Food ***©2012 Global Science Books***

Comparative Study of the Growth and Yield of *Pleurotus florida* (Oyster Mushroom) on Some Tropical Trees

Caleb Adewale Otunla* • Olufunmilayo Omowumi Idowu

National Horticultural Research Institute, P.M.B. 5432 Idi-Ishin, Jericho, Ibadan, Nigeria

Corresponding author: * **casotliz@yahoo.com**

ABSTRACT

Chopped stems of four tropical trees namely mango (*Mangifera indica*), neem (*Azadirachta indica*), acacia (*Acacia species*) and coconut (*Cocos nucifera*) with their mixed bed, as the fifth, were evaluated as substrates for the cultivation of *Pleurotus florida*, an edible mushroom. Observations were made for the growth and yield parameters of the mushroom namely; number of fruits (NF), fruit weight (FW), width of pileus, length of stipe, biological efficiency (BE) and production efficiency (PE), mycelia extension, days to full colonization, days to initiation and extension per day. The results obtained from this study indicated that the fruit weight (FW) of *P. florida* (80 g) was highest when cultivated on chopped mango stem. The same trend was observed in BE (46%) and PE (17%). Chopped coconut stem produced the least FW (48 g) and length of stipe (4 cm). Its BE (27%) and PE (11%) were also the least. However, the highest width of pileus (12 cm) was produced by coconut while chopped acacia stem (6 cm) produced the least. The highest mycelia extension (11 cm) was obtained from coconut while the least was from mango. The results obtained indicated that the stem of mango is a suitable substrate for the cultivation of *P. florida* (Oyster mushroom).

Keywords: biological efficiency, production efficiency

Abbreviations: ANOVA; analysis of variance, **BE**, biological efficiency; **DMRT**; Duncan‘s multiple range test; **FW**, fruit weight; **NF**, number of fruits; **PE**, production efficiency; **PVC**, poly vinyl chloride

INTRODUCTION

Edible mushrooms are nutritionally endowed fungi (mostly Basidiomycetes) that grow naturally on the trunks, leaves and roots of trees as well as decaying wood materials (Iwalokun *et al*. 2001). Mushrooms are actually fruits of the fungus (Okhuoya and Okogbo 1990). The fruit body lasts for a few years but the mycelium living on the organic materials in the soil may survive for years (Oyetayo and Oyetayo 2008). Mushrooms have high contents of qualitatively good protein, crude fibre and minerals but are poor sources of lipids (Fasidi and Kadiri 1990). They have high nutrient value of almost twice that of any other vegetable or fruits (Sivrikaya *et al*. 2002). They are non-traditional horticultural crops having high quality of proteins, high fibre value, vitamins and minerals (Narayanasamy *et al*. 2009). Mushrooms are rich sources of mineral elements and vitamins, with mineral elements already detected being potassium, phosphorus, calcium, sodium, magnesium, zinc, iron, manganese, nickel, copper, chromium, cobalt and vitamins (B, C, K) and niacin (Ogundana and Fagade 1982; Zakhary *et al*. 1983). They are rich in protein, minerals, and vitamins, and they contain an abundance of essential amino acids (Sadler 2003). In medicine, they are used to immodulate both humoral and cellular immune factors in the body (Wasser 2002). Pharmaceutical applications of mushrooms had been in their use as anticancer, antibacterial, antifungal and antiviral agents (Wasser 2002). Most mushrooms make their appearance during the rainy season (Aletor 1995). Attempt had been made on the husbandry of the more nutritious species of mushrooms on agro waste. *Lentinus subnudus* and *Tuber-regium* had been successfully cultivated on various cellulolytic agricultural wastes (Fasidi and Ekuere 1993; Fasidi and Kadiri 1993). The rapid growth and the ability to utilize various lignocellulosic substances make *Pleurotus* species cultivation possible in different parts of the world. *Pleurotus* species have been grown on different kinds of sawdust, straw and many other agricultural and industrial wastes (Hadder *et al*. 1993). Some of these otherwise valueless lignocellulosic wastes: cotton wastes, sawdust, cereal stover, corncob, wheat, paddy straw and sugarcane bagasse, have been used either mixed or singly as substrates for the cultivation of various species of edible mushrooms by various researchers (Fasidi and Kadiri 1993; Manzil *et al.* 1999; Ragunathan and Swaminathan 2003). *Pleurotus* spp. can also colonize and produce mushrooms on pretreated conifer (*Pinus* spp.) wood chips but they do not always readily colonize non-pretreated conifer wood, due to the presence of inhibitory components (Croan 2004). Some strains can, however, be adapted for cultivation on conifer sawdust-based substrates (Ruan *et al.* 2006). *Pleurotus* spp. can also be cultivated on wood waste or unused wood residues associated with harvesting or thinning operations, which can enhance economic returns needed to support ecosystem management (Croan 2002). A lot of studies were reported on the suitability of various substrates for mushroom production namely straws of rice (*Oryza sativa*), wheat (*Triticum vulgare*), ragi (*Elucine coracana*), bazra (*Pennisetum typhoides*), sorghum (*Sorghum vulgare*), maize (Zea mays), wood of poplar (*Populus robusta*), oak (*Quercus luecothricopora*), horse chest nut (*Aesculus indica*), *Acacia* sp., chopped banana pseudostem, cotton stalk, pea shells and poplar saw dust (Saidu *et al*. 2011). Cultivation of saprophytic edible mushrooms may be the only currently economical biotechnology for lignocellulose organic waste recycling that combines the production of protein rich food with the reduction of environmental pollution (Obodai *et al.* 2003). Most of the commercial producers of mushroom in Malaysia presently are using sawdust and rice husk (Saidu *et al.* 2011). Substrates may also be obtained from various plant remnants without enrichments by expensive additives. Similarly, utilization of agricultural waste as growing media

