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Evaluation of selected organic residues as supplements on growth and yield of Oyster mushroom, *Pleurotus florida*

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Abstract

Introduction: The growth and yield of a mushroom are dependent on its ability to utilize the inherent nutrients in the substrate. In order to acquire a good knowledge of the mushroom fruiting substrates, the nutritional contents of the substrate can be improved by the addition of some nitrogenous supplementation to the substrate

Methodology: The suitability of some locally available organic materials/wastes as yield boosters for the cultivation of Oyster mushroom *Pleurotus florida* was evaluated. Corn bran (CB), wheat bran (WB), rice bran (RB), palm kernel cake (PKC), groundnut cake (GNC), soya meal and poultry manure (PM) were separately added to sawdust from *Gmelina aborea.*

Results: Data analysis indicated significant variations among treatments in all the parameters taken. The presence of the various additives in the substrate significantly enhanced the biological efficiency (BE) of the mushroom when compared to the control ($p<0.05$). *P. florida* had its highest BE (68.74%) on sawdust added with rice bran (RB) and its least on the control (17.98%). Days to mycelium colonization were shortest on CB (23) and longest on PM (39). Shortest days to primodia initiation were observed on CB (29) and the longest on PM (48). Also, protein content in the fruiting bodies was significantly highest in substrates added with PKC (30.98) and WB (30.94) ($p<0.05$) and least in control (22.48).

Conclusion: It was evident that the inclusion of these additives significantly improved the growth, yield, and nutritional contents of the investigated mushroom. PKC and WB may be used to enhance both the yield and nutritional values of the mushroom.

Keywords: Biological efficiency, nutritional quality, organic additives, Oyster mushroom, *Pleurotus florida*

1. INTRODUCTION

Mushrooms are becoming important to human diets all over the world. Therefore, it is necessary to investigate the appropriate substrate and supplements on which they can be cultivated to maximize yield and ensure a constant supply.

Most agricultural wastes are generally incinerated in the open, with its attendant threat to the environment or dumped indiscriminately in the open. It can act as a breeding ground for vectors, and its leachate can pollute both the adjacent streams and groundwater. However, value can be added to these wastes through their use in the cultivation of edible and medicinal mushrooms, an efficient way to biologically recycle these wastes [1].

Mushrooms are cultivated on lignocellulosic materials such as maize cobs, cereal straws, cotton wastes, sugar cane bagasse, wood shavings, oil palm wastes, banana leaves, coconut pericarp, water hyacinth, cocoa pods, and sawdust [2, 3, 4, 5, 6]. One of the major factors limiting substrate colonization by mushroom mycelium is the nutrient composition and the nature of the basal medium on which it is growing. These play an important role in the fructification of the mushroom. The growth and yield of a mushroom are dependent on its ability to utilize the inherent nutrients in the substrate [7]. To acquire a good knowledge of the mushroom fruiting substrates, the nutritional contents of the substrate can be improved by the addition of some nitrogenous supplementation to the substrate [8].

Pleurotus spp, commonly called oyster mushrooms are the most successfully cultivated mushroom. They are considered as delicacy rich in protein and are highly palatable. This group of mushroom secret strong extracellular enzymes which have the potential to digest, mineralize, absorb and grow on complex organic compounds such as lignin, cellulose and hemicellulose in agro-industrial wastes [9, 10].

To acquire good mushroom fruiting substrates, the nutritional contents of the substrate can be improved by adding some nitrogenous supplements to the substrate [8]. This study was aimed at increasing the growth, yield, and biochemical composition of the fruiting bodies of *P. florida* as affected by the addition of some organic residues to its basal substrate (sawdust) as possible nitrogen sources.

2. METHODS AND MATERIALS

The Oyster mushroom, *P. florida* investigated in these research works was collected from the mushroom production unit of the Vegetable Programme of National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. The inoculum used was obtained by tissue culture of the sporocarp of the test mushroom, which was maintained on potato dextrose agar (PDA) for regular subculturing throughout the period of investigation [11].

