4): 313–321. https://doi.org/10.1080/19315260.2023.2216684.

Karmani, M., Subramaniam, G., Sivasamugham, L. A., Cheng, W. H. and Wong, L. S. (2022). Effects of different substrates on the growth and nutritional composition of *Pleurotus ostreatus*: A review. *Journal of Experimental Biology and Agricultural Sciences*, 10(3): 481–486. https://doi.org/10.18006/2022.10(3).481.486.

Khan, M. E., Elum, C. E., Ijeomah, A. O., Ameji, P. J., Osigbemhe, I. G., Etim, E. E., Anyam, J. V., Abel, A. and Agber, C. T. (2023). Isolation, characterization, antimicrobial and theoretical investigation of some bioactive compounds obtained from the bulbs of *Calotropis procera*. *Journal of the Nigerian Society of Physical Sciences*, 5: 1576. https://doi.org/10.46481/jnsps.2023.1576.

Khan, M. E., Osigbemhe, I. G., Sikiratu, Y., Oyeza, I. N., Adebayo, K. O., Aliyu, H., Genevieve, S. O., Aliyu, H. N., Alexander, A., Yahaya, M. K., Ugbenyo, N. O. and Abdulazeez, A. M. (2025). Phytochemical, nutritional, anti-nutritional evaluation and antimicrobial analysis of *Pleurotus ostreatus* from Oshogbo in Osun State, Nigeria. *Dutse Journal of Pure and Applied Sciences*, 11(1b): 292–300. https://doi.org/10.4314/dujopas.v11i1b.31.

Kunjadia, P. D., Nagee, A., Pandya, P. Y., Mukhopadhyaya, P. N., Sanghvi, G. V. and Dave, G. S. (2014). Medicinal and antimicrobial role of the oyster culinary-medicinal mushroom *Pleurotus ostreatus* (higher Basidiomycetes) cultivated on banana agro-wastes in India. *International Journal of Medicinal Mushrooms*, 16(3): 227–238. https://doi.org/10.1615/IntJMedMushr.v16.i3.30.

Lesa, K. N., Khandaker, M. U., Faruque, M. R. I., Sharma, R. Y., Islam, F., Mitra, S. and Emran, T. B. (2022). Nutritional value, medicinal importance, and health-promoting effects of dietary mushroom (*Pleurotus ostreatus*). *Journal of Food Quality*, 2022(1): 2454180, 1–9. https://doi.org/10.1155/2022/2454180.

Lokman, M., Ali, L. M., Sadia, Q. A., Sami, S. A., Alam, M. A., Proma, N. M., Islam, M. R. and Hossain, M. K. (2025). Deciphering the antioxidant and neuropharmacological effects of methanolic extract of *Artocarpus chama* leaves and its n-hexane and ethyl acetate fractions: GC-MS analysis, experimental, and in silico investigations. *Food Science and Nutrition*, 13(11): e71227. https://doi.org/10.1002/fsn3.71227.

Lysakowska, P., Sobota, A. and Wirkijowska, A. (2023). Medicinal mushrooms: Their bioactive components, nutritional value and application in functional food production – A review. *Molecules*, 28(14): 5393. https://doi.org/10.3390/molecules28145393.

Muhammed, H. M., Hafizat, K., Rabe, A. M., Danladi, G. H., Stephen, D. Y. and Isah, A. O. (2023). Determination of nutritional value of *Pleurotus ostreatus* Jacq. ex Fr. P. Kumm. (oyster mushroom) cultivated on some plant substrates. *FUDMA Journal of Sciences*, 7(5): 30–33. https://doi.org/10.33003/fjs-2023-0705-1891.

Nwaji, C. C., Agubata, Z. C., Ugbaja, C. G., Ekwueme, G., Moro, D. D., Aduo, B. C. and Olusola, A. O. (2024). Effect of different substrates on phenotype, nutritional, phytochemical composition and antioxidant activity of *Pleurotus pulmonarius*. *Fundamental and Applied Agriculture*, 9(4): 283–293. https://doi.org/10.5455/faa.226318.

Obinna-Echem, P. C. and Chukunda, F. A. (2018). Nutrient composition of mushroom: *Pleurotus ostreatus* (Jacq. ex Fr. Kumm.) grown on different agricultural wastes. *Agricultural and Food Science Research*, 5(1): 1–5. https://doi.org/10.20448/journal.512.2018.51.1.5.

Onyeka, E. U., Udeogu, E., Umelo, C. and Okehie, M. A. (2018). Effect of substrate media on growth, yield and nutritional composition of domestically grown oyster mushroom (*Pleurotus ostreatus*). *African Journal of Plant Science*, 12(7): 141–147. https://doi.org/10.5897/AJPS2016.1445.

Rahman, S. and Shaheen, N. (2022). Phytate-iron molar ratio and bioavailability of iron in Bangladesh. *Tropical Medicine and International Health*, 27(5): 509–514. https://doi.org/10.1111/tmi.13750.

Suwannarach, N., Kumla, J., Zhao, Y. and Kakumyan, P. (2022). Impact of cultivation substrate and microbial community on improving mushroom productivity: A review. *Biology (Basel)*, 11(4): 569. https://doi.org/10.3390/biology11040569.

Tarko, D. B. and Sirna, A. M. (2018). Substrate optimization for cultivation of *Pleurotus ostreatus* on lignocellulosic wastes (coffee, sawdust, and sugarcane bagasse) in Mizan-Tepi University, Tepi Campus, Tepi Town. *Journal of Applied Biology and Biotechnology*, 6(4): 14–20. https://doi.org/10.7324/JABB.2018.60403.

Thiex, N. (2009). Evaluation of analytical methods for the determination of moisture, crude protein, crude fat, and crude fiber in distillers dried grains with solubles. *Journal of AOAC International*, 92(1): 61–73. https://doi.org/10.1093/jaoac/92.1.61.

Yemm, E. W. and Willis, A. J. (1954). The estimation of carbohydrates in plants by anthrone. *Biochemical Journal*, 57(3): 508–514. https://doi.org/10.1042/bj0570508.