

Chemical Composition and Nutritional Value of Mature and Young Fruiting-Bodies of *Pleurotus Pulmonarius* Produced On *Andropogon Gayanus* Straw and *Khaya Ivorensis* Sawdust

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Abstract: *Pleurotus. Pulmonarius* was cultured in the laboratory of the Department of plant Sciences and Biotechnology, Michael Okpara University of Agriculture, Umudike. The mycelium of the mushroom was bulked up on guinea corn grains and was used to produce fruit-bodies on *Andropogon gayanus* straw and *Khaya invorensis* sawdust. The Chemical composition and nutritional values of the young and mature fruit-bodies evaluated. The nutrient composition in terms of the crude oil, protein, ash, total carbohydrate content mineral and vitamins contents were analyzed, and these were found out to vary dependent upon the stage of fruit-body development and substrate types. The moisture content was at maximum at immature stage and decreased during further development of the mushroom while the ash and fibre contents showed an opposite trend. The highest ash and fibre contents were obtained from the matured fruit-bodies and the lowest in the young fruit-bodies. Similarly the fats and protein contents of the mature fruit-bodies were higher than those of the young fruit-bodies. However the carbohydrate contents of the mushroom fruit-bodies were neither influenced by the substrates nor their stages of development. There was no significant difference between the proximate compositions of the fruit-bodies harvested from *Andropogon gayanus* straw and those from *Khaya invorensis*. The fruit-bodies were equally rich in Niacin, Thiamine, Ascorbic acid and Riboflavin. However the concentrations of the vitamins (in mg/100g) were more in the fruit-bodies harvested from *A. gayanus* straw than those from *K. invorensis* sawdust. In each case however, matured fruit-bodies had higher contents of the vitamins than young fruit-bodies. The result of the analyses shows that *P. pulmonarius* fruit-bodies contained minerals (Potassium, Sodium, Magnesium, Phosphorus and Calcium) and bio-active compounds (Alkaloids, Phenol, Tannin, Saponin and Hydrogen cyanide) in varying quantities. and mineral elements (Potassium, Sodium, Magnesium, Phosphorus and Calcium). *Andropogon* straw produced fruit-bodies with higher Potassium, than those from *Khaya* sawdust and this mineral occurred more in the matured fruit-bodies than in young ones in each case. The other minerals were low and did not show any defined trend in both the substrate and in the stages of development. Similarly, Alkaloids, contents of both matured and young fruit-bodies and from the two substrates were higher than the rest of the bioactive compounds respectively. The results of the investigation were discussed in relation of the best stage of the fruit-bodies for consumption and best substrate for the cultivation of the mushroom.

Key words: Chemical composition, nutritional value *Pleurotus pulmonarius* Matured fruit-bodies, young fruit-bodies

I. Introduction

Mushrooms are fleshy noticeable fruiting-bodies of fungi, typically produced above the ground on soil or other food sources. The word mushroom is most often applied to those fungi belonging to the Division *Basidiomycotina* and a few members of the Division *Ascomycotina*). The fruiting -bodies of most mushrooms are shaped like an umbrella with central stalk (stipe) supporting a cap (pileus), which bears gills (lamellae) that produce spores on the lower side. In some species e.g *Pleurotus*, the stipe may be absent especially those growing on wood (Jose *et al*; 2002). As fungi, mushrooms lack chlorophyll and therefore cannot make their own food using solar energy. Instead, they have the ability to use the available substrates in nature by breaking down lignocellulosic compounds. They are therefore, saprophytes or parasites.

The use of mushroom as food in Nigeria is probably as old as civilization, (Ayodele, and Okhuoya, 2009). In the ancient days, mushrooms were gathered from the wild and eaten. The edible mushrooms were identified by associating them with the places they grow, the seasons of growth and also, the type of dead trees they grow on. However, there are iso of families who have perished after eating meals of poisonous mushroom such as *Amanita Species*. Such deaths have in no way, made many communities in the rural area shy away from eating mushrooms (Zoberi, 2000). Mushrooms with their flavour, texture, nutritional value and high productivity have been identified as an excellent food source to alleviate poverty in developing country (Eswaran and Ramabadram, 2000). Mushrooms have been evaluated for their nutritional status on the basis of

their chemical and proximate compositions. Cultivated and wild mushrooms contain reasonable amounts of proteins, carbohydrate, minerals, fibers and vitamins, (Stamets, 2000). Furthermore, mushrooms are low in calories, sodium, fats and cholesterol.

