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# Substrate fortification and proximate analysis of cultivated mushroom (*Pleurotu ostreatus*)

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## ABSTRACT

The mineral contents, fatty acid, and nutritive composition of mushroom *Pleurotus ostreatus* species grown on various (fortified and unfortified) substrates were analysed. The yield from unfortified and fortified substrates ranged from 40-74 g/kg, while the percentage protein content, carbohydrate, Crude fats, Moisture content, and Ash were all experimentally determined. The average values were 27.83%, 26.37%, 3.74%, 84.50% and 0.84% respectively. The Mineral contents of the grown mushrooms were also determined. The parameters were found to be higher than those of pulses, vegetables and meat. 

## KEYWORDS

Mushroom;
Substrates;
Mineral content;
Fatty acid;
Nutritive composition.

## INTRODUCTION

There is urgent need for prompt and sustainable actions to be taken on the disposal and management of wastes of all kinds. Waste problems are at the critical levels both in our cities, towns and villages. Agricultural wastes though, biodegradable constitute serious health threat to lives in both towns and cities, most especially during the harvesting periods of fruits and vegetables. Domestic and industrial wastes are another kind of wastes posing problems to the conducive living in our society. Osun state southwest of Nigeria, being an agrarian state is not shielded from this menace of domestic wastes and wastes from agro-allied industries, which are abundant. Streams and Rivers in the localities are often blocked with sawdust from the saw mills and garbage of wastes.

Mushrooms are saprophytic, growing on dead organic matter of vegetative origin. Mushrooms can utilize almost all agricultural wastes as substrates[1]. The Science Laboratory Technology Department of the Federal Polytechnic Ede, Osun state of Nigeria, through her Microbiology Unit, has been using sawdust from the neighbourhood sawmills for the cultivation of mushrooms. This attempt is one of the sustainable ways of managing waste from this agro-allied industry. The cultivated mushrooms and mushroom stocks production has become popular among the members of the Polytechnic community and beyond. Thus, the need to increase the mushroom production output.

Saprophytic species are cultivated for mushroom production on lignin and cellulose containing substrates such as wood logs, saw dust, straw and cotton waste, besides many other agricultural and food wastes, which can easily be transformed into a wide diversity of products (edible or medicinal food, feed and fertilizers), protecting and regenerating the environment[2]. The proficiency of fungi in converting substrate to protein is far superior to that of several plants and even animals[3].

Mushrooms serve as delicacies for human consumption and as neutriceuticals i.e. food that also cures. Mushrooms, the fruiting bodies of basidomycetous fungi, contain substances of various kinds that are highly valued as medicines, flavoring and perfumes[3]. It is considered health food as it is low in calories, fat and cholesterol, while rich in protein, carbohydrate, fibers, vitamins and minerals[4]. *Pleurotus ostreatus* is an edible and are among the easiest mushroom to cultivate[5]. It is a white rot basidiomycete, which belongs to the subclass of ligninolytic microorganisms that produce lactases, manganese peroxidases, amylase, cellulase, pectinase and protease[6].

During the growth of mushroom mycelia and the development to mature fruit bodies (or sporophores), biochemical changes are known to occur, as a result of which enzymes are secreted extracellularly to degrade the insoluble materials in the substrates into simple and soluble molecules which are subsequently utilized by intracellular enzymes within the mushroom[7]. Consequently, enzymes play significant role in mushroom development; in addition, they also affect the food nutrient, flavour and shelf life of these fungi[8]. Accumulations of lignocellulosic materials in large quantities from agricultural residues present disposal problems which results in deterioration of the environment. In Egypt, rice straw is used extensively as a substrate in cultivating *Pleurotus ostreatus* and *Agaricus species* for production of fruit bodies mushroom. Unprocessed citrus pulp wastes (orange, lemon.) could be alternatively utilized as carbon sources to grow microorganisms[9]. Many workers used papaya (Carica papaya) peel and latex for preparation of papain, proteolytic enzymes, ethanol and other products[10].

Sawmill industry is a thriving business in Osun state and quite a good fortune has being made in this line of business. However, the sawdust, a by-product of the mill constitutes environmental problems to the community where these mills were located. Quite a lot of uses have being found for the utilization of this waste. The Science Laboratory Technology Department of the Federal Polytechnic, Ede Nigeria has been utilizing sawdust from the community sawmills for the cultivation of mushroom. So, the aim of this work was to integrate more agricultural wastes into the mushroom production for increase output and contrasting its nutritional content with those grown on unfortified substrates.

