Morphological Characterization and Proximate Analysis of Three Edible Mushrooms in Plateau and Kogi States, Nigeria

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The study examined the morphological and proximate compositions of three edible mushrooms including *Termitomyces clypeatus* R. Heim, *Lentinus squarrosulus* Mont. and *Lentinus tigrinus* (Bull.) Fr. in Plateau and Kogi States, Nigeria. The collection of the fruiting bodies was done at random during the rainy season (July to September). The fruiting bodies of the macrofungi at the point of collection were photographed on site and the important morphological features were recorded before collection and packaging. The moisture content, protein content, total carbohydrate, ash content, crude fiber and crude fat compositions of the edible mushrooms were determined. *T. clypeatus* mushroom had a significantly (p≤0.05) higher moisture content (91.67%) and lower crude protein content (2.5%), compared to *L. tigrinus* and *L. squarrosulus*. *T. clypeatus* mushroom had a significantly (p≤0.05) lower crude fiber (2.10%) and crude fat (2.27%) contents, compared to the significantly higher (p≤0.05) crude fiber and crude fat compositions of *L. tigrinus* and *L. squarrosulus*. The ash content and carbohydrate content of the mushrooms species ranged from 0.90% to 20.33% and 6.88% to 26.18% respectively. Based on the high nutritional value of the three edible mushrooms assessed, it can thus be inferred that the mushrooms are valuable diet assets.

Keywords: Morphology, Proximate, Characterization, Edible mushrooms, Nutritional diet.

INTRODUCTION

There is a very high incidence of malnutrition, especially of protein deficiency in developing countries and this has become worrisome. This austere condition is predominantly common in sub-Saharan Africa region, which has the highest incidence of under nourishment with one in three people deprived of access to sufficient food (FAO, 2006; Abdalla et al., 2016). The issue of protein deficiency in developing countries especially Nigeria is a prevailing reality which may persist in perpetuity if care is not taken. In order to meet the protein source deficit, there is need for unconventional alternative sources of protein such as mushrooms.

Edible mushrooms with high nutritive content value are considered as one of the most unexploited resources of the world (Kayode et al., 2013). They have potentials to contribute enormously to food value of our habitual diet as they may contribute enormously to the supply of both macro and micro-nutrients in our diet. Nutritive value of edible mushrooms is attributed to their high content of essential amino acids, vitamins, minerals and low lipid compare to some vegetables and fruits including carrots, tomatoes, asparagus, potatoes and oranges (Kayode et al., 2013; Okwulehie and Ogoke, 2013; Adejumo and Awosanya, 2005).

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Mushrooms have potential in addressing current food crisis problems in Africa as well as future problems resulting from population explosions. They can solve world’s food shortage problem due to the fact that they occupy a place above vegetables and legumes but below the first class proteins in meat, fish and poultry (Boa, 2004). They can also resolve most of the world’s health problems because they are endowed with bioactive compounds that are of medicinal value (Change and Miles, 2004; Colak et al., 2018). Termitomyces mushrooms are known to contain bioactive components with potentials for treating neurodegenerative disorders and as antioxidants, immunomodulators, antitumors, and antimicrobials (Hsieh and Ju, 2018). In addition, preliminary studies have revealed that Termitomyces and Lentinus mushroom species possesses substantial antimicrobial and antioxidant properties (Oyetayo, 2011). As such the results of this study tend to provide more insight into the food values of indigenous edible mushrooms to be collected from the study area, which are almost neglected as food sources in preference to exotic and most times costlier food items. The aim of the study is to morphologically characterize and assess the proximate composition of three edible species of mushrooms.

**METHODS**

**Study Area**

The experiment was carried out in Jos, Plateau and Iyamoye, Kogi States, Nigeria. The Lentinus species were collected from Plateau state, while the Termitomyces species was collected from Kogi State because of relative abundance and edibility of these mushrooms in the respective states. Jos is located in Northern Guinea savanna and is situated between latitudes 8° and 30° and 10° 10 N and longitude 8° 20 ’ and 9° 30 E. It has an average elevation of about 1,250m above sea level and stands at a height of about 600m above the surrounding plains. The average temperature in Jos ranges between 21°C to 25°C. The climate of the state is cool due to its high altitude. The mean annual rainfall is 1,260mm, while the relative humidity increases from May to October and decreases gradually from November to April (Olowolafe, 2002).

