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Evaluation of Three Organic Agricultural Wastes as Substrates for Cultivation of Mushroom (*Pleurotus Tuberregium* Fr.)

[1] Okafor Maryrose Chikaosolu, [2] Okigbo Raphael Nnajiofor
[1, 2] Department of Botany, Biological Sciences, Nnamdi Azikiwe University, Awka, Nigeria

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Corresponding Author: **Okafor Maryrose Chikaosolu**

Abstract
Evaluation of three organic agricultural wastes as substrates for cultivation of mushroom (*Pleurotus tuberregium* Fr.) was investigated in this study. *Pleurotus tuberregium* was cultivated using three substrates viz 80% saw dust and 20% cassava peels (A), 80% saw dust and 20% yam peels (B) and 80% saw dust and 20% rice bran (C) to determine the substrate with highest growth and yield. The methods used were processing of the organic wastes, bagging, sterilization, inoculation of the spawn, incubation, cropping, watering and harvesting. All treatments for the experiment were laid out using a Completely Randomized Design (CRD) with the three treatments replicated four times. Means were analyzed statistically using (ANOVA) to test for significance. Means were separated using Duncan's New Multiple Range Test (DNMRT) using Statistical Analysis System (SAS) software. The result revealed that there were significant differences ($P < 0.05$) in the stipe girth of the mushroom under different substrates at 2.433 ± 0.60^{a} for substrates A, 2.883 ± 0.85^{b} for substrate B and 3.850 ± 0.86^{c} for substrates C. There was no significant difference ($P > 0.05$) in the stipe height between substrate A and substrate B but showed significant difference in substrate C at 7.033 ± 0.95^{b}. The pileus girth showed significant difference ($p < 0.05$) in substrates C at 22.804 ± 1.57^{b} and no significant difference in substrate A and Substrate B. The study revealed that though there were growth in all the three substrates but substrate C gave highest growth parameters and yield.

Keywords: Mushroom, Cultivation, Organic Wastes, Spawn, Growth and Yield

Introduction

Agricultural wastes are defined as the residues from the growing and processing of raw farm products such as vegetables, fruits, meat, poultry, dairy products, and crops [1]. Agricultural wastes also comprises of leaves, peels from starchy crops like cassava, yam, potatoes, and coco yam. A typical Nigerian cannot do without carbohydrate food daily, such as garri, akpu, fried and boiled yam, rice and in processing of these food, agricultural wastes are generated. One of the major causes of environmental pollution is agricultural wastes, which are found in abundance in our surroundings. Mostly they are disposed by means of incineration which causes air pollution and natural composting which causes land pollution [2].

Mushroom "Elo" in Igbo language of Nigeria, is a plump spore producing fruit body, which naturally grows above the soil or in its food sources [3]. Mushroom are saprophytic in nature with conspicuous fruiting body which may be either epigeous or hypogenous and are big enough to be picked or harvested [4]. As a fungus, mushrooms do not have chlorophyll like green plants for producing their food but can be found flourishing on lifeless natural substances like wood, rice straw, plantain leaves and orange leaves and natural composting which causes land pollution [5].

There are millions of mushroom species in the world that grow in the wild forest and they are classified into two groups, namely, the edible mushroom and non edible mushroom (toadstools) [6]. The non poisonous mushrooms such as *Pleurotus* species, *Araucaria auricate* and *Calvata cyathiteries* normally found in Nigeria is extremely rich in proteins, crude fibre, minerals, vitamins, and carbohydrates while the non edible mushrooms are poisonous which include *Amanita photodiodes*, *Amanita verna*, and *Celeriac marginal* [7].

Oyster mushroom is the primary mushrooms in terms of both consumer favorite and production globally due to its ease and little price of its cultivation technology [8]. Many organic wastes have lofty potential for use as substrates in mushroom farming [9, 10]. Mushroom production may possibly take part in a significant role in managing farm organic wastes when agricultural and food processing by-products were used as growing media for edible mushroom [11]. Mushroom (*Agaricus bisporus*) has been

cultivated in most forest areas using peeling of cassava and yam peels but yields from the substrates have been low and inconsistent [12]. Mushroom farming requires suitable nitrogen substance for big output which can be fulfilled by different constituents such as bran, urea, sunflower seed, molasses and horse manure [13]. One of the principles of commercial farming of mushrooms, mainly in a rising economy like Nigeria, is the accessibility of huge amount of several agro-industrial wastes which conserve as substrates for the cultivation of mushrooms [14]. There is need to test the production of oyster mushroom in different substrates [15]. Yam and cassava peels should be augmented with sufficient minerals to support the growth and yield of *Pleurotus tuberregium* [16].