## MATERIALS AND METHODS

Ten different sawdust collected from sawmills in the locality were used for the study. The cassava peel (C.P), the maize straw (M.S) and orange pulp (O.P), wastes respectively were dried and milled. The milled wastes were used to fortify sawdust in various ratios as shown in TABLE 1.

The mushroom cultured spawn mixture from I.I.T.A (International Institute for Tropical Agriculture) was mixed with freshly sterilized substrates (fortified and unfortified) placed in polythene bags. The average weight of each bag with its content is l kilogramme. The bags were closed and incubated for 15 days (2 weeks) at $25^0$ C and $30^0$C in darkness in accordance to[8]. The bags were opened after 2 weeks and sprayed with water using knapsack sprayer to increase the humidity of the cultured media in order to initiate the development of mushrooms. The time taken for the full development of mushrooms, fruit bodies and the yield on each of the substrates types were recorded.

The moisture content was determined according to A.O. A.C[11]. Lipid content was determined after extraction of the dried and powdered mushroom using hot extraction method (Soxhlet apparatus) with of methanol and chloroform[12]. The fatty acid methyl esters were prepared and were analysed with Hewlett Packard GC (HP 6890 series) Powered with HP Chemstation software, with flame ionization detector (FID) and HP. inNowax (cross-linked PEG)column. The method described by[7] was used to estimate the carbohydrate content of mushroom fruit body. Crude protein was measured by Kjeldahl method as (N.x 6.25) as adopted by[10].

## RESULTS AND DISCUSSION

The cassava peel (C. P), the maize straw (M. S) and the orange pulp (O.P) waste respectively were dried and milled. The milled wastes were used to fortify the sawdust in various ratios as shown in TABLE 1. The TABLE 1 shows the yield of the mushroom using different substrates: the substrates are in the first column of the table while the last column shows the average yield of ten replicate yields. The average yield obtained by fortification of sawdust, using cassava peel (C.P) ranges from 53-74 g/kg. The lowest yield was obtained with least fortification (1:3). This shows that fortification of sawdust with some wastes will improve its yield. The cassava peel fortified saw- dust gave the highest yield due to its high starch content. As the cassava peel content increases, yield also increases.

The maize straw (M.S) fortified sawdust also gave an average yield that ranges from 51-54 g/kg, giving the highest yield with the highest amount of maize straw (1:3). Although, the average yield of orange pulp (C.P) fortified sawdust is the lowest when compared with the yields from other wastes. The average yield ranges from 42-44g/kg but it is still higher than the average yield of 100% sawdust (40 g/kg). Thus indicating that yield of cultivated mushroom could be improved by fortification of the sawdust. It could be concluded that the fortification had increased the materials (food materials) that improves the growth of mushroom. Fortification improved yield as shown by[8] where the highest yield of 957.9g/kg was obtained using rice straw substrate fortified with lemon pulp.

The yield of the extracted oil from the cultivated mushroom was shown in TABLE 2. The fatty acid ranges between 2.00-5.92% with the yield from the unfortified sawdust having the highest 5.92% while the lowest yield was obtained with cassava peel fortified sawdust (1:2). The fatty acid obtained with unfortified lemon waste was the highest as reported by[8]. The following fatty acids were present in the extracted oil, Myristic and Palmitic acids (C14:0-C16: 1): saturated fatty acids. The percentage yield of the saturated fatty acid ranges from 25.0-29.80%. The unsaturated fatty acids present in the extracted oil are Oleic (C18:0), Linoleic (C18: 1). Linolenic (C18:2) and Arachidinic acids (C20: 0). The percentage of the unsaturated fatty acids ranges from 70.2-79.5%. The valued show that mushroom contains a high percentage of unsaturated fatty acids, which are of low cholesterol thus; mushroom could be used for dieting. The Linolenic acid, which gave the highest percentage value, is an essential oil, which could be used for infant feeding.