Received: 24 March, 2012. Accepted: 3 November, 2012.

Original Research Paper

for the production of mushroom play a key role in reducing the waste and at the same time useful as a fertilizer (Sher *et al.* 2011). *Pleurotus* species have extensive enzyme systems capable of utilizing complex organic compounds that occur as agricultural wastes and industrial by-products (Baysal *et al.* 2003). For this reason, it is not necessary to process substrates for cultivation of *Pleurotus* species (Yalinkiliç *et al.* 1994). These mushrooms are also found to be one of the most efficient lignocelluloses solid state decomposing types of white rot fungi (Baysal *et al.* 2003).

For many reasons, the fungi of the *Pleurotus* genus have been intensively studied in many different parts of the world; they have high gastronomic value. The nutritional requirements and the limits of the physical environment for mycelia growth and fruiting have been investigated for many *Pleurotus* sp. Recent studies have indicated that cotton waste is also a good substrate for the cultivation of *Pleurotus* sp. (Narayanasamy *et al.* 2009). Paddy straw mushroom (*Pleurotus florida*) is an edible mushroom of the tropic and sub-tropic region (Narayanasamy *et al.* 2009). They are able to colonize and degrade a large variety of lignocellulosic residues, they require shorter growth time when compared to other edible mushrooms, they demand few environmental controls, their fruiting bodies are not very often attacked by diseases and pests and they can be cultivated in a simple and cheap way (Jwanny *et al.* 1995; Patrabansh and Madan 1997). Mushroom cultivation ensures their availability throughout the world irrespective of season since cultivated mushrooms can be grown under different climatic conditions on cheap, readily available agro wastes. The cultivation process guarantees edibility and serve as the most economically viable process for the bioconversion of low value wastes produced primarily from the activities of agricultural, forest and food processing industries to produce higher value fungal protein for human consumption (Wasser 2002). This study was, therefore, aimed at investigating the effects of different substrates on the growth and yield of *P. florida* (oyster mushroom).