Kogi State has an average maximum temperature of 33.2°C and an average minimum temperature of 22.8°C. Lokoja, the State capital is generally hot throughout the year with an average humidity of 68 to 70%. The climatic cover of Kogi State is tropical, which is divisible into two major seasons; dry season and wet season. The dry season lasts from November to February, while the rainy season lasts from March to October. The annual daily mean temperature is 28°C, while in the hot season; the average temperature is about 35°C. High humidity is also common (Ibitoye, 2006). Annual rainfall ranges from 1016mm in the driest parts of the State to 1524mm in the wettest parts (KOSEEDS, 2014).

**Sample Collection and Identification**

The collection of the fruiting bodies was done at random during the rainy season (July to September) the study location. The fruiting bodies of the macrofungi at the point of collection was photographed on site and the important information was recorded (Plate 1).

The samples after collection were properly labeled and wrapped in brown paper in order to avoid excess humidity. All the collected samples were taken to the laboratory for identification. Identification was done using illustrations in colour field guides and description keys as described in Peter (2000); Largent and Theirs (1977); Miller and Miller (2006); and Neale and Syme (1998). These provide general details of identification tools according to certain important features. It includes features like gill attachment to stem, spore colors under microscope, spore print color, volva and ring attachments to the stipe. This guide was used to identify the mushroom family and genera. Secondary sources like books and online information was used to compliment the identification tools.

**Morphological identification of the edible Mushrooms**

The three edible mushrooms collected were characterized and identified using the stature types and field guide identification keys.

**Proximate Analysis**

The three mushrooms after collection and proper identification were taken for proximate analysis on dry basis. Proximate analyses was done using the procedure of Association of Official Analytical Chemists (2006) to determine the moisture, protein content, total carbohydrate, ash content, crude fiber and crude fat (ether-extract) composition of the edible mushrooms.

**Experimental Design and statistical analysis**

Completely Randomized Design (CRD) experimental design was adopted for the purpose of this study in which...
the mushroom samples were replicated three (3) times. Data collected from the proximate analysis were subjected to analyses of variance to determined significant difference at 5% probability level.

Plate 1: Collection of the Mushroom Samples

RESULTS

Morphological Identification of the Edible Mushroom

The morphological identification of the mushroom was based on pleurotoid and tricholomatoid stature types’ description and other identification keys as describe in field guides. The general and physical characteristics of the three edible mushrooms collected are described in Table 1, Plates 2 to 4.

Table 1: Classification of the mushroom species.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Phylum</th>
<th>Class</th>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basidiomycota</td>
<td>Basidiomycetes</td>
<td>Polyporaceae</td>
<td>Lentinus squarrosulus Mont. 1842</td>
</tr>
<tr>
<td>2</td>
<td>Basidiomycota</td>
<td>Basidiomycetes</td>
<td>Polyporaceae</td>
<td>Lentinus tigrinus (Bull.) Fr. (1825)</td>
</tr>
<tr>
<td>3</td>
<td>Basidiomycota</td>
<td>Agaricomycetes</td>
<td>Lyophyllaceae</td>
<td>Termitomyces clypeatus R.Heim (1951)</td>
</tr>
</tbody>
</table>

_Lentinus squarrosulus_ Morphological Description

The pileus/cap range between 55 mm and 90 mm in diameter. The entire height ranges between 50 mm and 85 mm. The cap is convex when young with depressed center, umbilicate to deeply infundibuliform with age. The cap surface is dry, cream to yellowish white. It has irregular and involute pileus margin which splits with age. The entire cap surface is made up of scales recurved fibrillose to floccose fibrillose. The gills are decurrent and slightly crowded. The stipe is centrally to eccentrically attached, ranging between 38 mm to 54 mm long and 2.5 mm to 4 mm wide. Stipe flesh is fleshy, tough and cylindrical to slightly tapering towards the base. The entire surface of the stipe is covered by floccose fibrils. It grows on dead/decaying wood substrate (Plate 2).

_Lentinus tigrinus_ Morphological Description

The pileus/cap range between 100 mm to 120 mm in diameter. It is fleshy to coriaceous in texture, convex at early stage to broadly, deeply infundibuliform when aging; surface often with dark brown scales which becomes scattered and crowded at the center with age mostly concentric. Annulus and volva are both absent. The stipe is equal measuring 38 mm to 70 mm long and 8 mm to 15 mm wide, yellowish white in colour, having eccentric attachment and branched clamp connections. The gills are decurrent, crowded, and cream to yellowish white. It has wavy margin. The pileus margin in section is undulating. It has gregarious growing habit on dead/decaying wood substrate (Plate 3).