Edible mushrooms have also been considered to have medicinal value and to be devoid of undesirable effects. They may be eaten as meat substitutes and used as flavourings in foods, soups and sauces. They also contain large amount of vitamins and minerals. (Oie, 2003, Okwulehie *et al*; 2007,).

Oyster mushroom contains substances which lower the cholesterol level in serum and liver of rats (Okwulehie *et al*; 2007).

Okwulehie and Odunze (2004b) reported that *Auricularia judae*, *P. squarrosulus*, and *Russula* species were found to contain appreciable amounts of alkaloids, phenols, saponins and flavonoids. Alkaloids have powerful effects in animal physiology and are of interest in pharmaceutical industries for drug manufacture (Edeoga and Gomina, 2000). The present investigation is aimed at growing the edible mushroom *P. pulmonarius* using sawdust of *Khaya invorensis* and *Andropogon gayanus* straw; to evaluate the nutritive and phytochemical values of the mushroom, and find out the stage at which the mushroom contain more nutrient and recommend them to be consumed at that stage.

II. Materials And Methods

The spawn used for the research work was supplied from diplomat farms and services limited, Faculty of Agriculture, Teaching and Research Farms, Rivers State University of Science and Technology, Port Harcourt.

The substrates, sawdust of *Khaya invorensis* and straw of *Andropogon gayanus* used for the cultivation of *P. pulmonarius*. were moisturized, heaped and covered to allow for fermentation process. The *Andropogon* straw substrate chopped into about 10cm average lengths and soaked overnight in clean water (Sharma, 2003). The substrates were drained and 200kg weighed into 15x30cm of polyethylene bags. The polybags containing the substrates were pasteurized for one hours at 100⁰C in a gas-heated drum. (Okwulehie and Okoro, 2013)

After cooling, the substrates were inoculated with equal quantities of the grain-spawn. The bags were placed in wooden chambers and covered by rapping them with thick paper to allow for full colonization of the substrate by mycelia. After 4days they were transferred to wooden racks in the cropping room.

III. Data Collection

Fruiting of the mushroom commenced on the different substrates 12 days after inoculation and the first flush was harvested two days afterwards. The collected fruit-bodies were arranged according to their stages of development into young and matured, i.e. while young the pileus of the fruit-bodies appear like a small ball, while the mature fruit-bodies have fully open pileus (cap).

Proximate analysis

The determination of the total dry matter, protein, crude oil and ash contents of the young and mature fruit-bodies were separately done according to AOAC, 1995 procedures on dry matter basis. In other words, the dry matter content was analyzed at 65°C in an oven. Analysis of protein content was done according to the Kjeldahl method with a conversion ratio of 6.25 (Manzi, *et al*: 1999). Analysis of crude oil content was done by Soxhlet extraction with hexane, while ash content was analysis was by incineration of samples at 550°C. Total carbohydrates were calculated as the residual difference after subtracting protein, crude oil and ash contents on dry matter basis of the fruit-bodies samples. The total energy of 100 g of the fruit-bodies samples was calculated using the following equations (Manzi *et al*: 2004).on the basis of edible weight Kalmis *et al*: (2011). Energy, kcal =4 (protein content g + carbohydrates content, g) + 9 (crude oil content, g)

Energy, kj = 17 (protein content g + carbohydrates content, g) + 37 (crude oil content, g)

Mineral Content determination

The concentration of mineral elements in the fruit-bodies of Potassium, Sodium, Magnesium, Phosphorus and Calcium were determined using the wet digestion extraction method according to Nivozamsky *et al*; (1983).

Phytochemical contents

Quantitative estimation of the Chemicals:

Each value is the mean of three replicate determinations ± standard deviation.

Determination of Alkaloids

Five grams (5g) of the dry powdered sample was used to determine the alkaloids contents of the mushroom following the method of Harborne (1973). The alkaloid was expressed as percentage, i. e.

$$\% \text{ Alkaloids: } \frac{\text{weight of residue}}{\text{weight of sample}} \times 100$$

Determination of Flavonoids:

About 5g of the dry powdered sample was used to determine of Flavonoids according (Boham and Kocipai, 1994). The sample was mixed with 100mls of 2m HCl at room temperature. The solution was boiled for 30min with water bath, cool and filtered. 20mls of Ethyl Acetate was added to the filtrate and filtered again with a weighed filter paper. The filter paper was oven dry, cool and weighed

$$\% \text{ Flavonoids: } \frac{\text{weight of residue}}{\text{Weight of sample}} \times 100$$