MATERIALS AND METHODS

Collection of materials

Within the premises of the National Horticultural Research Institute (NIHORT), Ibadan, the trees involved: mango (*Mangifera indica*), neem (*Azadirachta indica*) and acacia (*Acacia species*) trees were obtained for this study but the coconut tree (*Cocos nucifera*) was obtained at Apete Area of Ibadan metropolis. These trees were between 25-27 years old before harvesting. The spawn of *P. florida* was obtained from the mushroom unit, NIHORT, Ibadan. The inoculums used were generated from the mushroom sporophore obtained at Songhai in Porto Novo in Benin Republic and maintained on Potato Dextrose Agar (PDA) for regular subculturing.

Composting of materials

The stems (the bark with the inner tissues excluding the leaves) of the trees (substrates) were harvested at their vegetative stage during the dry season and stored for a period of about three months. With a hand cutter, each of the tree stems (substrates) was chopped into pieces of length 3-5 cm. The substrate used were acacia, coconut, mango, neem and the mixed bed which was prepared by mixing equal portions of the four trees together. They were separately soaked overnight and excess water was removed by pressing the following morning until the moisture content was about 65%. Polyethylene bags were filled with each of the substrate with each bag weighing 500 g and packed tightly. Heat resistant PVC tube was used to make the neck of the bag. The opening was then covered with a cotton plug. These bags were sterilized in an autoclave at 121°C for 30 min and allowed to cool to room temperature.

Spawn inoculation and incubation

After cooling, about 50 g of inoculum (10% by weight of the substrate in each bag) was introduced into the bags through the neck. The experiment was a completely randomized design with three replicates per treatment. They were incubated for 30 days after spawning. The bags were brought out for weighing and then transferred into the fruiting house. It was conducted during the raining season.

Data collection and analysis

Harvesting of the mushrooms was done manually and weighed. The data collected for five (5) fruits per flush included; number of fruits, NF, fruit weight, FW (g), width of pileus (cm), length of stipe (cm), PE (%), BE (%), mycelia extension (cm), days to full colonization, primodia initiation and the average extension per day (cm). The data obtained were subjected to analysis of variance ANOVA. Significant means were separated using Duncan's multiple range test, (DMRT) at $P \leq 0.05$.

RESULTS

The results of the growth and yield of the mushroom (*P. florida*) as affected by the different substrates are summarized in **Tables 1** and **2**. The results of the ANOVA revealed that the substrates had significant effects on NF, FW, width of pileus, length of stipe, BE, PE, mycelia extension and days to full colonization except days to initiation and average extension per day.

Mushroom grown on chopped stems of neem and acacia produced the highest number of fruits (13) followed by mango (12) though, these were not significantly different from one another (**Table 1**). Coconut produced seven (7) numbers of fruits while the mixture of all the substrates produced the least (3). Mango stem produced significantly higher FW (80 g) than others. This was followed by acacia which produced 72 g. However, coconut produced the least FW (48 g). Similar trend was observed in the BE and PE (**Table 1**) in the order mango > acacia > mixed > neem > coconut.

While coconut and mixed bed produced the largest width of pileus (12 cm), acacia produced the least (6 cm). The width of pileus decreased in the order of coconut > mixed bed > neem > mango > acacia (**Table 1**). Contrary to the NF and FW, mixed bed produced the longest (6 cm) length of stipe. This was significantly different from acacia that produced 4 cm. Chopped stem of neem produced 4 cm length of stipe which was not significantly different from coconut that produced 4 cm. However, mango produced the shortest length of stipe (4 cm). Like the width of pileus, coconut stem produced the longest mycelia extension (14 cm) while mango produced the shortest (11 cm). This was similar to the trend obtained in the length of stipe (**Table 1**). However, the longest average mycelia extension per day occurred in mango while the shortest was in acacia (**Table 2**).