**TABLE 1 : Yields of 100% Saw-dust and Saw-dust fortified with other wastes**

| Substrates (g) | ±S.D | ± S.D | ± S.D | ± S.D | ± S.D | ± S.D | ± S.D | ± S.D | ± S.D | ± S.D | Ave.yeild |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sd 100% | 40±5.0 | 35±3.5 | 45±4.5 | 42±4.5 | 41±6.6 | 37±5.0 | 38±3.5 | 44±4.0 | 42±4.0 | 41±3.0 | 40 |
| Sd+C.P 1:1 | 50±7.0 | 47±6.5 | 60±5.5 | 54±5.5 | 53±4.5 | 50±4.5 | 53±4.5 | 57±3.5 | 56±4.5 | 55±4.0 | 53 |
| Sd+C.P 1:2 | 60±6.0 | 62±5.5 | 62±4.5 | 61±6.5 | 60±5.5 | 57±5.5 | 58±6.0 | 60±4.5 | 61±3.0 | 60±3.5 | 57 |
| Sd+C.P 1:3 | 76±10 | 70±6.0 | 80±8.5 | 75±7.5 | 72±4.5 | 67±6.0 | 66±4.5 | 81±7.0 | 79±4.0 | 75±5.0 | 74 |
| Sd+M.S 1:1 | 52±6.5 | 50±4.5 | 53±4.5 | 50±5.5 | 50±5.5 | 48±5.5 | 50±5.0 | 54±5.0 | 55±4.5 | 53±3.0 | 51 |
| Sd+M.S 1:2 | 51±3.7 | 50±6.5 | 51±3.5 | 50±4.5 | 51±4.5 | 49±.4.5 | 50±3.5 | 52±4.5 | 51±3.5 | 50±4.0 | 50 |
| Sd+M.S 1:3 | 54±5.5 | 51±7.5 | 56±4.5 | 60±4.5 | 57±5.5 | 51±3.5 | 50±4.0 | 60±3.5 | 58±5.0 | 56±4.5 | 54 |
| Sd+O.P 1:1 | 45±7.3 | 41±5.5 | 47±6.5 | 46±5.5 | 44±4.5 | 41±5.0 | 40±5.5 | 46±4.0 | 47±3.5 | 43±4.0 | 44 |
| Sd+O.P 1:2 | 46±7.5 | 42±3.5 | 49±4.50 | 43±4.5 | 41±5.5 | 40±3.5 | 42±4.5 | 46±3.5 | 46±5.0 | 47±3.0 | 44 |
| Sd+O.P 1:3 | 43±6.5 | 40±2.7 | 46±4.5 | 43±6.5 | 40±4.5 | 40±4.5 | 42±4.0 | 48±6.5 | 47±4.0 | 41±4.0 | 42 |

**Sd = Saw dust; S.D = Standard Deviation; C.P = Cassava peels; M.S Maize Straw; O.P = Orange Pulp wastes.**

TABLE 2 : Fat profile of mushroom (*Pleurotus ostreatus*)

| Fatty acids | Saw dust | Cassava peels | | | Maize straw | | | Orange pulp | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100% | 1:1 | 1:2 | 1:3 | 1:1 | 1:2 | 1:3 | 1:1 | 1:2 | 1:3 |
| C14:0 | ND | ND | 2.8 | 2.0 | ND | ND | ND | 2.9 | ND | ND |
| C16:0 | 14.0 | 13.5 | 13.0 | 13.2 | 15.2 | 14.0 | 14.5 | 12.9 | 2.1 | 13.2 |
| C16:1 | 12.0 | 11.5 | 11.7 | 10.2 | 13.9 | 14.8 | 14.5 | 14.0 | 18.4 | 14.8 |
| C18:0 | 7.2 | 12.0 | 11.5 | 12.2 | 11.2 | 10.8 | 9.8 | 9.0 | 8.7 | 11.4 |
| C18:1 | 10.2 | 10.0 | 9.5 | 9.0 | 13.2 | 11.3 | 11.7 | 17.2 | 6.4 | 11.4 |
| C18:2 | 50.0 | 49.2 | 48.6 | 46.4 | 43.7 | 43.6 | 45.5 | 44.0 | 61.1 | 48.9 |
| C20:0 | 6.6 | 3.8 | 2.9 | 3.4 | 3.0 | 3.0 | 4.0 | N.D | 3.3 | N.D |
| C20:4 | N.D | N.D | N.D | 3.6 | N.D | 2.5 | N.D | N.D | N.D | N.D |
| Saturated | 26.0 | 25.0 | 27.5 | 25.4 | 29.0 | 28.9 | 29.0 | 29.0s | 20.4 | 28.0 |
| Unsaturated | 74.0 | 75.0 | 72.5 | 74.5 | 71.1 | 71.2 | 71.0 | 70.2 | 79.5 | 71.7 |

**ND: Not Detected**

The protein content of the mushroom for the unfortified and fortified is shown on the second column of TABLE 3. For the unfortified its average percentage of 26.30%, while for sawdust fortified with cassava peel it ranges between 27.00-31.50%, for sawdust fortified with maize straw it ranges between 26.20-28.50 % and for orange pulp fortified sawdust, the protein values range between 26.50-28.80% respectively. The protein content was enhanced by the fortification with 31.50% been the highest. The mushroom protein content is high. The protein, which is easily digestible, has its quality between that of vegetable and meat[5]. (The mineral contents of a plant are a reflection of those present in the substrate on which it is grown, as reported by[8]. Hence, the enhancement of the protein content of the mushroom grown on the fortified sawdust. Mushroom is a fungus, which has a capacity to synthesis protein from

