

African Crop Science Journal by African Crop Science Society is licensed under a Creative Commons Attribution 3.0 Uganda License. Based on a work at www.ajol.info/ and www.bioline.org.br/cs
DOI: <http://dx.doi.org/10.4314/acsj.v24i3.4>



NUTRITIONAL PROFILE AND YIELD OF OYSTER MUSHROOM CULTIVATED ON SELECTED AGRICULTURAL WASTES

O.M. ADEDOKUN and M. GEORGE-DAVID

Department of Crop and Soil Science, Faculty of Agriculture, University of Port-Harcourt, PMB 5323,
Choba, Rivers State, Nigeria

Corresponding author: olutayo.adedokun@gmail.com

(Received 22 March, 2016; accepted 13 July, 2016)

ABSTRACT

Research on mushroom production and products is gaining more grounds globally and in particular Nigeria. This study was carried out to determine nutritional relationship between the substrate used for cultivation and the fruiting body on each of the substrates. Agro-wastes, namely: palm (*Elaeis guineensis*) fruit shaft, plantain (*Musa paradisiaca*) leaves, sawdust and kenaf (*Hibiscus cannabinus*) stem, were assessed for suitability as substrates for cultivation of oyster mushroom (*Pleurotus florida* Singer). The spawn of the mushroom was used to inoculate each of the substrates, using a complete randomised design, with five replicates for each substrate. Results showed that all the substrates supported mycelia growth and development of fruiting bodies of the fungus. There were significant differences ($P < 0.05$) among substrates in terms of number of days to complete mycelia run, with the least recorded in palm fruit shaft (25.20), and the highest in kenaf (32.40). Total yield also differed significantly ($P < 0.05$), with the highest in palm fruit shaft (51.4 g 100 g⁻¹) and lowest in plantain leaves (6.0 g 100 g⁻¹). There was also significant difference ($P < 0.05$) in the nutritional content of fruiting bodies, the highest fat content being on plantain leaves (1.72 g 100 g⁻¹) and the lowest on palm fruit shaft (0.55 g 100 g⁻¹). The trend was similar for mushroom substrates, plantain leaves having (2.55 g 100 g⁻¹) and palm fruit shaft, (0.41 g 100 g⁻¹). Starch content for fruiting bodies was highest on sawdust (5.31 g 100 g⁻¹) and lowest on kenaf (2.66 g 100 g⁻¹), while for mushroom substrates, kenaf was (0.33 g 100 g⁻¹) and palm fruit shaft was (4.45 g 100 g⁻¹). There was a positive correlation ($r = 0.24$) between the nutrient of fruiting bodies and that of the substrate on which it was cultivated.

Key Words: Kenaf, nutrient composition, mushroom fruiting body, mushroom substrate, *Pleurotus florida*

RÉSUMÉ

La production de la pleurote et produits dérivés fait de plus en plus objet de recherche dans le monde et surtout au Nigeria. La présente étude a été réalisée afin de déterminer la relation nutritionnelle entre le substrat de culture utilisé et type de champignon obtenu. Des déchets agricoles comme le faux régime de palmier (*Elaeis guineensis*), les feuilles du bananier plantain (*Musa paradisiaca*), la sciure et tige de kenaf (*Hibiscus cannabinus*), ont été évalués pour leur aptitude à servir de substrats de culture pour la pleurote (*Pleurotus florida* Singer). Les spores du champignon ont été utilisés pour inoculer chaque substrat. Les résultats ont montré que tous les substrats ont supporté la croissance du mycélium et le développement. Des différences significatives ont été observées entre les substrats ($P < 0.05$), en ce qui concerne le nombre de jours nécessaires pour accomplir un cycle mycelien. Le cycle mycelien le plus court a été observé sur le faux régime de palmier (25.20), tandis que le cycle le plus long était observé sur le kenaf (32.40). Les rendements totaux varient d'un substrat à un autre ($P < 0.05$); le meilleur rendement a été obtenu sur faux régime de palmier (51.4 g 100 g⁻¹) et le plus faible rendement obtenu sur les feuilles du bananier plantain (6.0 g 100 g⁻¹). Des différences significatives ont été aussi observées au niveau