_Termitomyces clypeatus_ Morphological Description

The pileus/cap range between 88 mm and 185 mm in diameter. The cap is conical to convex with age. The nature of cap is smooth when young to rugose (wrinkled) with age. The margin of the pileus is smooth when young,
wavy and cracked with age, while the pileus margin in section is straight. The length and diameter of the stipe ranged from 85 mm to 156 mm and 5 mm to 14 mm respectively. The stipe is equal in shape and tapers towards the slightly swollen or bulbous base. The attachment of the stipe is central. Gills are adnexed, crowded and closely free. There are streaked light brown variety and they appear membranaceous. Annulus and volva are absent. The mushroom is usually found on the ground/soil (Plate 4).

Plate 4: *Termitomyces clypeatus* R.Heim (1951)

Proximate Composition of the edible mushroom species

The result of the moisture content and crude protein composition of the mushroom species (Figure 1) revealed that *T. clypeatus* mushroom had a significantly (p≤0.05) higher moisture content of 91.67%, while *L. tigrinus* and *L. squarrosulus* had a lower moisture content of 31.04% and 27.55% respectively. The moisture content of *L. tigrinus* and *L. squarrosulus* were not significantly different from each (p≥0.05). The crude protein content of *T. clypeatus* mushroom (2.5%) was significantly (p≤0.05) lower than the protein content of *L. tigrinus* (7.15%) and *L. squarrosulus* (5.28%) which were not significantly different from each other (p≥0.05).

*T. clypeatus* mushroom had a significantly (p≤0.05) lower crude fiber (2.10%) and crude fat (2.27%) contents, compared to the significantly higher (p≤0.05) proximate compositions of *L. tigrinus* having 14.63% crude fiber and 7.89% crude fat contents and *L. squarrosulus* which possesses 11.21% crude fiber and 5.88% crude fat. The crude fiber and crude fat contents of *L. tigrinus* and *L. squarrosulus* were significantly different from each other (Figure 2).

The ash content of the mushrooms species ranged between 0.90% and 20.33% (Figure 3). *T. clypeatus* mushroom species had the lowest significantly different ash content (0.90%), while *L. tigrinus* had the highest ash content (20.33%) not significantly different from ash content of *L. squarrosulus* species (18.43%). In the same similar trend, the carbohydrate content of the mushroom species ranged between 6.88% and 26.18% (Figure 3). *T. clypeatus* mushroom had the lowest significantly different (p≤0.05) carbohydrate content (6.88%), while *L. tigrinus* mushroom species possessed the highest carbohydrate content which is not significantly different from the carbohydrate content of *L. squarrosulus* (25.03%).

Figure 1: Moisture content (%) and Crude Protein (%) Content of the Edible Mushrooms

Means in the same column having the same superscripts are not significant (p≥0.05)

Figure 2: Crude Fiber (%) and Crude Fat (%) Contents of the Edible Mushrooms

Means in the same column having the same superscripts are not significant (p≥0.05)
DISCUSSIONS

Moisture Content (%)

The high moisture content observed in *T. clypeatus* (91.67%) compared to the other *Lentinus* species (Figure 1) can be attributed to its big size and more succulent nature. However, the high moisture content gives an indication that great care must be taken in handling and preservation of the mushroom species as it is subject to high susceptibility to fungal and bacterial infections (Sylvester et al., 2014), rapid deterioration (Adejumo and Awosanya, 2005) and reduction in its storage and shelf life span (Olusanya, 2008). The range of moisture content of the mushrooms (27.55% to 91.67%) as obtained in this study is higher than 7% reported for *Pleurotus sajo caju* (Kayode et al., 2013), 9.77% for *L. tigrinus* (Olayinka, 2016) and 18.78% for *L. squarrosulus* (Sylvester et al., 2014). However, the high moisture content obtained for *T. clypeatus* (Figure 1) is similar to 90.13% reported by Srikram and Supapvanich (2016). The variation in the moisture contents of the mushroom species might be attributed to environmental factors during growth and storage (Mattilla et al., 2001), climate differences, species and geographical area (Srikram and Supapvanich, 2016).