Most type of *Pleurotus species* demonstrate excellent flexibility to a large variety of hotness, rendering it promising to produce this fungus all through the year devoid of restricted atmospheric conditions. Despite that more than 200 species of edible mushrooms have been used for functional foods worldwide for a long time, only about 35 species have been commercially cultivated [17].

Mushrooms contain bioactive substances that are effective against cancer, cholesterol reduction, stress, insomnia, asthma, and diabetics [18]. Due to elevated quantity of proteins in mushrooms, it can be used to aid the protein undernourishment breach [19]. People are looking for alternate means of protein, consequently of health challenges and high cost of living, people these days can hardly afford meat, while the once that can afford have one or other health challenges making meat unfit for them [19]. Moreover, cultivation of indigenous type of non-poisonous and therapeutic mushrooms has become extremely vital in order to stop them from extinction generated by haphazard forest burning, industrization and deforestation [20].

Mushroom in Africa have been exploited for their medicinal benefits, nutritional benefits (food), economical and environmental as well as ecological benefits [21]. Studies done on the implementation of mushrooms as sources of minerals (iron, calcium and phosphorus), vitamins (B, C and D) and treatment of certain diseases of mankind such as cancer, asthma, coughs and diabetes in some parts of Nigeria [22]. *Pleurotus ostreatus* produces medicinal and pharmacological metabolites of antimicrobial, immune stimulant, antioxidant and antitumor interest [23]. This source of healthy alternative to food, medicine and unemployment is weighed down with diseases and pests [21]. Cultivation of mushroom with agricultural wastes is a phenomenon whereby waste that is nuisance to the environment is converted to useful product. Currently, several agricultural debris are produced in Nigeria which are inefficiently employed and growing of *P. tuberregium* on them for valuable running and use is good [24].

In spite of nutritional, economic and health benefit of mushroom to us, growing of mushroom on a high level is still exceedingly small and the majority of the mushrooms eaten by the public are harvested from their natural habitat [25]. The low or non-availability of mushroom in Nigeria and Africa in large is as a consequence of poor technical and infrastructural support from national and international agencies on its production, scarcity of mushroom scientists, and poor knowledge of mushroom diversity amid others [26]. This may possibly also be credited to the fact that commercial cultivation and production of high-quality edible mushrooms like *Pleurotus* and *Agaricus* genera have not been considered by Nigerian farmers, rather, there is high dependence on its natural occurrence which is limited in supply whereby local mushrooms are still being sought for in bushes and farms for eating and vending [27].

Hence, having critically reviewed some literature of past work on cultivation of mushroom with some agricultural wastes, there is need to cultivate and evaluate the growth and yield of oyster mushroom using the three organic agricultural waste that are persistently increasing in our environment. Moreso, as an answer to low or non-availability of mushroom in Nigeria, there is therefore a growing effort aimed at promoting the growing of mushroom locally by Nigerian farmers. This is in view with its potential contribution especially to rural dwellers to agricultural production and the nation's endowment with good quality mushroom which should be mass produced for local consumption and export. Another important reason why the marketable production of mushroom should be given attention is its capability to produce on agricultural and industrial wastes which can be recycled into food while also making the environment less endangered by pollution.