de la qualité nutritionnelle du champignon ($P < 0.05$). Les champignons de meilleures qualités nutritionnelles étaient obtenus sur les feuilles de bananier plantain ($1.72 \text{ g } 100 \text{ g}^{-1}$), tandis que les champignons à faible teneur en nutriments ont été obtenus sur faux régime de palmier ($0.55 \text{ g } 100 \text{ g}^{-1}$). Le même constat a été fait au niveau des substrats; les feuilles de bananiers plantain ayant ($2.55 \text{ g } 100 \text{ g}^{-1}$) contre ($0.41 \text{ g } 100 \text{ g}^{-1}$) faux régime de palmier. La teneur en amidon la plus élevée a été obtenue sur la sciure ($5.31 \text{ g } 100 \text{ g}^{-1}$), tandis que la plus faible teneur était sur kenaf ($2.66 \text{ g } 100 \text{ g}^{-1}$). En ce qui concerne la teneur en amidon des substrats, le kenaf exhibait ($0.33 \text{ g } 100 \text{ g}^{-1}$) et faux régime de palmier a exhibé ($4.45 \text{ g } 100 \text{ g}^{-1}$). Une corrélation positive ($r = 0.24$) a été observée entre les nutriments au sein du champignon et ceux du substrat sur lequel il est cultivé.

Mots Clés: Kenaf, composition nutritionnelle, champignon, substrat de champignon, *Pleurotus floridanus*

INTRODUCTION

Mushrooms (*Agaricus bisporus*) are fungi that are heterotrophic and depend on other organisms for food. Oyster mushrooms belong to the species of *Pleurotus*, which are edible and have excellent flavour and taste (Shah *et al.*, 2004). Mushrooms are recognised universally as food and are grown commercially in many parts of the world, including Nigeria. Mushroom substrate means a highly specific, nutrient-rich product prepared from selective organic and inorganic materials for the purpose of cultivating mushrooms. Substrates are both a physical support and a source of nutrients for the mushrooms needed to complete their life cycle (Diego *et al.*, 2011). Production of substrate for mushroom growth is recognised as the most critical stage of cultivation because it has a dramatic effect on yield, quality and economic viability of the crop (Dhar, 1994).

Oyster mushrooms are known to have medicinal properties such as antitumor, antiviral, antineoplastic, antimutagenic, antilipemic, antioxidant (Yashvant *et al.*, 2012) and contain good amount of protein, vitamins, minerals, low fat, crude fiber (Arun and Ramteke, 2010). Oyster mushroom cultivation is of economic importance in the area of agricultural waste recycling, animal feed, soil remediation, nutrition (Adedokun and Ataga, 2006; Emuh, 2010), economic use of land, income generating (Spore, 2006) and health.

Globally, huge volumes of wastes are generated through agricultural, forestry, industrial processes and their accumulation causes environmental pollution. Many agricultural wastes such as banana leaves, corn husk, corn cobs, palm fruit shaft, cotton wastes, sawdust,

wheat straw, cassava peel, rice straw, cocoa pods and coconut husk have been used as substrates (growth medium) for mushrooms production (Adedokun *et al.*, 2003; Amunke *et al.*, 2011; Stanley *et al.*, 2011; Gume *et al.*, 2013; Adedokun, 2014).

Sawdust is composed of tiny particles of wood produced when wood is sawed. Kenaf (*Hibiscus cannabinus*) is a fibre plant native to east-central Africa, where it has been grown for several thousand of years for food and fibre. It is a common wild plant of tropical and subtropical Africa and Asia and has been used as a source of textile fibre for such products as rope, twine, bagging and rugs (LeMahieu *et al.*, 1991). Cultivation of mushroom on kenaf plant stem is novel in mushroom cultivation because to date there is little or no record of kenaf being used as substrate in mushroom cultivation. Dry plantain leaves are waste got from the plant *Musa paradisiaca*, which are abundant in Africa and are regarded by most individuals as garbage. Oil palm fruit shaft is a by-product after processing the fruit of the plant *Elaeis guineensis*. According to Sreekala *et al.* (1997), mesocarp fibres are left as waste material after oil extraction, creating great environmental problems.

The aim of this study was to examine the growth of Oyster mushrooms on selected agricultural wastes and investigate the relationship between the nutrient of the sporophores (fruiting bodies) and the substrate on which they were grown.

MATERIALS AND METHODS

This study was carried out at the mushroom unit of the University of Port-Harcourt Demonstration

Farm, Choba Port-Harcourt in Rivers State, Nigeria. It lies at latitude 4 °53N and longitude 6° 57E.