DISCUSSION

The varied substrate media yielded different amounts of mushrooms as observed in the total NF, FW, width of pileus and length of stipe. This result is in accordance with the view of the other researchers. The trials conducted by growing oyster mushroom (*P sajor-caju*) on rice and wheat straw with nutrient suplementation recorded higher yields on both the substrates (Larborde *et al.* 1993). Sangwan and Sanni 1995 cultivated *P sajor caju* (Fr.) Singer on different agro-industrial wastes, alone and in combination, as amendments for the growing medium of *P sajor-caju.* The addition of sugarcane bagasse to wheat or paddy straw was the most effective and increased the BE from 99% to 118% and 119%, respectively. Ragunathan and Swaminathan (2003) discovered that when *Pleurotus* spp. were cultivated on various agro-wastes, *P sajor-caju* and *P citrinopileatus*

Table 1 Mushroom yield on 5 different substrates.

Substrate	NF	FW (g)	Width of pileus (cm)	Length of stipe (cm)	PE (%)	BE (%)
Mango	12.00a	80.00a	6.76cd	3.93c	17.18a	45.71a
Neem	12.33a	60.67d	9.00bc	4.43bc	13.89c	34.67d
Mixed Bed	2.33c	67.33c	9.73ab	6.23a	15.36b	38.48c
Acacia	12.33a	72.33b	6.43d	4.73b	16.95a	41.14b
Coconut	6.67b	48.00e	12.13a	4.40bc	10.96d	27.41e
$LSD_{0.05}$	3.29	4.43	2.55	0.70	1.09	2.58

Means with the same letters along column are not significantly different from one another (DMRT at $P \leq 0.05$)
NF = number of fruits, FW = fruit weight, PE = production efficiency, BE = biological efficiency

Table 2 Mushroom growth on 5 different substrates.

Substrate	Days to full colonization	Days to initiation	Average mycelia extension/day (cm)	Mycelia extension (cm)
Mango	31.00b	28.33b	0.43a	11.30e
Neem	33.33a	30.00ab	0.36b	13.20b
Mixed Bed	31.33b	28.67b	0.37b	11.97d
Acacia	33.33a	30.67a	0.35b	12.50c
Coconut	33.33a	29.67ab	0.38b	13.97a
$LSD_{0.05}$	1.49	1.88	0.04	0.47

Means with the same letters along column are not significantly different from one another (DMRT at $P \leq 0.05$)

gave maximum yield on cotton stalks while *P. platypus* gave the maximum yield on sorghum stover. Using varied substrate media for the cultivation of mushroom causes different yield amount because of the biological and chemical differences between the substrates medium and genotype of the cultured mushroom. For the production of *P. florida*, as discovered in our study, mango tree substrate medium might be the most convenient culture medium. The effects of physical and chemical properties of substrates on yield and BE have been investigated in *Agrocybe aegerita*, *Volvariella volvacea*, *Pleurotus* spp., *Lentinula edodes* and *Ganoderma lucidum*. Philippoussis *et al.* (2001) used three agricultural wastes namely wheat straw, cotton wastes and peanut shells. He observed that *V. volvacea* presented higher growth rate when the composted cotton waste medium was used. Obodai *et al.* (2003) also tried banana leaves, cocoyam peelings and oil-palm pericarp for the cultivation of *V. volvaceae* but the highest production was recorded on banana leaves. Ozcelik and Peksen (2007) found out that the culture medium prepared from *Eucalyptus citriodora* sawdust extract was the most promising to grow *Lentinula edodes.* Peksen and Yakupoglu (2009) discovered that for the cultivation of *Ganoderma lucidum*, the substrate formulations producing the highest yield and BE were 80% sawdust+20% tea waste and 75% sawdust+25% tea waste. Liang *et al.* (2009) reported variable ranges of BE when different lignocellulosic materials were used as substrates for cultivation of oyster mushrooms. Chitamba *et al*. (2012) stated while evaluating the growth of *P. ostreatus* on different substrates that cotton lint waste gave the highest BE followed by wheat straw but wood shavings and corn cobs produced low BE. This study showed that the composition of substrate has a great influence on yield and BE.

