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Evaluation of Yield and Nutritional Composition of Oyster Mushroom *(Pleurotus ostreatus)* Grown on Different Substrates

***O.J. Olujobi and E. A. Adeniji**

Department of Forest Resources and Wildlife Management, Ekiti State University, P.M.B. 5363, Ado-Ekiti, Nigeria.
[*Corresponding Author: E-mail: olujobioj@yahoo.com; ☎: +2348038079501]

ABSTRACT

This study examined the yield and nutritional composition of oyster mushroom (*Pleurotus ostreatus*) grown on different substrates. The experiment consisted of six treatments viz: Sawdust, Coconut-husk, Maize-cob, Maize-cob + Sawdust, Coconut-husk + Maize-cob and Sawdust + Coconut-husk. Each substrate was moistened and left for 12 hours. Thereafter, 1 % $CaCO_3$ and 5 % wheat bran were added to 600g of each substrate. The substrates were divided into three of 200g each. The replicates were placed inside polythene bags of size 15 x 35 and steam sterilized at 121ºC for 20 minutes in an autoclave. Sterilized substrates were inoculated with Pleurotus spawn inside the polythene bag and then air-tight sealed with a rubber band. The substrates were kept in the darkroom at 25 ºC to ramify. The ramified substrates were kept moist for the mushroom to sprout. The result revealed that mushroom produce on sawdust substrate gave the highest yield on a fresh weight basis (16.67 ±1.20g). While sawdust + coconut-husk performed best in terms of nutritional composition with 14.00 % ash, 2.63 % protein, 42.87 % carbohydrates, 2.70 % calcium, and 650 %phosphorus. In conclusion, the quantity of mushroom produced was highest in sawdust while sawdust with coconut-husk produced mushroom with the highest nutritional quality. The study recommends sawdust for commercial production of oyster mushroom and sawdust + coconut-husk for optimum nutritional benefits.

Keywords: *Growth, N*utritional composition, Pleurotus ostreatus, *S*ubstrates, *Yield.*

INTRODUCTION

The increase in population coupled with an inadequate supply of food, diminishing quality of health and increasing environmental degradation due to careless disposal of wastes generated in towns and cities are some of the key underlying problems affecting humankind (Girmay *et al*. 2016). One important aspect of mushroom cultivation is that it helps sustain society through the creation of employment. Mushroom cultivation involves providing the right environment for the fungi to expand their mycelia to the point that the mycelia mass will transform into fruiting bodies (the mushroom). Mushroom cultivation is a non-farm enterprise that can be integrated into small farms to increase incomes and enhance farmers livelihoods (Ekonem and Ubengama, 2002). Mushroom cultivation can help reduce vulnerability to poverty and strengthen livelihoods through the generation of a fast yielding and nutritious source of food and a reliable source of income (Anon Biotech, 2010). Mushroom can be cultivated on a part-time basis, and it requires little maintenance (Elaine and Nair, 2009). Mushroom production can be done anywhere at any time. It is an enterprise for both men and women and it is especially an excellent enterprise for women since it does not demand much labour and energy. Mushroom production indirectly provides materials that are used to improve the soil structure for the production of other crops (Elaine and Nair, 2009). The substrate used for the production of mushroom can be used as animal feed (Gianotti *et al*., 2009). Through the provision of income and improved nutrition, successful cultivation and trade in mushrooms can strengthen livelihood assets and enhance an individual's and a community's capacity to access other economic opportunities (Elaine and Nair, 2009).

Various species of mushrooms picked from the wild include *Volvariella volvacea* (growing mostly on palm trees) and Termitomyces species (growing mainly on termite hills). Other species include *Pholiota species, Lepiota species* and *Coprinus species* (Dzomeku, 2009; Osemwegie *et al*., 2010; Tiimub *et al*., 2015). The most commonly produced and introduced species of mushroom was the *Pleurotus species* (edible), which is the lignocellulolytic type, more economical, easier to produce than the local ones and also stands valuable. The qualities of *Pleurotus ostreatus* such as high yielding, ability to grow on a wide variety of substrates such as sawdust or other organic wastes, makes it a preferred choice for cultivation than the local ones. The nutritional content of *Pleurotus ostreatus* also makes it outstanding for its acceptability by consumers as it provides high-quality protein, mineral and vitamins which are of direct benefits to human health and fitness (Girmay *et al*., 2016).