2.1 Spawn preparation

Spawn was prepared in 200 ml capacity bottles. Sorghum grains were washed to remove dust, broken, and immature kernels, added with 20% rice bran to prevent the seeds from clogging together after sterilization, and soaked in clean water overnight. This was drained and filled in the bottles after mixing with 1% calcium carbonate. The grains were autoclaved, cooled, and inoculated with actively growing mycelium of the mushroom on potato dextrose agar slants and were incubated at (27±2)° C for mycelia growth for 15 days until the mycelium fully ramified the grains [12].

2.2 Substrate preparation

Sawdust of *Gmelina aborea* was collected from Forestry Research Institute of Nigeria, Ibadan. This was divided into portions to which 10% each of the following supplements was added, CB, WB, RB, PKC, GNC, SOYA, PM and to the control was no supplement added. Water was separately added to the various substrate mixtures to moisture content (M.C) of about 65% with calcium carbonate (1%) to adjust the pH of the substrate to 7.5. This is to ensure optimum M.C and pH for *Pleurotus spp* production [12].

2.3 Effect of substrate mixtures on mycelia growth and fruiting body production

Portions of the various substrate mixtures outlined above were filled separately in test tubes and polyethylene bags for the evaluation of the mycelia growth and fruiting body production respectively. Each treatment was replicated four times. The filled test tubes were autoclaved at 121°C for 15 minutes while the bags (300 g/bag) were pasteurized at 70°C for 6 hours according to the method of Fasidi and Ekuere [13] slightly modified by Idowu *et al*, [14]. The test tubes were autoclaved and used for mycelia growth monitor while the bags were used for fruiting body formation of the mushroom. The bags could

also have been autoclaved if there was an autoclave big enough to contain the quantity used in this research work. Pasteurizing the bags however achieved the desired result.

After cooling, both the test tubes and the substrate bags were inoculated with actively growing mushroom mycelium prepared as stated above and were both incubated at room temperature [(27±2)°C] in a dark room with sufficient ventilation for 15 and 30 days respectively. Vertical mycelium growth was observed and measured every other day for two weeks on the test tubes. At the expiration of the incubation period for the substrate bags, they were cut open on the sides without disturbing the mycelium and were sprayed with water twice a day using a hand sprayer with the bags kept undisturbed for the appearance of fruiting bodies.

Days to full colonization and appearance of mushroom primodia were taken. The fruiting bodies were harvested as they appeared and appropriate growth data were taken. Means of the data collected were compared and biological efficiency (ratio of fresh mushrooms harvested to substrate dry weight x 100) was calculated.

For the proximate analysis, freshly harvested mushroom fruiting bodies from the different treatments were dried at 80°C for two days. They were weighed, powdered in a Moulinex blender and sieved through a 450µm sieve. The final powdered samples were stored in desiccators until needed for all the analyses done. Determination of nitrogen was by the micro-Kjeldhal method. Moisture content was done according to the method of AOAC [15]. Dry mushroom sample (1g) was placed in a preweighed crucible in a muffle furnace heated gradually at 550°C and the resulting residue was weighed to determine the ash content [16]. The residues from the incinerated samples above were used for the determination of macro and micro elements contents of all the mushroom samples.

3 RESULTS

Figure 1 shows the biological efficiency of *P. florida* when different organic additives were added to its substrate to boost its growth. The presence of the various additives in the basal substrate enhanced the biological efficiency of the mushroom when compared with the control. *P. florida* had its highest BE on rice bran (RB) and its least on the control. Days to mycelium colonization were shortest on CB and longest on PM and groundnut cake (GNC). Shortest days to primodia initiation was observed on corn bran and the longest on PM.

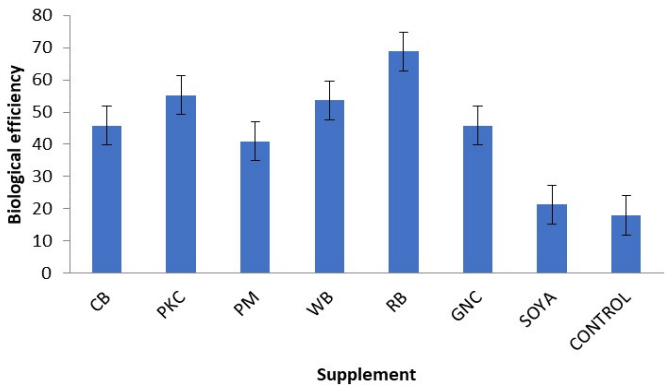

Fig 1: Effect of different additives on the biological efficiency of *P. florida*.