Out of all the substrates investigated, mango produced the highest FW, PE and BE. This could be due to the physical nature, high porosity and level of aeration within the substrate. From this result, mango stem was the most suitable for the production of *P. florida* (Oyster mushroom) amidst all the substrates evaluated. Sivrikaya and Peker (1999) stated that great potential of wood wastes of timber mills of Eastern Black Sea region offers a unique chance for the mushroom growers. The use of this substrate gave the highest yields in terms of total number of fruits and weight, biological efficiency, production efficiency and extension per day. Further-more, these trees that are usually burned or left in the field to rot can be effectively channeled towards the production of oyster mushroom thus, providing economic gain if producers of oyster mushrooms make it a profession.

ACKNOWLEDGEMENTS

We are indeed grateful to Mr Ajayi EO, Mrs Akinrinsola FO, Mrs Majekadegbe GA and Mr Daropale O for their support and encouragement in the course of this research work.

REFERENCES

Aletor VA (1995) Compositional studies on edible tropical species of mushrooms. *Food Chemistry* **54**, 265-268

Baysal E, Peker H, Kemal M, Temiz A (2003) Cultivation of oyster mushroom on waste paper with some added supplementary materials. *Bioresource Technology* **89**, 95-97

Chitamba J, Dube F, Chiota WM, Handiseni M (2012) Evaluation of substrate productivity and market quality of oyster mushroom (*Pleurotus ostreatus*) grown on different substrates. *International Journal of Agricultural Research* **7**, 100-106

Croan SC (2004) Conversion of conifer wastes into edible and medicinal mushrooms. *Forest Product Journal* **54**, 68-76

Croan SC (2000) Conversion of wood waste into value-added products by edible and medicinal *Pleurotus* (Fr.) P. Karst. species (Agaricales s.l., Basidiomycetes). *International Journal of Medicinal Mushroom* **2**, 73-80

Fasidi IO, Ekuere UV (1993) Studies on *Pleurotus tuber-regium* (Fries) Singer: Cultivation, proximate composition and mineral content of sclerotia. *Food Chemistry* **48**, 255-258

Fasidi IO, Kadiri M (1990) Change in nutrient contents of two Nigerian mushrooms, *Termitomyces robustus* (Beeli) R. Heim and *Letinus subnudus* Berk during sporophore development. *Die Nahrung* **34**, 415-420

Fasidi IO, Kadiri M (1993) Use of agricultural wastes for the cultivation of *Lentinus subnudus*. *Nigerian Review of Biology in the Tropics* **41 (3)**, 411-415

Hadder Y, Kerem Z, Gorodecki B (1993) Biodegradation of lignocellulosic agricultural wastes by *Pleurotus ostreatus*. *Journal of Biotechnology* **30**, 133-139

Iwalokun BA, Usen UA, Otunba AA, Olukoya DK (2007) Comparative phytochemical evaluation, antimicrobial and antioxidant properties of *Pleurotus ostreatus. African Journal of Biotechnology* **6 (15)**, 1732-1739

Jwanny EW, Rashad MM, Abdu HM (1995) Solid-state fermentation of agricultural wastes into food through *Pleurotus* cultivation. *Applied Biochemistry and Biotechnology* **50 (1)**, 71-78

Laborde J, Lanzi G, Francescutti B, Giordani E (1993) Indoor composting: General principles and large scale development in Italy. In: Chang ST, Buswell JA, Chiu SW (Eds) *Mushroom Biology and Mushroom Products*, The Chinese University Press, Hong Kong, pp 93-113

Liang Z, Wu C, Shieh Z, Cheng S (2009) Utilisation of grass plants for cultivation of *Pleurotus citrinopeleatus*. *International Biodeterioration and Biodegradation* **63**, 509-514

Manzi P, Gambelli L, Marconi S, Vivanti V, Pizzoferato L (1999) Nutrients in edible mushrooms: An inter-species comparative study. *Food Chemistry* **65**, 477-782

Narayanasamy P, Suganthavel P, Sabari P, Divya J, Vanchinathan M (2009) Cultivation of mushroom (*Plerotus florida*) by using two different agricultural wastes in laboratory condition. *The Internet Journal of Microbiology* **7 (2)**