The aim of this study is to evaluate three organic agricultural wastes as substrates for cultivation of oyster mushroom (*Pluerotus tuberregium* Fr.). The Objectives of the Study: To evaluate the growth of *pluerotus tuberregium* using 20% cassava peels and 80% saw dust, 20% yam peels and 80% saw dust and rice bran 20% and 80% saw dust as planting substrates for mushroom production. To determine the yield of *Pleurotus tuberregium* using 20% cassava peels and 80% saw dust, 20% yam peels and 80% saw dust and rice bran 20% and 80% saw dust as planting substrates for mushroom production. To ascertain the substrate with great potential for the growth and yield of *Pleurotus tuberregiu.*

Materials and Method

Sample Collection

The organic wastes used for growing the mushroom (*Pleurotus tuberrgium* Singer.) in this work were cassava (*Manihot esculenta* Crantz.) peels, yam (*Dioscorea rotundata* Poir.) peels, rice (*Oryza glaberrima* Steud.) bran and saw dust. The cassava (*Manihot esculenta*) peels and yam (*Dioscorea rotundata*) peels were obtained from farms in Ifite Awka while the spawn also known as "seed" of mushroom, the saw dust and rice (*Oryza glaberrima*) bran were obtained from Dilomat Research Farm, Rivers State University of Science and Technology.

Processing of the Organic Wastes Used in the Growing of the Mushroom (*Pleurotus tuberregium*)

The cassava (*Manihot esculenta)* peels and yam (*Dioscorea rotundata*) peels were sorted to remove pieces of sticks and non-biodegradable materials. They were properly dried in an open space under sun at about 36°C for two weeks. The dried cassava (*Manihot esculenta)* and yam (*Dioscorea rotundata*) peels were later ground into fine powder using Okigbo *et al*., (2020) method.

The saw dust was also physically examined to remove sticks and non-biodegradable materials like plastics and pieces of metals and mixed together.

- Then 8 kg of saw dust was measured out in three places using Defender 2000 Bench Scale (USA).
- Two kg each of cassava peels, yam peels and rice bran were also measured out respectively using Defender 2000 Bench Scale (USA).

- Then saw dust and cassava peels were mixed in the ratio of 8 kg for saw dust and 2 kg for cassava peels to form **substrate A** (8:2).
- The same ratio of 8 kg of saw dust was mixed with 2 kg of yam peels to produce **substrates B** (8:2).
- Also 8 kg of saw dust was mixed with 2 kg of rice bran to get **substrate C** at (8:2) ratio.

Each of the three substrates were mixed thoroughly using shovel and hand trowel, about two Litres of water was added while mixing to make the substrates moist but not over wet. In composting, the substrates were partially composted for 4 weeks to allow decomposition for quick release of nutrients [25].

Bagging/ Casing

The method used for bagging/casing [28]. Each of the substrates, substrate A (saw dust and cassava peels), substrate B (saw dust and yam peels) and substrate C (saw dust and rice bran) were packaged individually into 20 cm width by 30 cm length heat-resistant polythene bags using hand trowel. The substrates were well compressed into the bags by using the hand applying pressure while hitting it on the ground during packaging. The bags were well compacted during the bagging for easy spawn penetration and colonization.

The substrates were properly labeled with masking tape and indelible marker immediately after packaging.

Each substrate was randomized and replicated four times. After the packaging the substrates were ready for sterilization.

Sterilization of Substrates

The substrates were sterilized locally before they were used to grow the mushroom (*Pleurotus tuberregium)*. This was done by subjecting the substrates to intense heat to destroy contaminants in the substrates by using 200 L of metallic drum and firewood. The fire wood was set up and the drum placed on top of the tripod stand. The drum has a layer for easy standing of the substrates in readiness for sterilization. One-quarter of the two hundred Litres of metallic drum was filled with water; the level of the water was slightly below the layer. The samples were arranged in the drum and covered before setting the fire on. It was heated at temperature of 100 °C for 6 hours. This was painstakingly done in other to provide aseptic condition for the running of the spawn for growing of the mushroom (*Pleurotus tuberregium)*. The fire was put off by removing the firewood after 6 hours of heating. The samples were allowed to cool to temperature of about 30℃ in the 200 L Metalic drum before removing it. The substrates were taken to the inoculation room in readiness for inoculation or planting of spawn.