CB (corn bran), PKC (palm kernnel cake,) PM (poultry manure),WB (wheat bran), RB (rice bran), GNC (ground nut cake), SOYA (soy meal), and the control.

P. florida had its highest number of fruit bodies on GNC, PKC and RB respectively and the lowest was on the control. The total fruiting body yield was highest on RB and lowest on others. The widest pileus was observed on WB and PKC with the narrowest on the control. The longest stipe was obtained on PKC and the shortest was obtained on the control. The biggest fruit size was recorded on RB and smallest was on PM. The production efficiency was highest on RB and was least on the control (Table 1).

Nitrogen and protein contents of mushroom fruiting bodies harvested on supplemented substrates were higher than those from the control substrate to which no supplement was added (Table 2). Fat content was low in the mushroom fruiting bodies. *P. florida* was observed to have high ash content in its fruiting bodies.

Table 3 shows the macro-element contents of *P. florida* grown on sawdust supplemented with different organic additives. *P florida* fruiting bodies contained a high amount of all the macro-elements (potassium, sodium, magnesium, calcium, and phosphorus) tested. Its fruiting bodies were also found to contain a very high amount of virtually all the micro-elements with the exception of copper.

Table 1: Effects of different substrate additives on the growth and yield of *P florida*

Additives	Number of fruits	Total fruit weight (g)	Width of pile-us (cm)	Length of stipe (cm)	Mean fruit weight (g)	Production efficiency (%)
CB	10.43^{b}	53.89^{d}	6.07^{de}	5.27^{e}	5.18^{d}	17.65^{d}
PKC	10.86^{b}	65.07^{b}	8.81^{a}	8.11^{a}	6.01^{c}	20.74^{b}
PM	8.43^{d}	48.23^{e}	7.00^{c}	6.23^{d}	5.74^{c}	15.42^{f}
WB	9.57^{c}	63.16^{c}	8.04^{b}	7.00^{b}	6.62^{b}	19.82^{c}
RB	10.71^{b}	80.94^{a}	7.99^{b}	6.73^{c}	7.59^{a}	25.69^{a}
GNC	12.43^{a}	53.88^{d}	5.94^{e}	5.04^{f}	4.34^{e}	16.56^{e}
SOYA	6.86^{e}	25.05^{f}	6.27^{d}	5.24$^{e\,ff}$	3.66^{f}	8.05^{g}
CONTROL	3.29^{f}	21.17^{g}	5.61^{f}	4.84^{g}	4.03^{e}	6.48^{h}

Means followed by the same superscript letter(s) in each column are not significantly different (P>0.05) according to DMRT.
CB (corn bran), PKC (palm kernel cake,) PM (poultry manure), WB (wheat bran), RB (rice bran), GNC (groundnut cake), SOYA (soy meal), and the control.

Table 2: Effects of different nitrogen additives on the proximate contents of *Pleurotus florida*

TRT	PRO-TEIN (%)	FAT (%)	MOIS-TURE (%)	ASH (%)
CB	27.36^{c}	1.27^{de}	7.16^{bc}	14.01^{a}
PKC	30.98^{a}	1.51^{d}	6.63^{c}	13.36^{b}
PM	29.17^{b}	1.39^{d}	8.04^{a}	13.68^{b}
WB	30.94^{a}	2.31^{bc}	6.83^{c}	11.70^{d}
RB	29.20^{b}	2.23^{c}	6.89^{c}	13.04^{b}
GNC	29.07^{b}	2.65^{b}	7.43^{b}	12.22^{c}
SOYA	28.72^{bc}	3.07^{a}	7.16^{bc}	12.55^{c}
CONTROL	22.48^{d}	1.01^{e}	6.97^{c}	14.31^{a}

Means followed by the same superscript letter(s) in each column are not significantly different (P>0.05) according` to DMRT.CB (corn bran), PKC (palm kernnel cake,) PM (poultry manure),WB (wheat bran), RB (rice bran), GNC (groundnut cake), SOYA (soy meal), and the control.