Determination of tannin

The method of Okeke and Elekwa, (2003) was used for tannin determination using 5g of the sample shaken with 50mls of H₂O and and left to stand for 30 min. The solution was filtered and 2mls of the filtrates was introduced into a test tube and 3mls of 0.1M FeCl₃ and 2ml of potassium ferro cyanide were added. Addition of 46mls of water was done. It was filtered again and 1ml of the filtrate was used to read the absorbance at 710nm within 10 min

Determination of saponins

Saponins determination was carried out using (Harborne, 1973) method, Five (5) g of the sample was boiled with 100mls of 20% ethanol in a water bath for 1.30min and filtered while still hot. The filtrate was collected and heated for 30 min, in 40mls of ether then poured into a separating funnel, the lower part of the filtrate in the separating funnel was collect and 60mls of n-butanol was added and the upper layer/part was collect while the lower part was discarded, the filtrate was evaporated to dryness using steam Bath at 70⁰C. in an oven cooled and weighed.

Determination of phenol content

The total phenol content was determined using (Harborne, 1973) method. The fat free 0.2g sample was boiled for 15mins with 50ml of ether for the extraction of phenol. five ml of the extract was pipetted into a 50ml flask and 10ml of distilled water was added also 2ml of ammonium hydroxide solution and 5ml of concentrated amyl alcohol were added and made up to mark and left to react for 30min for color development. The absorbance of the solution was read at 505nm wave length using a spectrophotometer.

Determination of vitamins content

The contents of five vitamins in the mushroom fruit-bodies namely niacin, thiamine, ascorbic acid and riboflavin were by the spectrophotometric method (AOAC), 1980. The powdered samples were determined extracted by EDTA/TCA extraction method and the extracts read off at different wavelengths using the spectrophotometer.

IV. Results

The result of the investigation on the nutritive (Proximate) composition of the mature and young fruit-bodies of the mushroom is summarized in Table 1. The result indicates that the moisture content was at maximum at immature stage (21.88 ±1.33 and 25.88 ± 0.23 in SDK and ADS respectively) and lowers in the young fruit-bodies (17.35 ±0.83 19.94 ± 0.11 in SDK and ADS respectively) while the ash and fibre contents showed an opposite trend. The highest ash and fibre contents (8.54 ±0.09, 7.71 ± 0.11 and 7.52 ± 0.06, 6.64±0.02 in SDK and ADS respectively) and lower in young fruit-bodies (5.89 ± 0.64, 4.49 ± 0.03 and 5.26 ± 0.06, 3.89 ± 0.04 in SDK and ADS respectively)) Similarly the fats and protein contents of the mature fruit-bodies obtained in SDK and ASD, (4.32±0.11, 7.06 ±0.10 and 3.89 ± 0.04, 8.51 ± 0.10) were higher than those of the young fruit-bodies obtained in SDK and ASD, (3.31 ± 0.06 , 4.61 ± 0.10, and 1.46 ± 0.02, 4.08±0.10) However the carbohydrate contents of the mushroom fruit-bodies were neither influenced by the substrates nor their stages of development. There was no significant difference between the proximate composition of the fruit-bodies harveste from *Andropogon gayanus* straw and those from *Khaya invorensis*.

Table 1: Proximate composition of fruit bodies

Parameters	Young Fb On Sdk	Mature Fb On Sdk	Young Fb On Asd	Mature Fb On Asd
Moisture (%)	21.88 ± 1.33	17.35± 0.83	25.88± 0.23	19.94± 0.11
Ash (%)	5.89 ± 0.84	8.54 ± 0.09	5.26 ± 0.06	7.52 ± 0.06
Fibre (%)	4.49 ± 10.03	7.71 ± 0.11	3.89 ± 0.04	6.64 ± 0.02
Fats And Oil (%)	3.31±0.06	4.32 ± 0.11	1.46 ± 0.02	3.89 ± 0.04

Protein (%)	4.61±0.10	7.06± 0.10	4.08± 0.10	8.51± 0.10
Total Cho (%)	59.83±1.22	55.68±1.00	59.43± 0.14	53.99± 0.25
Energy (Kcal)	287.75±0.21	289.84±1.02	269.18±2.10	283.01± 0.51
Energy (Kj.)	1217.95± 0.24	1226.42±0.18	1133.69± 0.11	1197.93± 0.32

Values shown represent triplicate mean ± standard deviation
 SDK = Sawdust of *Khaya*; ASD = *Andropogon* Straw

The result of the investigation on the mineral composition of the mature and young fruit-bodies of the mushroom is summarized in Figure I. Matured fruit-bodies produced on AS (*Andropogon* straw) yielded the highest quantity of Potassium followed by young fruit-bodies from AS (*Andropogon* straw). Calcium of the mature and young fruit-bodies was appreciable but did not differ significantly. The contents of the minerals were low and did not depend neither on the stage of the fruit-bodies nor on the substrates.