Substrate source. Dry plantain banana leaves, kenaf stem, sawdust and palm fruit shaft were the materials used as substrates. Dry plantain leaves and kenaf stem were collected from the University of Port-Harcourt Demonstration Farm. Sawdust was collected from a mill at Rumuosi, nearby the University and palm fruit shaft was from oil mill at Aluu, nearby the University. These materials were selected because they are readily available as agricultural waste. The pure culture of the mushroom used for this study was that of PF001UPHNIG from the mushroom Bank of University of Port-Harcourt Mushroom Farm.

Substrate preparation. Substrate samples were sun-dried and analysed to determine nutrient status prior to mushroom cultivation. Four agricultural wastes: palm fruit shaft, dry plantain leaves, kenaf and sawdust were used as test substrates. Each substrate was mixed in a ratio of 80% dry substrate, 15% wheat bran and 5% lime with 150-200 ml of water, depending on substrate, but ensuring no water logs. The method used for mushroom cultivation was that of modified Stamets (2000). Five hundred grammes of each material was packed and sealed in polyethylene bags, and sterilised and inoculated with 10% (w/w) of spawn in a sterile environment and later transferred to an incubation room for ramification. Each substrate was replicated five times.

Data collection. Mycelia run were assessed by recording the number of days mushroom mycelia fully colonised a substrate bag.

Fruiting and harvesting. Substrate bags, when fully colonised with mycelia, were transferred to the fruiting room and opened to initiate fruiting, through sprinkling of water on the bags. Sporophores (fruiting bodies) were harvested by hand-twisting, weighed with electronic digital balance and dried in a fabricated solar dryer of temperature 48±2°C for 4 days. When constant weight was observed, the dried samples were kept in air-tight envelopes and taken to the laboratory for analysis.

After harvesting, the test substrates as well as fruiting bodies, were analysed for total starch and total fat content, determined by the amylo-glucosidase/ α -amylase method, with UV-Visible spectrophotometry (McCleary *et al.*, 1997). Total fat was analysed using the chloroform/methanol gravimetric method according to AOAC Official Method 983.23. (1990).

Data obtained were analysed using analysis of variance (ANOVA) procedure of SAS statistical software package (2001).

RESULTS

Mycelia run on various substrates. *Pleurotus floridanus* cultivated on test substrates colonised all the substrates used (Plate 1). However, the rate of colonisation was different among substrates. Substrate colonisation by mycelia was significantly superior in palm fruit shaft and least in Kenaf. When compared with palm fruit shaft, the percentage change for days to mycelia-run of other substrates are: 115, 127 and 128% for sawdust, plantain leaves and kenaf, respectively. Palm fruit shaft substrate differed significantly ($P < 0.05$) from kenaf and plantain leaves, but not sawdust.

Mushroom yield. Table 2 displays yield of Oyster mushroom. Overall, the highest total yield was obtained from palm fruit shaft. There was significant ($P < 0.05$) difference between the yield of palm fruit shaft and other substrates. However, there was no significance different ($P > 0.05$) between the yield of kenaf and sawdust. Furthermore the yield of Oyster mushroom between flushes was significantly different ($P < 0.05$), the first yield being greater than the subsequent flush.

TABLE 1. Mycelia run on substrates

Substrates	Mycelia run (days)
Palm fruit shaft	25.20
Kenaf	32.40
Sawdust	29.00
Plantain leaves	32.20
LSD (0.05)	4.63