It is not well known especially among the rural poor that mushrooms are full of nutrients and can therefore make a very important contribution to human nutrition. Protein is one of the most important nutrients in food, being particularly important for building body tissues. Mushrooms with protein content ranging from 3-7 % when fresh to 25-40 % when dry can play an important role in enriching human diets when meat source is limited (MushWorld, 2004). Mushrooms can be eaten fresh or cooked, unlike other protein sources such as soya and yeast that have to be processed in some manner before they are acceptable on the table (MushWorld, 2004). Mushroom cultivation has been reported to represents the only economically viable biotechnology process for the conversion of waste plant residues from forests and agriculture (Wood and Smith 1987). Recently, it has been revealed that mushroom cultivation can play a significant role in preventing environmental pollution (Arowosoge *et al.,* 2017). These methods represent the potential to create a clean ecosystem, where no damage will be left after fungal implementation.

Generally, mushroom cultivation technology is very vital in the tackle against shortage of food supplements, diminishing quality of human health and pollution of the environment, which human beings still face, and will continue to face, due to the continued increase of the world population, natural resource degradation and impacts from climate change (Chang, 2008; Oseni *et al*., 2012). It is, therefore, hoped that the vocation of mushroom farming will become a very important cottage industry in integrated rural development programs. This will lead to the economic betterment of not only small-holder farmers but also landless labourers and other weak sections of the society (Shah *et al*., 2004; Flores, 2006; Sher, 2006; Hassan *et al*., 2011). This study aimed to assess the effect of different substrate formulation using agro-waste on the growth and nutritional parameters of mushroom.

MATERIALS AND METHODS

Materials and Substrate Preparation

Materials for substrate preparation were agricultural wastes sourced from University farm and sawdust obtained from the Department of civil engineering wood laboratory. Substrate preparation, pasteurization, inoculation and ramification were carried out following the procedures used by Nurudeen *et al.* (2014). The experiment was divided into six substrate treatments viz: Sawdust (SD), Coconut-husk (CH), Maize-cob (MC), Maize-cob + Sawdust (MS), Coconut-husk + Maize-cob (CM) and Sawdust + Coconut-husk (SC). Each substrate was chopped to fine particles, well moistened and left for 12 hours. Thereafter, 1 % $CaCO_3$ and 5 % wheat bran were added to 600g of each substrate to enhance mushroom growth. Each substrate was subdivided into three parts of 200 g each as a replicate, these were placed into transparent polythene bags of size 15 x 35 cm. The substrates were steam sterilized at 121 ºC for 20 minutes in an autoclave. *Pleurotus* spawn was added at the rate of 2 g per packet of the sterilized substrates and then air-tight sealed with rubber band. After inoculation, the bags were kept in the darkroom for the spawn to ramify. The temperature and humidity of the incubation chamber were maintained at 25 ºC and 70-80%, respectively.

Pleurotus ostreatus Cultivation and Data Collection

The ramified substrates were brought out and spread in a sterilized bowl in the laboratory. The substrates were kept moist by sprinkling water twice a day forthe mushroom to sprout. Growth parameters such as length of the stipe, diameter of pileus and height of mushroom were measured in centimetres using the meter rule. The number of fruiting bodies were counted for each treatment and weighed immediately after harvest using weigh balance (Ohaus Scout pro) to determine the fresh weight. After recording the weight, fruit bodies were oven-dried at 80 ºC for 24 hours to determine the dry weight. Mean weight for each treatment were recorded.