4. Discussion

In nature, *Pleurotus sp* mostly grow on the dead part of plants which are generally poor in nutrients and vitamins [5]. It has been established that both mycelia growth and fruiting body development depend on lignocellulosic materials, particularly the carbon: nitrogen ratio (C:N) which has been reported to be 50:1 in various substrates [12].

In this present study, the supplementation of the basal mushroom substrate (sawdust) with the various organic additives enhanced the biological efficiency, production efficiency and mycelia growth of *P.florida* when compared with the control. This is necessary because the nitrogen content in most of the substrates employed for mushroom cultivation ranges between 0.5 and 0.8% [17, 18]. Hence the addition of nitrogen sources to the sub-

Table 3: Effects of different nitrogen additives on Macro and micro nutrient contents of *Pleurotus florida* fruiting bodies

Treatment	K (%)	Na (ppm)	Mg (%)	Ca (%)	P (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)
CB	2.66^{a}	92.85^{b}	0.33^{a}	0.16^{ab}	1.79^{c}	44.75^{b}	69.75^{b}	0.77^{cd}	117.12^{b}
PKC	2.56^{ab}	78.01^{e}	0.32^{a}	0.15^{b}	1.93^{a}	34.19^{d}	74.16^{a}	0.61^{d}	120.33^{b}
PM	2.61^{a}	83.43^{d}	0.33^{a}	0.13^{bc}	1.86^{b}	39.47^{c}	71.93^{ab}	0.69^{d}	118.39^{b}
WB	2.22^{bc}	100.62^{a}	0.30^{b}	0.18^{a}	1.73	51.43^{a}	67.96^{c}	1.32^{b}	100.07^{d}
RB	2.43^{b}	89.43^{bc}	0.28^{bc}	0.16^{ab}	1.76^{cd}	28.77^{e}	65.77^{c}	1.14^{b}	106.38^{c}
GNC	2.56^{ab}	85.22^{cd}	0.31^{ab}	0.15^{b}	1.74^{d}	43.09^{b}	68.32^{bc}	0.82^{c}	107.85^{c}
SOYA	2.61^{a}	87.08^{c}	0.34^{a}	0.16^{ab}	1.69^{de}	40.22^{bc}	70.47^{b}	1.11^{bc}	115.18^{b}
CONTROL	2.61^{a}	80.85^{de}	0.29^{b}	0.16^{ab}	1.01^{e}	51.41^{a}	66.54^{c}	1.73^{a}	154.44^{a}

Means followed by the same superscript letter(s) in each column are not significantly different (P>0.05) according to DMRT.
CB (corn bran), PKC (palm kernnel cake,) PM (poultry manure),WB (wheat bran), RB (rice bran), GNC (groundnut cake), SOYA (soy meal), and the control.

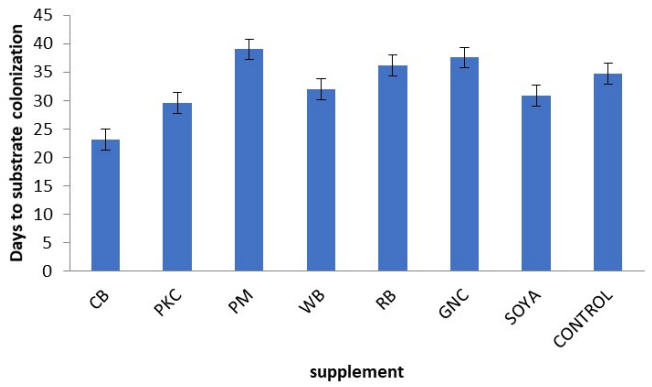

Fig 2: Effect of substrate additives on number of days to substrate colonization of *P. florida*

CB (corn bran), PKC (palm kernel cake,) PM (poultry manure),WB (wheat bran), RB (rice bran), GNC (groundnut cake), SOYA (soy meal), and the control.