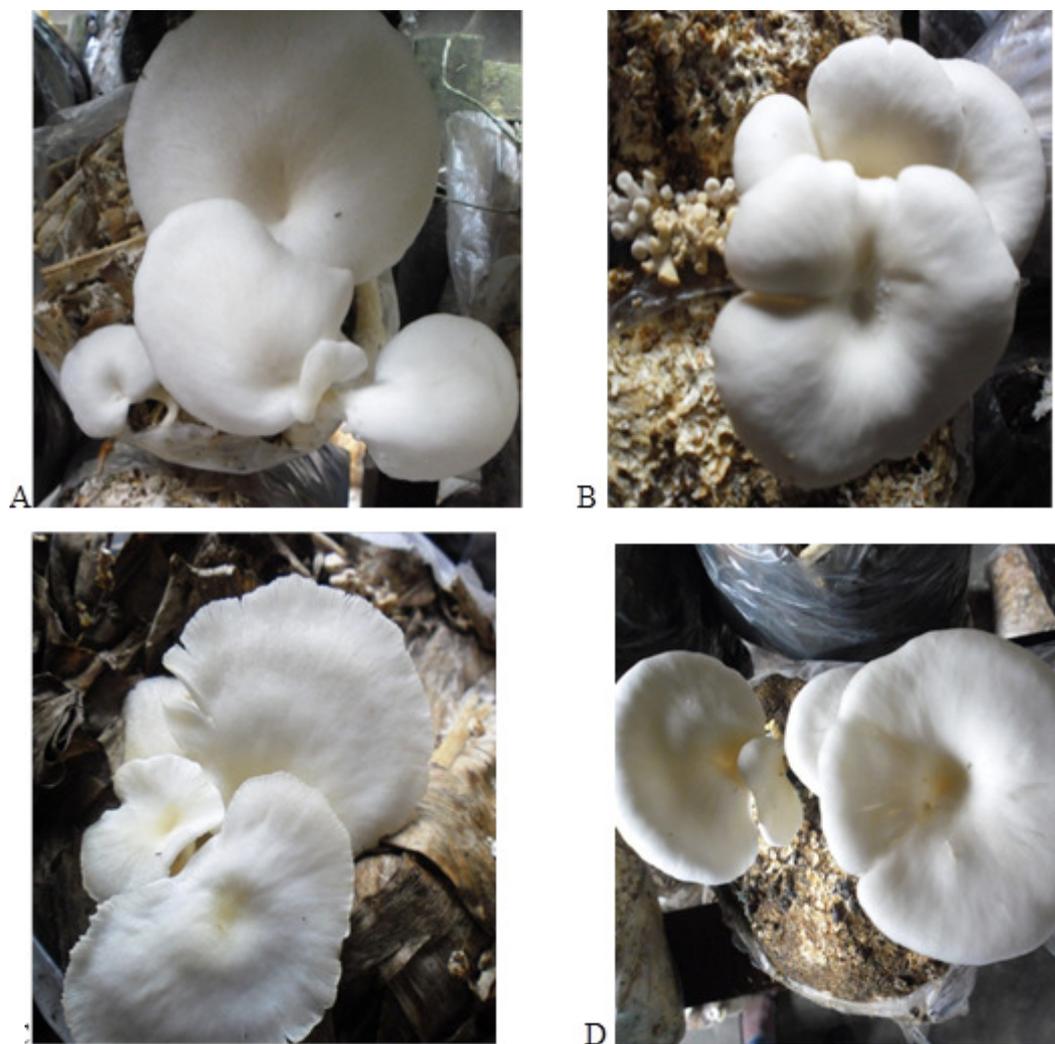


Plate 1. Fruiting bodies of *Pleurotus floridanus* cultivated on different substrates. A = kenaf, B = palm fruit shaft, C = plantain leaves, D = sawdust.

TABLE 2. Total yield of mushroom on different substrates

Substrate	Flushes (100 g ⁻¹)		Total (100 g ⁻¹)
	1 st	2 nd	
Palm fruit shaft	37.2	14.2	51.4
Kenaf	22.6	10.1	32.7
Sawdust	22.9	11.3	34.2
Plantain leaves	4.8	1.2	6.0
LSD (0.05)	8.92	4.23	

TABLE 3. Nutritional contents of fruiting bodies and substrates

Substrate	Starch content (100 g ⁻¹)		Fat content (100 g ⁻¹)	
	Substrate before study	Mushroom	Substrate before study	Mushroom
Palm fruit shaft	4.45	4.56	0.41	0.55
Kenaf	0.33	2.66	1.18	1.01
Sawdust	2.81	5.31	1.09	1.01
Plantain leaves	2.15	4.49	2.55	1.72
LSD (0.05)	0.28	1.01	0.74	0.87

Nutritional contents. The nutritional contents of mushroom and substrate samples are as presented in Table 3. The fat and starch content varied from one substrate to another, the fat content was lower than the starch content for both mushroom and substrate. The fat content of the mushroom was proportional to that of the substrate; the lowest being in palm fruit shaft and the highest in plantain leaves. There was significant difference ($P < 0.05$) among substrates as well as the mushrooms harvested from them. Starch content of the mushroom compared well with substrates, except for sawdust. Kenaf had the lowest starch content both for substrate and mushroom. The highest substrate starch content was recorded in palm fruit shaft whereas starch content for mushroom was highest on sawdust substrate. There was significant difference ($P < 0.05$) for starch content among the substrates; however, mushrooms harvested on kenaf were significantly different from those harvested on other substrates, which are not significantly different from one another.

DISCUSSION

Mycelia- run and mushroom yield on substrates.