Proximate Analysis of Dried Mass of *Pleurotus ostreatus*

Proximate determination was performed on the dried mushroom for moisture, fat, fibre, crude protein, and ash according to the standard methods of AOAC (2005).Moisture content was determined by heating 2.0 g of each fresh sample to a constant weight in a crucible placed in a Gallenkamp oven at 105^0 C for one hour. Crude protein (% total nitrogen x 6.25) was determined by Kjeldahl method; fat by Soxhlet apparatus; ash by incinerating the sample in a muffle furnace at 550^0 for 5 hours; fiber by digesting the sample with H_2SO_4.Carbohydrate content was determined by subtraction of other proximate values from 100%.{carbohydrate in food by difference = 100% − (% moisture + % protein + % fat + % ash + fibre)}.

Mineral analysis:

The minerals contents of dried mushroom were determined after digestion with a mixture of concentrated nitric acid, sulphuric acid and perchloric acid (10:0.5:2 v/v) (Ogundele *et al*., 2017). Calcium and magnesium were determined by flame photometric method while phosphorus was determined using atomic absorption spectrophotometer (AAS) apparatus (GBC 904AA; Germany) (AOAC, 2005)

Data Analysis

Data obtained on growth and yield of *Pleurotus ostreatus* were subjected to analysis of variance (ANOVA) at p = 0.05, to determine differences in mean, while the mean was separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Growth of *Pleurotus ostreatus* on different substrates.

The result on growth revealed that mushroom stipe length was significantly higher ($p < 0.05$) for sawdust substrates, while the diameter of pileus was significantly higher ($p < 0.05$) for maize-cob + sawdust substrate (Table 1). Result on mushroom height revealed that sawdust had the highest mean value(4.43 ± 0.70cm), while sawdust + coconut-husk had the least mean height (2.01 ± 0.18cm). However, the height of mushroom was not significantly different ($p < 0.05$) for sawdust, maize-cob, maize-cob + sawdust and coconut-husk + maize-cob substrates (Table 1). The observed stipe length, diameter of pileus and mushroom height obtained in this study suggests that mushroom produced by all the substrates attained a moderate size that was marketable. This assertion is in line with the submission of Nurudeen *et al.* (2019) who reported similar result for *Pleurotus sajor-caju* grown on some of the examined substrates.

Table 1: Growth values (cm) of *Pleurotusoestreatus* cultivated using different agro-waste substrates

GROWTH INDICES (CM)	SUBSTRATES					
	SD	CH	MC	MS	CM	SC
LENGTH OF STIPE	3.58 ±0.08^{a}	2.16±0.63^{bc}	3.28±0.14^{ab}	3.50±0.63^{ab}	2.52±0.39^{bc}	1.30 ±0.13^{c}
DIAMETER OF PILEUS	5.51±0.32^{ab}	3.41 ±0.54^{b}	3.86 ±0.69^{b}	7.22 ±1.54^{a}	4.80±0.17^{ab}	3.73 ±0.47^{b}
HEIGHT OF MUSHROOM	4.43 ±0.70^{a}	3.02 0.67^{ab}	3.95 ±0.31^{a}	4.21 ±0.27^{a}	4.15 ±0.31^{a}	2.01 ±0.18^{b}

Mean in the same row followed by the same letters are not significantly different at $p \leq 0.05$ Key: **SD**- Sawdust, **CH:** Coconut-Husk, **MC:** Maize-cob, **MS:** Maize-cob + Sawdust, **CM:** Coconut-Husk + Maize-cob, **SC:** Sawdust + Coconut-Husk.