Inoculation and Incubation

The method used to inoculate and incubate the spawn [28]. The inoculation was carried out in inoculation room of about 18.10 x 30.50 x 6.20 m at 25℃. Inoculation were done in well sterilized area; high sanitation is maintained during inoculation by sterilizing the laboratory bench, the spatula and hands with 70% ethanol and covering of the nose with nose mask to avoid contamination of the spawn. The spawn were scoop out from the bottle using the spoke because they were congealed in the container. Forty grammes of spawn were measured out using Camry Digital Scale (USA). Forty grammes of spawn were planted in the substrates by sparsely spreading it evenly on the substrates. The Spawn (guinea corn covered by hypae of *Pleurotus tuberregium* in a bottle) also known as the seed of mushroom from Dilomat Farm were introduced (planted) into the sterilized substrates and closed air tight to prevent any form of contamination to the mycelia growth. After spawn inoculation, the substrates were covered with sterile foam material and sealed air-tight with rubber bands. Inoculated substrates were kept in the incubation room for the development of the mycelia. The humidity and temperature of the room were maintained by the LG air-conditioner (India). The incubation room was also free from light. The inoculated substrates lasted for about six weeks in the incubation room. At the end of six weeks of incubation, some samples were partially colonized while some were fully colonized. The samples were ready for cropping where it will be given the right environment for the development of pinhead and sporophore.

Cropping

The partially and fully colonized bags were taking to the crop house. The crop house was well ventilated for easy entry of air. The crop house windows were covered with black nylon for regulating light passage. All the samples were arranged in a metal rack in readiness for watering to maintain the humidity of the house. The mouth and bottom of the bags were cut open using surgical blade for easy passage of water during watering. The samples were well watered morning and evening by sprinkling water through the mouth and bottom using hose. The mouth of the hose was partially covered with hand during watering to decrease the pressure of the water, so that the bags will be well watered. Watering is needed to induce flush of pinhead and for fruitification. Pinhead developed after four (4) days of watering in some samples. Some of the pinheads were ready for harvest after 10 days of watering.

Subsequently, harvesting of sporophores was carried out every four (4) days for 5 times.

Harvesting of Mushroom (*Pleurotus tuberregium*)

The method used in harvesting; the sporophores were harvested when they were ten days after sprouting. This was done manually by placing one of the index fingers on the surface of the bag (to prevent premature sporophore from coming out of the bag) and with the other hand holding the base of the stipe, the sporophore is twisted and pulled out from the bags [20]. A soft brush was used to remove substrates that came out with the sphorophore, and then the sporophores were put into a plastic basket and taken to the laboratory for analysis.

Examination of Sporophores

The sporophores were examined in quadripulate noting the following parameters; stipe height, stipe width, pileus diameter, fresh weight and dry weight to determine the growth and the yield of the different substrates. The stipe height, the stipe width and the pileus diameter were determined using a thread and ruler.

The fresh weight and the dry weight were measured using the Camry Digital Scale (USA). To get the fresh weight the, sporophores harvested from the individual three different substrates were directly placed on the Camry Digital Scale (USA) respectively and their values were gotten and recorded immediately in a notebook. After measuring and recording of the fresh weight, the sporophores from the three different substrates were put in three separate trays and labeled. The three labeled trays were taking to the drying room for drying in other to get the dry weight. They were

dried for twelve hours. The dried mushrooms were taking back to the laboratory, measured and recorded as the dry weight using a Camry Digital Scale (USA).

Statistical Analysis

All treatments for the experiment were laid out using a completely randomized design (CRD) with the three treatments replicated four times. Data collected from the examination of the sporophore were subjected to analysis of variance (ANOVA). Variables for which significant treatment effects found were characterized further using Duncan's New Multiple Range Tests (DNMRT) at 5% level of significance. The analysis was carried out using Statistical Analysis System (SAS) software (2020).

Results and Discussion

Growth parameters of *Pleurotus tuberregium* mushroom under different substrates

Table 1 revealed the mean stipe girth of the sporophore harvested from the three substrates A, B and C. It showed that substrates C had the highest stipe girths all through the period of the study with the highest mean of 4.0 ± 0.85 cm of stipe girth in week 4, followed by 3.9 ± 0.73 cm in week 2 and week 3, 3.7 ± 0.48 cm in week 1 and week 6 and 3.6 ± 0.48 cm lowest stipe girth in week 5. Moreso, substrates B and substrates a showed highest stipe girth of 3.3 ± 0.73 cm and 2.8 ± 0.55 cm in week 6 respectively.