**TABLE 3 : Chemical composition of the mushroom (*P. ostreatus*) cultivated on different substrates.**

| Substrates | % Protein | % Total Carbohydrate | % Crude Fat | % Moisture Content | % Ash Content |
|---|---|---|---|---|---|
| 1. | 26.30 | 24.08 | 5.92 | 89.20 | 0.91 |
| 2. | 27.00 | 25.92 | 4.00 | 85.30 | 0.82 |
| 3. | 29.20 | 29.72 | 2.00 | 82.25 | 0.85 |
| 4. | 31.50 | 33.00 | 3.00 | 88.15 | 0.75 |
| 5. | 26.00 | 20.88 | 3.99 | 84.20 | 0.90 |
| 6. | 27.20 | 24.07 | 4.20 | 83.25 | 0.92 |
| 7. | 28.50 | 26.68 | 4.00 | 80.10 | 0.89 |
| 8. | 28.80 | 27.04 | 3.89 | 80.30 | 0.78 |
| 9. | 27.30 | 26.70 | 3.45 | 85.15 | 0.79 |
| 10. | 26.50 | 25.60 | 2.90 | 87.13 | 0.75 |

its substrate thus, the high protein content and its enhancement as was also reported by[7].

The carbohydrate content was 24.07% for mushrooms grown on the unfortified substrate, and a range of value of 24.07- 33.00% respectively for the mushroom grown on fortified substrates, thus showing an enhancement of the carbohydrate content. The content is not high, thus having a low energy value as shown by[1]. The variations were the same as reported by[3]. They reported a variation of between, 20-32%. It has high moisture content 80.20 -89.20% for unfortified and fortified substrates. Its shelf-life is low due to the high moisture content; it is therefore a highly perishable material. Its ash value is also lows it ranges from 0.7%-0. 92%;

**TABLE 4 : Average nutritive metals in cultivated mushroom on the unfortified and fortified substrates**

| | Ca mg/l | Mg mg/l | K mg/l | Na mg/l | Mn mg/l | Fe mg/l | Cu mg/l | Zn mg/l |
|---|---|---|---|---|---|---|---|---|
| UNF | 400 | 1200 | 28710 | 70.37 | 4.91 | 29.80 | 5.45 | 1.93 |
| CPF | 418.33 | 1170 | 26371.67 | 72.92 | 5.15 | 41.03 | 5.55 | 2.27 |
| MSF | 393.33 | 1217 | 27975.0 | 70.88 | 4.95 | 36.73 | 5.27 | 1.75 |
| OPF | 420 | 1258.33 | 27700 | 71.83 | 5.02 | 35.68 | 5.19 | 2.01 |
| FSD | 8000 | 1000 | 2100 | 65.31 | 19.62 | 45.67 | 2.75 | 1.25 |

**Key: UNF= Unfortified Substrate; CPF= Cassava Peel Fortified Substrate; MSF= Maize Straw Fortified Substrate; OPF= Orange Pulp Fortified Substrate; FSD= fortified saw-dust**

The average mineral contents found in the cultivated mushroom are shown in TABLE 4. The calcium concentration ranges between 393.33- 8000.00mg/l, the fortified sawdust has the highest while the maize straw has the lowest. The Magnesium concentration ranges between 1000.00-1258.33 mg/l, the potassium concentration is 2100.00-28710mg/l. Sodium concentration ranges between 65.31-72.92mg/l, while Manganese concentration ranges between 4.51-19.62 mg/l showing that fortified sawdust has the highest, iron concentration also ranges between 29.80- 45.67 mg/l, copper ranges between 2.75-5.19, mg/l. The Zinc concentration is the lowest in all the samples while that of potassium is the highest. The mineral content is higher than those present in pulses as reported by[14]. The mushroom sshowed higher source of mineral contents when compared to pulses[10].

## CONCLUSION

The present study indicates that it is feasible to use

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agricultural wastes (orange pulp and mango fruit waste, maize straw and saw dust) as raw materials for the production food grade fungus *Pleurotus ostreatus* which are rich in vitamins and nutritive elements for healthy living. Moreover, utilization of these agro wastes for the cultivation of this mushroom is an effective method for the production of nutritional food and offers a holistic and sustainable approach to waste management in our community.

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