Yield of *Pleurotus ostreatus* grown on different agro-waste substrates

The results on the mean yield of *P. Ostreatus* showed that sawdust substrate had significantly ($p < 0.05$) highest yield on a fresh weight basis (16.67 ±1.20g). While on dry weight bases, the mushroom yield for all treatments was not significantly different ($p < 0.05$) (Table 2). Results on the number of fruiting bodies showed that coconut-husk substrate had the highest mean value of 6.67 ±0.33, followed by maize-cob (5.33 ±0.67), while the least number of fruiting bodies was obtained for maize-cob + sawdust substrate (2.00 ±0.58). The observed higher fresh weight of mushroom obtained for sawdust, coconut-husk + maize-cob, maize-cob and maize-cob + sawdust substrates was an indication that the substrates could be cultivated for commercial production of *Pleurotus ostreatus*. However, the lowest yield obtained for sawdust + coconut-husk in terms of fresh weight could be attributed to the low moisture contents of the mushroom as it looks less succulent than those of other substrates. The above observations revealed that the yield of *Pleurotus ostreatus* is a function of the nutritional composition of the substrate upon which it is grown. This assertion further corroborates the report of Ogundele *et al.* (2017) on *Pleurotus ostreatus* grown on sawdust of different tree species.

Table 2: Yield of *Pleurotus ostreatus* on different substrates

YIELD INDICES	SUBSTRATES					
	SD	CH	MC	MS	CM	SC
FRESH WEIGHT	16.67±1.20^{a}	5.33±0.33^{c}	13.00±1.53^{b}	12.67±0.82^{b}	13.33±0.33^{b}	2.00 ±1.00^{d}
DRY WEIGHT	1.33 ±0.33^{a}	1.00 ±0.58^{a}	1.33 ±0.33^{a}	1.00 ±0.58^{a}	1.00 ±0.58^{a}	1.33 ±0.33^{a}
NO OF FRUITING BODIES	5.00 ±0.57^{ab}	6.67±0.33^{a}	5.33 ±0.67^{a}	2.00 ±0.58^{c}	4.33±0.33^{abc}	2.67 ±1.45^{bc}

Mean in the same row followed by the same letters are not significantly different at $p \leq 0.05$
Key: **SD**- Sawdust, **CH:** Coconut-Husk, **MC:** Maize-cob, **MS:** Maize-cob + Sawdust, **CM:** Coconut-Husk + Maize-cob, **SC:** Sawdust + Coconut-Husk.

Proximate composition of mushroom produced from substrates

The result of proximate composition showed that sawdust substrate had the highest percentage of moisture content (71.19 %), this was followed by sawdust + maize-cob, while sawdust + coconut-husk had the least value of 60.47 % (Table 3). Ash content was highest on mushroom produced from sawdust + coconut-husk substrate with a value of 12.00 %. This was followed by maize-cob, sawdust, coconut-husk and maize-cob + coconut-husk with 9.84 %, 8.21 %, 7.10 %, and 6.44 % respectively. Maize-cob + sawdust had the least value of4.65 %. these values indicates *that pleurotus ostreatus* from all the substrates are good sources of mineral when compared to values obtained for cereals and tuber. The fat content was highest in mushroom from coconut-husk (0.88 %), followed by maize-cob + coconut-husk (0.80 %) while sawdust substrate had the least value of 0.50 %.The generally low percentage value of fat obtained in this study for all the substrates suggests that mushrooms are poor sources of lipids, hence they could be a good diet for people suffering from obesity.

The result for protein showed that mushroom from sawdust + coconut-husk had the highest value followed by sawdust while maize-cob + sawdust had the least value of 0.66% (Table 3). Crude fibre was highest for mushroom grown on coconut-husk (7.00 %), followed by sawdust + coconut-husk, maize-cob + sawdust, corn-cobs + coconut-husk and corn-cobs with values of 6.00, 5.94, 5.00 and 5.00 (%), respectively. This result agreed with Manzi *et al.* (2001) who reported a similar dietary fiber range in *Pleurotus ostreatus.* Fibre plays an active role in cleaning the digestive tract and increases faeces consistency. It also helps in reducing blood sugar and also acts as a general body purifier.