The result of the investigation on the Phytochemical composition of the mature and young fruit-bodies of the mushroom is summarized in Figure II. The result shows that alkaloids of the young and mature fruit-bodies produced on *Khaya* sawdust and *Andropogon* straw were high while the other bioactive chemicals were very low

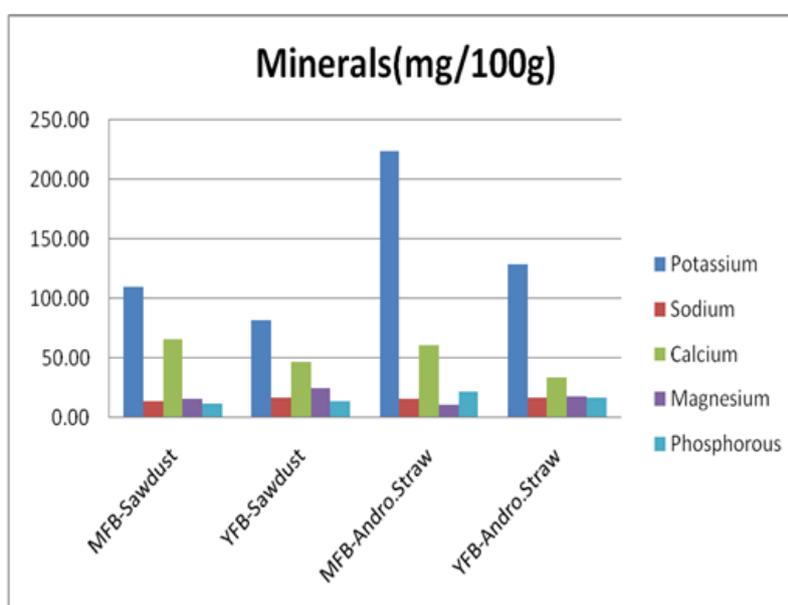


Fig. I: Mineral composition of fruit-bodies of *P. pulmonarius* Values shown represent triplicate mean ± standard deviation

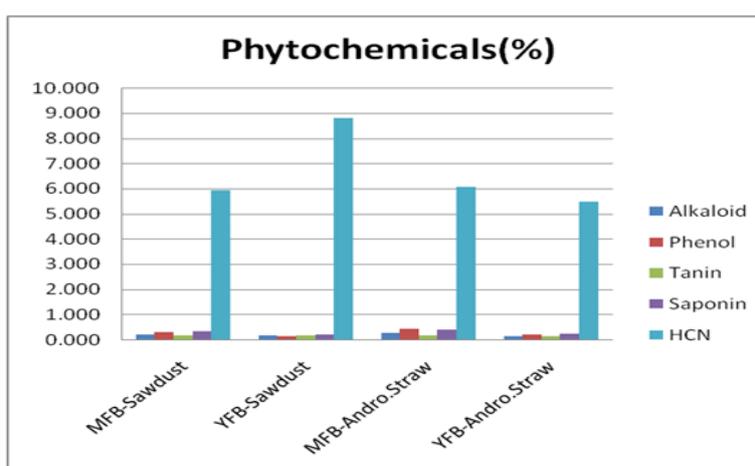


Fig. II: Phytochemical composition of *P. pulmonarius*
 Values shown represent triplicate mean ± standard deviation
 KEY: MFB = Matured fruit-bodies; YFB = Young fruit-bodies

Table 2: Vitamin composition of *P. pulmonarius* at the stages of growth

Sample	Niacin (mg/100g)	Thiamine (mg/100g)	Ascorbic Acid (mg/100g)	Riboflavin (mg/100g)
Matured Fruit Bodies from SDK	0.20 ±0.006	0.23 ±0.006	45.33 ±2.31	0.066 ±0.012
Young Fruit Bodies from SDK	0.11 ±0.01	0.22 ±0.006	54.27 ±2.54	0.087 ±0.035
Matured Fruit Bodies from ASD Straw	0.84 ±0.02	0.24 ±0.00	86.53 ±6.72	0.093 ±0.006
Young Fruit Bodies from ASD	0.44 ±0.006	0.23 ±0.006	55.73 ±2.54	0.088 ±0.023

Values shown represent triplicate mean ± standard deviation

SDK = Sawdust of Khaya; AS = Andropogon Straw

Similarly the result of the vitamins contents of the fruit-bodies is shown in Table 2. However the concentrations of the vitamins (in mg/100g) were more in the fruit-bodies harvested from *A. gayanus* straw than those from *Kaya. invorensis* sawdust. In each case however, matured fruit-bodies had higher contents of the vitamins than young fruit-bodies.