Three substrates used in this study compared well with sawdust in mycelia run, yield and nutritional content (Tables 1, 2 and 3) which is widely used for mushroom production. Palm fruit shaft substrate scoring best. Cultivation of mushroom on kenaf plant stem is novel in mushroom cultivation because to date there is little or no record of kenaf being used as substrate in mushroom cultivation. This may be harnessed for cultivation in areas where it occurs in

abundance. The fact that all the agricultural substrates used supported growth of mushroom mycelia and fruiting bodies could be due to the ligno-cellulosic substances present in the test substrates. Various researchers have reported the bio-conversion of ligno-cellulosic residues through cultivation of mushrooms (Onyango *et al.*, 2011; Adedokun, 2014). Utilisation of these ligno-cellulosic agricultural residues for mushroom production could obviate a number of environmental concerns resulting from disposal of the materials as wastes.

The full mycelia colonisation, which was attained at different times (Table 1) by each substrate suggests that complete ramification of any substrate by mycelia of mushrooms is substrate dependent. Since the quantity of the substrates was similar, the variations observed in the colonisation of mushroom mycelia could be attributed to differences in bio-chemical composition, such as lignin, cellulose, starch, and other essential plant components. Findings in this research agree with the work of several researchers (Shah *et al.*, 2004; Adebayo *et al.*, 2009; Kymberly, 2010); but not with Onuoha *et al.* (2009) who reported no colonisation of substrates from oil palm fibre.

Mushroom growth on palm fruit shaft, plantain leaves and kenaf is good news in Africa because it is an innovative value addition to by-products to which little or no value would ordinarily have been attached. The quantity of wheat bran supplement may be increased to boost yield (Adedokun *et al.*, 2003; Oei, 2003). The sporophores of oyster mushroom were harvested in two flushes and the maximum yield was obtained in first, which was greater than the

second flush. The reduction in yield could have been caused by the depletion of nutrients from substrates (Amuneke *et al.*, 2011).

Nutritional composition of mushroom substrates and fruiting bodies. The results on nutritional composition of substrates and fruiting bodies agree with those of Silva *et al.* (2002) who reported that although, there may be correlation in chemical composition of mushroom and substrate used for cultivation, chemical composition of mushroom does not correspond to the chemical composition of substrate. The findings of Khan *et al.* (2008) reported that the nutritional composition of oyster mushroom differs significantly when grown in different substrates. Other works have also reported varied amount of fat contents in oyster mushrooms grown on different substrates (Vimla, 2009). The relatively low content of starch and fat supports other research claims that mushroom are low carbohydrate, low in fat vegetables (Chang and Mshigeni, 2001).

REFERENCES

- Adebayo, J.G., Banjo, N.O. and Abikoye, E.T. 2009. Evaluation of yield of oyster mushroom (*Pleurotus pulmonarius*) grown on cotton waste and cassava peel. *African Journal of Biotechnology* 8(2):215-218.
- Adedokun, O.M. 2014. Oyster mushroom: Exploration of additional agro-waste Substrates in Nigeria. *International Journal of Agricultural Research* 9 (1):55-59.
- Adedokun, O.M., Ayodele, V.I. and Fasidi, I.O. 2003. Spawn production and growth of *Pleurotus tuber regium* (fries) singers on agricultural wastes. *Bioscience Research Communications* 15 (6): 437 - 444
- Adedokun, O.M. and Ataga, A.E. 2006. Effects of crude oil and oil products on growth of some edible mushrooms. *Journal of Applied Science and Environmental Management* 10 (2): 91 - 93.
- Amuneke, E.H., Dike, K.S. and Ogbulie, J.N. 2011. Cultivation of *Pleurotus ostreatus*: An edible mushroom from agrobased waste products. *Journal of Microbiology and Biotechnology Research* 1:1-14.
- Arun, I. and Ramteke, A. 2010. Studies on cultivation and biological efficiency of mushrooms grown on different agro-residues. *Dunărea de Jos” University - Galați. Innovative Romanian Food Biotechnology* 6: 25-28.
- AOAC Official Methods of Analysis, Method 983.23. 1990. Association of Official Analytical Chemists: 15th Ed, Arlington, VA.
- Chang, S.T. and Mshigeni, K.E. 2001. Mushrooms and human health: Their growing significance as potent dietary supplements. The University of Namibia, Windhoek. pp.1-70.
- Dhar, B.L. 1994. Mushroom composting for *Agaricus bisporus/bitorquis*. In: Nair, M.C. (Ed.). *Advances in Mushroom biotechnology*, Jophpur: Scientific Publishers. pp. 84-90.
- Emuh, F.N. 2010. Mushroom as a purifier of crude oil polluted soil. *International Journal of Science and Nature* 1(2): 127-132.
- Gume, B., Muleta, D. and Abate, D. 2013. Evaluation of locally available substrates for cultivation of some edible mushrooms. *African Journal of Microbiology Research* 7: 2228-2237.
- Khan Asaduzzaman, Md., Tania Mousumi, S.M. Ruhul Amin, Nadia Alam and Nazim Uddin Md. 2008. An investigation on the nutritional composition of mushroom (*Pleurotus florida*) cultivated on different substrates. *Bangladesh Journal on Mushroom* 2(2):17-23.
- Kymberly, R.D. 2010. Vigor, sex and woody substrates: Lessons from the cultivation of *Pleurotus Ostreatus*. University of Wisconsin-Green Bay Solid Waste Research Program.
- LeMahieu, P.J., Oplinger, E.S and Putnam D.H. 1991. Kenaf an alternative field crops manual. Wisconsin Agricultural extension service. <http://bioweb.sungrant.org/Technical/Biomass+Resources/Agricultural+Resources/New+Crops/Non-Wood+Fiber+Crops/Kenaf/> (Accessed April 29, 2014).
- McCleary, B.V., Gibson, T. S. and Mugford, D. C. 1997. Measurement of total starch in cereal products by amyloglucosidase - α - amylase method: Collaborative study. *Journal of Association of Official Analytical Chemists International* 80: 571-579.