The result for carbohydrates showed that mushroom produced by coconut-husk had the highest value (22.66 %), this was followed by sawdust + coconut-husk, maize-cob + coconut-husk, maize-cob + sawdust and sawdust with values of 18.19, 17.97, 17.33 and 15.68 (%), respectively. Similar result has been reported by Hossain *et al*. (2007) and Manzi *et al.* (2001) both of whom asserted that carbohydrates are mainly present in *Pleurotus ostreatus*as polysaccharides. The moderately high value of carbohydrate obtained for *Pleurotus ostreatus* in all the substrates investigated suggests that mushroom could be a good source of energy for daily activities. The relatively high nutritional contents in terms of carbohydrates, protein and ash for Pleurotus mushroom grown on sawdust and coconut-husk substrates agrees with the report of Itelima, (2011) and Nurudeen *et al.* (2013).

Mineral contents of mushroom grown on different substrates

Results of mineral contents of mushroom showed that phosphorus had the highest value in sawdust + coconut-husk substrate (650mg), this was followed by coconut, while maize-cob + sawdust substrate had the least value of 404.63mg (Table 4).

Table 3: Proximate composition of mushroom produced from different substrates **(%)**

PARAMETER	COMPOSITION (%)					
	SD	CH	MC	MS	CM	SC
PROTEIN	1.75	0.88	0.88	0.66	1.53	2.63
CRUDE FIBRE	2.67	7	5	5.94	5	6
ASH	8.21	7.1	9.81	4.65	6.44	12
FAT	0.5	0.88	0.75	0.62	0.8	0.71
MOISTURE	71.19	61.48	69.34	70.8	68.18	60.47
CARBOHYDRATE	15.68	22.66	14.22	17.33	17.97	18.19

Key: **SD:** Sawdust, **CH:** Coconut-Husk, **MC:** Maize-cob, **MS:** Maize-cob + Sawdust, **CM:** Coconut-Husk + Maize-cob, **SC:** Sawdust + Coconut-Husk.

Calcium was highest in sawdust + coconut-husk substrate (2.70 mg), followed by coconut, maize-cob, maize-cob + sawdust and maize-cob + coconut-husk substrates with values of 2.60, 2.30, 2.20 and 1.90 (mg), respectively while magnesium had the highest value (32.40mg)in mushroom from maize-cob substrate. The observed highest phosphorus values in all the substrate over magnesium and calcium in this study agreed with the result obtained by Ogundele *et al.* (2017) on sawdust. The high magnesium content found in mushroom from maize-cob could be attributed to relatively low protein and high carbohydrate values obtained in the substrate. Calcium values obtained in all the substrates in this study are adequate for good health in term of bone formation and a strong skeletal system. This assertion is in line with the submission of Ogundele *et al*., (2017) and Agomuo, (2011).

Table 4: Mineral contents of mushroom produced from different substrates (mg/100g)

MINERAL CONTENTS	SUBSTRATES					
	SD	CH	MC	MS	CM	SC
PHOSPHORUS	429.28	552.92	485.53	404.63	427.83	650
CALCIUM	1.6	2.6	2.3	2.2	1.9	2.7
MAGNESIUM	30.9	29.8	32.4	26.5	27	22.2

Key: **SD:** Sawdust, **CH:** Coconut-Husk, **MC:** Maize-cob, **MS:** Maize-cob + Sawdust, **CM:** Coconut-Husk + Maize-cob, **SC:** Sawdust + Coconut-Husk.

CONCLUSION

Yield performance and nutritional assessment of oyster mushroom *(Pleurotus ostreatus)* cultivated on different agricultural and wood wastes were established in this study. Sawdust substrate had the best overall growth performance in terms of length of stipe and height of mushroom. The yield also revealed that sawdust had the highest fresh weight. The result on nutritional composition revealed that sawdust + coconut-husk had the highest value in terms of protein, carbohydrate and mineral contents. Therefore, for commercial production of oyster mushroom, sawdust would be an ideal substrate while for nutritional benefits, sawdust + coconut-husk is recommended for mushroom production.

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