V. Discussion

Considering the results of the investigation, fructification occurred in both substrates. This result supports the earlier reports by Okwulehie and Okwujiako (2008); that *Pleurotus* species have a high saprophytic ability and can grow well in a variety of cellulosic substrates (Thambidurai *et al*, 2006). However, the highest growth was recorded in *Andropogon* straw (Okwulehie and Okwujiako, 2008).

The nutrient composition of *P. pulmonarius* as affected by maturity state and the type of substrate on which they were grown is summarized in Table 1. The moisture content was at maximum at the immature stage irrespective of the substrate, and decreased during further development of the mushroom. This is in line with the work of Ayodele and Okhuoya, (2008). However, the young fruit bodies from *Andropogon* has the highest moisture content than the young fruit bodies from sawdust while the matured fruit bodies of *Andropogon* had the lowest moisture content in the matured fruit bodies from sawdust. This can serve as supplement to vegetable which has high moisture content (Edoga and Gomina, 2000). However, the ash content showed an opposite trend, occurring more in matured fruit-bodies and less in young fruit-bodies irrespective of the substrate. The result is in variance with that of Kalmis *et al*; (2011), where young fruit-bodies contained more ash than the matured ones. The highest ash and fibre contents (7.71±0.11% and 6.64±0.02% respectively) were obtained from matured fruit bodies from sawdust and *Andropogon* substrates. This is possibly because of accumulation of more cellulolytic components in the mature fruit bodies. Matured fruit-bodies from ASD had the highest protein, followed by the matured fruit-bodies from SDK, while the young fruit-bodies had low protein. This result suggests that the fruit-bodies are better consumed when matured, and that *Andropogon* straw should be a preferred substrate for the cultivation of the mushroom, as reported by Okwulehie and Okwujiako, (2008). For Carbohydrate contents, the preference is neither here nor there.

For mineral contents, matured and young fruit-bodies of the mushroom produced on ASD contained more potassium than those produced on SDK, this result still projects ASD as the best substrate for the production of the fruit-bodies of the mushroom.

The Young and matured fruit-bodies of the mushroom, produced on SDK and ASD, contained little quantities of phenol, tannins, saponins and HCN, property which supports the safety of the mushroom for consumption. Similarly, the high alkaloids contents of the mushroom support the usefulness and therapeutic value of the mushroom. This is because alkaloids were ranked as the most efficient therapeutic significant plant substance (Okwu and Okwu, 2004.) According to Stray, (1998), pure isolated plant alkaloids and their synthetic derivatives are used as basic medicinal agents for analgesic and anti-spasmodic and bactericidal effects.

Matured fruit-bodies from *Andropogon* also had higher vitamins in mg/100g of Niacin (0.84±0.02), thiamine (0.24 ±0.00), ascorbic acid (86.53 ± 6.72) and riboflavin (0.093 ± 0.006), as opposed to the matured fruit-bodies from *Khaya* with Niacin (0.20 ± 0.006), thiamine (0.23 ± 0.006), ascorbic acid (45.33 ± 2.31) and Riboflavin (0.066 ± 0.012)

This investigation has demonstrated that *Andropogon* straw used as a substrate for *Pleurotus* mushroom cultivation performs better than sawdust. The observed difference in the chemical and in the nutritive values of the fruit bodies may be due to the nutritional and chemical endowments of the substrate. Using agro-wastes as appropriate substrate in cultivating *P. pulmonarius* a non-timber forest product and a product which is considered a waste is a major option or alternative to the incineration of these wastes in order to ensure a safe and healthy environment. The vast population of Nigeria, would also have a near solution to the problem of

protein hunger which is becoming more acute. Animal protein in the form of meat and milk are beyond the reach of low income group in the country.. Under the prevailing circumstances, exploiting agro-wastes for the cultivation of edible mushrooms would help to save the country from extreme protein hunger and contribute to the Vision 2020 .o the Nation

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