- Oei, P. 2003. Mycelia sell this fascinating mushroom growing book: Mushroom Cultivation, Third Edition, Backhuys Publishers, Leiden, The Netherlands. 429pp.
- Onuoha, C.I., Ukaulor, U. and Onuoha C.B. 2009. Cultivation of *Pleurotus pulmonarius* (mushroom) using some agro waste materials. *Agricultural Journal* 4(2):109-112.
- Onyango, B.O., Palapala, V.A., Arama, P.F., Wagai, S.O. and Gichimu, B.M. 2011. Suitability of selected supplemented substrates for cultivation of Kenyan native wood ear mushrooms (*Auricularia auricula*). *America Journal of Food Technology* 6: 395-403.
- SAS, 2002. SAS for Windows Release 9.1 (Statistical Analysis Systems Institute Inc. Cary, NC, USA).
- Shah, Z.A., Ashraf, M. and Ishtiaq, M.C. 2004. Comparative study on cultivation and yield performance of Oyster mushroom (*Pleurotus ostreatus*) on different substrates (wheat straw, leaves, saw dust). *Pakistan Journal of Nutrition* 3(3):158-160.
- Silva, S.O., Gomes da Costa, S.M. and Clemente, E. 2002. Chemical composition of *Pleurotus pulmonarius* (Fr.) Quel., Substrates and residue after cultivation. *Brazilian Archives of Biology and Technology* 45(4): 531-535.
- Sreekala, M.S., Kumaran, M.G. and Thomas, S. 1997. Oil palm fibres: Morphology, chemical composition, surface modification, and mechanical properties. *Journal of Applied Polymer Science* 66(5): 821-835.
- Stamets, P. 2000. Growing gourmet and medicinal mushrooms, ten speed press, California. 574pp.
- Stanley, H.O., Umolo, E.A. and Stanley, C.N. 2011. Cultivation of oyster mushroom (*Pleurotus pulmonarius*) on amended corncob substrate. *Agriculture and Biology Journal of North America* 2(8):1239 - 1243.
- Spore. 2006. Information for Agricultural development in ACP countries. CTA Issue, 124 (August).
- Vimla Dunkwal and Sudesh Jood. 2009. Effect of substrates on nutrient composition of oyster mushroom (*Pleurotus sajor caju*). *Journal of Dairying, Food and Home Sciences* 28 (2):132-136.
- Yashvant, P., Ram, N. and Singh, V.K. 2012. Medicinal properties of *Pleurotus* Species (Oyster mushroom): A Review. *World Journal of Fungal and Plant Biology* 3(1): 01-12.
- Zied, D.C., Savoie, J. and Pardo-Giménez, A. 2011. Soybean the main nitrogen source in cultivation substrates of edible and medicinal mushrooms. Soybean and nutrition. Hany El-Shemy (Ed.). ISBN: 978-953-307-536-5, InTech. <http://www.intechopen.com/books/soybean-and-nutrition/soybean-the-main-nitrogen-source-in-cultivation-substrates-of-edible-and-medicinal-mushrooms>.