Obodai M, Cleland-Okine J, Vowotor KA (2003) Comparative study of different lignocellulosic by-products. *Journal of Industrial Microbiological Biotechnology* **30**, 146-149

Ogundana SK, Fagade EO (1982) Nutritive value of some Nigerian edible mushrooms. *Food Chemistry* **8**, 263-368

Okhuoya JA, Okogbo FO (1990) Induction of edible sclerotia of *Pleurotus tuber-regium* (Fr.) Singer in the laboratory. *Annals of Applied Biology* **117**, 295-298

Oyetayo VO, Oyetayo FL (2008) Health promoting potentials of edible mushrooms indigenous to Nigeria. *Nigerian Journal of Mycology* **1**, 1-8

Ozcelik E, Peksen A (2007) Hazelnut husk as a substrate for the cultivation of shiitake mushroom (*Lentinula edodes*). *Bioresource Technology* **98**, 2652-2658

Patrabansh S, Madan M (1997) Studies on cultivation, biological efficiency and chemical analysis of *Pleurotus sajor-caju* (FR.) Singer on different biowastes. *Acta Biotechnology* **17 (2)**, 107-122

Peksen A, Yakupoglu G (2009) Tea waste as a supplement for the cultivation of *Ganoderma lucidum. World Journal of Microbiological Biotechnology* **25 (4)**, 611-618

Philippoussis A, Zervakis G, Diamantopoulou P (2001) Bioconversion of lignocellulosic wastes through the cultivation of the edible mushrooms *Agrocybe aegerita*, *Volvariella volvacea* and *Pleurotus* spp. *World Journal of Microbiological Biotechnology* **17**, 191-200

Ruan RG, Ding LC, Pan XH, Chen H, Luo YF (2006) Domestication and cultivation of *Pleurotus citrinopileatus* strain Ninghuang No. 16 on a substrate containing pine and fir sawdust. *Acta Edulis Fungi* **13**, 36-38

Ragunathan R, Swaminathan K (2003) Nutritional status of *Pleurotus* spp. grown on various agro-wastes. *Food Chemistry* **80 (3)**, 371-375

Sadler M (2003) Nutritional properties of edible fungi. *Nutritive Food Bulletin* **28**, 305-308

Saidu M, Salim MR, Yuzir AM (2011) Cultivation of oyster mushroom (*Pleurotus* spp.) on palm oil mesocarp fibre. *African Journal of Biotechnology* **10 (71)**, 15973-15976

Sangwan MC, Sanni LC (1995) Cultivation of *Pleurotus sajor-caju* (Fr.) Singer on agro-industrial wastes. *Mushroom Resources* **4**, 33-34

Sher H, Al-Yemeni M, Khan K (2011) Cultivation of oyster mushroom (*Pleurotus ostreatus* (Jacq) p. Kumm.) in two different agro-ecological zones of Pakistan. *African Journal of Biotechnology* **10 (2)**, 183-188

Sivrikaya H, Bacak L, Saraobasi A, Toroglu I, Eroglu H (2002) Trace elements in *Pleurotus sajor-caju* cultivated on chemithermo-mechanical pulp for biobleaching. *Food Chemistry* **79**, 173-176

Sivrikaya H, Peker H (1999) Cultivation of *Pleurotus florida* on forest and agricultural wastes by leaves of tree and wood waste. *Tropical Journal of Agriculture and Forestry* **23**, 585-596

Wasser SP (2002). Review of medicinal mushrooms advances: Good news from old allies. *Herbal Gram* **56**, 28-33

Yalinkiliç MK, Altun L, Baysal E, Demirci Z (1994) Development of mushroom cultivation techniques in Eastern Black Sea Region of Turkey. In: *Project of the Scientific and Technical Research Council of Turkey (TUBITAK)*, No TOAG-875, 287 pp

Zakhary WJ, Abo-Bakr MT, El- Mahdys RA, El-Tabey MAS (1983) Chemical composition of wild mushrooms collected from Alexandria, Egypt. *Food Chemistry* **11 (10)**, 31-41