Table 1: Mean Stipe Girth of the three Substrates (A, B and C)

Harvest Time	Mean Stipe Girth of the Substrates (cm)		
Weeks	Substrate A	Substrate B	Substrates C
1	2.1 ± 0.50	2.7 ± 0.57	3.7 ± 0.48
2	2.6 ± 0.33	2.7 ± 0.38	3.9 ± 0.73
3	2.4 ± 0.30	2.7 ± 0.73	3.9 ± 0.60
4	2.6 ± 0.65	2.8 ± 0.90	4.0 ± 0.85
5	2.6 ± 048	2.9 ± 0.53	3.6 ± 0.48
6	2.8 ± 0.55	3.3 ± 0.73	3.7 ± 0.80

Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

Table 2: Mean Stipe Height of the three Substrates (A, B and C)

Harvest Time	Mean Stipe Height of the Three Substrates (cm)		
Weeks	Substrate A	Substrate B	Substrate C
1	4.3 ± 0.75	4.6 ± 0.60	7.0 ± 0.68
2	4.3 ± 0.90	5.5 ± 0.20	7.2 ± 0.85
3	4.4 ± 0.73	4.9 ± 0.48	6.9 ± 0.83
4	4.5 ± 0.70	4.7 ± 1.25	6.8 ± 0.13
5	6.2 ± 1.22	5.1 ± 0.9	7.7 ± 0.68
6	4.5 ± 1.05	6.1 ± 1.08	6.6 ± 0.98

Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

Table 2 showed the mean stipe height of sporophore harvested from the three substrates. Table 2 also demonstrated that substrate C had the highest mean sitpe heights in the course of this study, with 7.7 ± 0.68 cm mean stipe height recorded in week 5 and lowest mean stipe height of 6.6 ± 0.98 cm recorded in week 6. Moreover, substrate B and substrates A showed the highest stipe height of 6.1 ± 1.08 cm and 6.1 ± 1.22 cm in week 5 and week 6 with lowest stipe height of 4.6 ± 0.60 cm and 4.3 ± 0.75 cm recorded in week 1.

Table 3 revealed the mean pileus girth of the sporophore harvested from the substrates. It was observed that substrate C gave the highest pileus girth of 25.3 ± 1.5 cm in week 4 and lowest pileus girth of 21.6 ± 0.88 cm in week 5. While substrate B and substrate A had highest pileus girth of 21.0 ± 0.83 cm and 20.9 ± 0.50 cm in week 3 and week 6 and lowest pileus girth of 20.1 ± cm and 19.0 ± cm in week 1and week 6 respectively.

There were significant differences ($P < 0.05$) in the Stipe girth of the mushroom under different substrates according to Table 4. Table 4 also revealed that there was no significant difference ($P > 0.05$) in the stipe height between substrate A (Saw dust and Cassava Peels) and substrate B (saw dust and yam peels) but showed significant difference ($P < 0.05$) in substrate C (saw dust and rice bran).

The pileus girth showed significant difference ($P < 0.05$) in substrate C and no significant difference ($P < 0.05$) in substrate A and Substrates B.

Table 3: Mean Pileus Girth of the three Substrates (A, B and C)

Harvest Time	Mean Pileus Girth of the Three Substrates (cm)		
Weeks	Substrates A	Substrates B	Substrates C
1	20.1 ± 0.80	20.6 ± 0.80	22.3 ± 0.58
2	20.8 ± 1.25	20.6 ± 0.38	22.4 ± 0.95
3	21.0 ± 0.83	19.0 ± 1.15	22.6 ± 0.95
4	20.8 ± 0.75	19.1 ± 1.65	25.3 ± 1.5
5	20.2 ± 0.85	20.2 ± 0.68	21.6 ± 0.88
6	20.1 ± 0.98	20.9 ± 0.50	22.6 ± 0.30

Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

Table 4: Effect of different substrates on the growth parameters of *P. tuberregium*