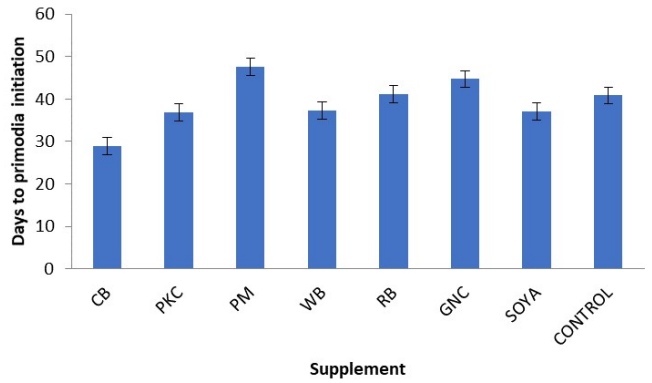

Fig 3: Effect of substrate additives on number of days to appearance of *P. florida:*

CB (corn bran), PKC (palm kernnel cake,) PM (poultry manure),WB (wheat bran), RB (rice bran), GNC (groundnut cake), SOYA (soy meal), and the control

strates resulted in higher mushroom yield.

The addition of RB increased significantly the biological and production efficiencies and all the growth characters evaluated for *P. florida*, a result consistent with the findings of Naraian *et al*., [5] who reported that during the cultivation of *P. florida* on maize cobs, the addition of soya meal as supplement to the maize cob substrate increased the biological efficiency by 93%.

Biological and production efficiencies of *P. ostreatus* was also found to increase most when palm kernel cake was used to supplemnt its sawdust substrate. This result is also in line with the findings of Fanadzo *et al.,* [19], Naraian *et al.,* [5] and Domondon *et al.,* [20], whose report indicated that the supplementation of wheat straw with cotton seed hull, increased the BE of *P. ostreaus,* cotton seed cake improved the yield of *P. florida* and grass chaff was found to boost the BE in the cultivation of *Stropharia* spp and oyster mushroom respectively. Idowu and Kadiri, [14] also reported a biological efficiency of up to 58.37% of *P. pulmonarius* grown on sawdust supplemented with PKC which is also in consonance with our findings. *P. florida* also recorded its highest yield, mycelia growth, production and biological efficiencies when RB was added to its basal substrates as a supplement.

This result is at variance with the finding of Gautam and Ram [21] who reported that the addition of WB to wheat straw during the cultivation of *P. florida* was significantly superior to the result obtained when rice bran was added to the same wheat straw substrate. This result could suggest that the use of wheat straw as a basal substrate might have boosted the performance of the mushroom as wheat straw is known to be richer in nutrients than sawdust.

The enhanced performance of all these mushrooms when their basal substrates were supplemented with organic residues suggests that the availability of several amino acids and protease as well as transaminase activities in these supplements boosted their performance.

Boosting sawdust substrate with the following nitrogen supplements CB, PKC, PM, WB, RB, GNC, and SOYA at a ratio of 1: 10 (supplement to sawdust) caused significant changes in the nutritional and chemical composition of mushrooms produced. This is in agreement with the findings of Banik and Nandi, [22] who reported a significant change in the nutrient composition of *Pleurotus sajor-caju* grown on spent rice straw compost supplemented with cotton seed powder.

4.1. Conclusion

Addition of RB to sawdust medium induced highest yield of *P. florida.* In terms of fruiting body yield, with saw dust as the basal substrate for all treatments, the yields are in the order RB > PKC > WB > GNC > PM > SOYA. Looking at the fruiting body qualities; for protein content, PKC > WB > RB > PM > SOYA > CB. Generally, all treatments perfomed significantly higher that control in terms of fruiting body yield, protein and fat content suggesting that mushroom growth and fruiting body yield can be improved by adding organic supplements to the basal substrate.

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Conflict of Interest

The Authors declare that there is no conflict of interest.

Authors Contribution

OOI , CAO, OAA: Conceived and designed the research. contributed to the writing of the paper. **OOI and CAO:** collected the data. **OOI:** Analyzed the data. All authors approved the final version of the manuscript

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