Substrates	stipe Girth	Stipe Height	Pileus Girth
A	2.433 ± 0.60^{a}	4.675 ± 1.03^{a}	20.083 ± 1.30^{a}
B	2.883 ± 0.85^{b}	5.135 ± 1.13^{a}	20.467 ± 1.29^{a}
C	3.850 ± 0.86^{c}	7.033 ± 0.95^{b}	22.804 ± 1.57^{b}

Values followed by the same letter (s) in a row are not significantly different from each other using Duncan Multiple Range Test at 0.05 levels.
Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

Yield of *Pleurotus Tuberregium* from the Three Substrates

Table 5 revealed that there were significant differences ($P < 0.05$) in the fresh weight of the harvested sporophores in substrate A (saw dust and cassava peels), substrate B (saw dust and yam peels) and substrate B (saw dust and bran) in week 1. In week 2 and week 6, there were also significant differences ($P < 0.05$) in all the substrates. There was no significant difference ($P > 0.05$) in substrates A and C but showed significant difference ($P < 0.05$) in substrate B in week 3. Table 4 also revealed that in week 4 and week 5 substrates A and B showed no significant difference ($P > 0.05$) but substrates C showed significant difference ($P < 0.05$).

Table 6 showed the dried weight in week 1 substrate A (saw dust and cassava peels) showed significant difference ($P < 0.05$) while substrates B (saw dust and yam peels) and C

(saw dust and rice bran) showed no significant difference (P > 0.05). In week 2 and week 3 there were significant differences (P < 0.05) in all the substrates. In week 4, week 5 and week 6 there were no significant differences in substrates A and B but substrates C showed significant difference.

Table 5: Fresh Weight of *Pleurotus tuberregium* harvested from the three substrates

Harvest Time	Fresh Weight of *Pleurotus tuberregium* (g)		
Weeks	Substrates A	Substrates B	Substrates C
1	5.8 ± 0.80[a]	6.0 ± 1.10[b]	6.8 ± 0.90[c]
2	6.4 ± 1.10[a]	4.0 ± 0.90[b]	6.0 ± 1.10[c]
3	5.0 ± 0.50[a]	4.4 ± 0.63[b]	5.0 ± 1.00[a]
4	4.5 ± 0.75[a]	4.5 ± 0.53[a]	7. 0 ± 0.75[b]
5	5.9 ± 1.13[a]	5.8 ± 0.80[a]	6.6 ± 1.30[b]
6	6.3 ± 0.50[a]	5.3 ± 0.75[b]	7.3 ± 1.50[c]

Values followed by the same letter (s) in a column are not significantly different from each other using Duncan Multiple Range Test at 0.05 levels.
Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

Table 6: Dry Weight of *Pleurotus tuberregium* harvested from the three substrates

Harvest Time	Dry Weight of *Pleurotus Tuberregium* (g)		
Weeks	Substrate A	Substrate B	Substrate C
1	1.1 ± 0.23[a]	1.2 ± 0.35[b]	1.2 ± 0.30[b]
2	1.2 ± 0.43[a]	0.7 ± 0.18[b]	1.1 ± 0.30[c]
3	0.8 ± 0.10[a]	0.7 ± 0.15[b]	1.0 ± 0.15[c]
4	0.7 ± 0.23[a]	0.7 ± 0.15[a]	1.2 ± 0.43[b]
5	1.1 ± 0.35[a]	1.1 ± 0.25[a]	1.2 ± 0.45[b]
6	1.2 ± 0.30[a]	1.2 ± 0.35[a]	1.5 ± 0.62[b]

Values followed by the same letter (s) in a column care not significantly different from each other using Duncan Multiple Range Test at 0.05 levels.
Substrate A: Mushroom cultivated on Saw Dust and Cassava Peels.
Substrate B: Mushroom cultivated on Saw Dust and Yam Peels.
Substrate C: Mushroom cultivated on Saw Dust and Rice Bran.

In this study, *Pleurotus tuberregium* also known as king tuber oyster mushrooms was successfully grown using three different substrates, saw dust and cassava peels (A), saw dust and yam peels (B), and saw dust and rice bran(C). The results obtained in this research showed that substrates C produced *Pleurotus tuberregium* with highest mean stipe girth of 4.0 ± 0.85 cm, highest mean stipe height of 7.7 ± 0.68 cm and highest mean pileus girth of 25.3 ± 1.5 cm. Substrate B produced higher mean stipe girth of 3.3 ± 0.73 cm, high mean stipe height of 6.1 ± 1.08 cm and high mean pileus girth of 20.9 ± 0.50 cm while substrate A gave high mean stipe girth of 2.8 ± 0.55 cm, higher mean stipe height of 6.2 ± 1.22 cm and higher mean pileus girth of 21.0 ± 0.83 cm. The above result agreed with the work of Ukioma and Ogbonnaya, Hassan *et al.* Which stated that farm wastes were good sources of media for mushroom growth, improving soil structure and enhanced quick release of nutrients to the soil [29, 11]. The work is also in support with Ab Rhaman *et al*. studies, which concluded that the exploitation of agricultural biomass or wastes as sources of mushroom substrates offers suitable ways to overcome the excess waste in the agriculture field [30].

This study demonstrated that *P. tuberregium* showed a preference for saw dust and rice bran substrate with regard to stipe girth, stipe height, pileus girth of the mushroom, fresh and dry weight over the saw dust and cassava peels, and saw dust and yam peels substrates. This research work agreed with the study of Moyin-Jesu, which reported that sawdust and rice bran efficiency as substrate for the production of mushroom could be credited to the fact that they were left to ferment before using it to cultivate the mushroom [25]. Moreover the natural wastes or food media used for growing the mushrooms were well sterilized and this described why there were development and yield in all the media and this supports the study of Moyin-Jesu, which recorded that food media used for the mushroom cultivation were heated very well in other to kill all the microbes and this attributed to increased spawning rate, weight, crown width and stalk length than those in the control treatment which was not sterilized [25]. The results also approved the work of Paul, which delineated that substrates used for mushroom cultivation should be decontaminated or autoclaved in order to wipe out any fungal or bacterial contenders [31]. This work also concurred with Hassan *et al.* study, who reported that pasteurization of maize stalks/cobs, paddy straw, and vegetable plant wastes enlarged appreciably the stalk diameter, stalk weight, and fresh weight of fruiting bodies of Oyster mushroom (*Pleurotus ostreatus*) [11]. The work is also in support of Okigbo *et al.* which reported that there was no growth observed in yam peels and cassava peels when used alone, due to inhibitory effects of pathogens present in the substrates which might have caused antagonistic effects on the growth of *P. tuberregium* because of lack of proper sterilization, but there was growth in this study because the substrates were well sterilized [21].

This work disagrees with the discovery of Okigbo *et al.* which reported that *P. tuberregium* did not grow in yam peels and yam peels and loamy soil substrates but there were development and sporophore production of *P. tuberregium* in yam peels and saw dust [32]. The study also disagreed with the study of Okigbo *et al.* which reported that there were no growth in cassava wastes and yam residues but agrees with the recommendation of Okigbo *et al.* that cassava residues and yam wastes should be supplemented with adequate nutrient in order to support the development and output of *P. tuberregium* as supplemented with saw dust in the experiment [16]. Many researchers have also shown the necessitate for enhancement of nitrogen-poor food media with wheat, rice bran or soybean bran or to mix diverse straws or grasses for *P. tuberregium* cultivation [33-34].

The major reason for *P. tuberregium* cultivation is sporophore production. This recent work divulges that the output was affected respectively by the different substrates used in cultivation. In general, substrate C that gave highest yield also recorded highest stipe girth, stipe height and pileus girth.

Conclusion

The outcomes obtained in this current study indicate that the performance and productivity of the *Pleurotus tuberregium* were vastly affected by the substrates from which it was produced. The study reveals that though there were growth in every one of the three substrates but substrate C (saw dust and rice bran) gave highest yield and recorded highest stipe

girth, stipe height and pileus girth. Therefore saw dust and rice bran substrate are suggested and recommended to mushroom farmers for high yield production. Also for the moment, saw dust, rice bran, cassava peels and yam peels are readily available agro-industrial waste posing several environmental challenges and so, its exploitation for the cultivation of mushroom will therefore facilitate to extensively address the problem of its management.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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