Crude protein (%)

Mushrooms have been reported to normally possess between 19% to 35% protein content compared to 7.3% in rice, 13.2% in wheat, 39.1% in soybean, and 25.2% in milk (Chang and Miles, 2004). The protein content obtained by Srikram and Supapvanich (2016) ranging between 1.09% to 1.32% for *T. clypeatus*, *L. squarrosulus*, and *P. sajor-caju* mushroom species is lower than 2.15% to 7.15% obtained in this study. However, higher values were discovered by Duru et al. (2018) in *P. squarrosulus* (21.31%), Olayinka (2016) in *L. tigrinus* (16.07%), and Das et al. (2017) in *L. squarrosulus*, *L. tuber-regium* and *Macrocybe gigantean* (20.97% to 31.04%) mushroom species. As affirmed by Barros et al. (2007), variations in the protein constituent could be ascribed to the influence of variability in the nature/kind of mushroom species, mushroom developmental stage, as well as the sampled part of the mushrooms (Barros et al., 2007), while Bernaś et al. (2006) attributed the differences to possibilities of species/strain specific, pileus size, time of harvest and the level of nitrogen available in the growth substrate.

Crude Fiber (%)

The crude fiber content of the *Lentinus* spp (11.21% to 14.63%) recorded in this study compares with the range of values reported by Falemara and Joshua (2016) for *Pleurotus ostreatatus* and *P. florida* (11.80% and 17.06%) and Ijioma et al. (2015) for *Russula sp* (17.9%) and *P. tuber-regium* (13.5%). However, Sylvester et al. (2014) and Olayinka (2016) reported a lower crude fiber content for *L. squarrosulus* and *L. tigrinus* ranging between 0.26% and 4.53%. Low crude fiber found in *T. clypeatus* mushroom species was similarly reported by Adebiyi et al. (2018). The fiber contents of this mushroom species will enhance better food absorption and suitable for people with cancer, diabetes and heart diseases as it aids the reduction of cholesterol levels in blood (Ugbogu and Amadi, 2018). Fiber though not digestible is of significant nutritional importance in the cleaning and maintenance of proper intestinal tract motility (Mukhopadhyay and Guha, 2015). Low fiber intake as a matter of fact, has been recommended by nutritionists for optimal growth particularly in the nutrition of infants and weaning children (Bello et al., 2008; Salamat et al., 2017).

Ash Content (%)

The ash content represents the total amount of mineral content present in the mushroom (Ulizijargal and Mau, 2011). It can be noted that the ash content is significantly lower in *T. clypeatus* (0.90%), compared to the ash content (18.43% to 20.33%) in the two *Lentinus* spp (*L. squarrosulus* and *L. tigrinus*) which were not significantly different from each other. The ash contents in the examined mushroom samples were at variant to 9.31%
found in *T. clypeatus* (Adebiyi et al., 2018), 7.84% associated with *P. squarrosulus* (Duru et al., 2018), 4.30% found in *L. tigrinus* (Olayinka, 2016), 7.4% determined in *L. tigrinus* (Dulay et al., 2014), 7.30% and 8.01% evaluated in *P. ostreatus* and *P. floridus* (Falemara and Joshua, 2016) and very low 1.14% established in *L. squarrosulus* (Sylvester et al., 2014).

**Carbohydrate (%)**

Carbohydrates are good sources of energy as such a high concentration of this is required in breakfast meals and weaning food formulas (Kassegn, 2018). The carbohydrate found in *T. clypeatus* (6.88%) is significantly lower than the quantity discovered in *Lentinus* species (25.03% to 26.18%). The high carbohydrate content of the *Lentinus* species gives an indication that they will supply more energy in human diet. Previous research studies earlier reported higher carbohydrate content in mushrooms varying from 56.35% and 75.35% in *L. squarrosulus* and *T. clypeatus* respectively (Adebiyi et al., 2018), 56.56% in *Tricholoma matsutake* (Odoh et al., 2017), to a range of 48.84% and 50.03% in *L. squarrosulus* and *L. tuber-regium* respectively (Das et al., 2017). This high carbohydrate content according to Adebiyi et al. (2018) explains why mushrooms are used locally as binder, bulking agent or thickeners in soup.

**CONCLUSION**

The research study morphologically characterized and analyzed the proximate constituents of three edible mushrooms (*T. clypeatus, L. squarrosulus* and *L. tigrinus*) which showed evidence of exceptional crude protein, fiber, fat, carbohydrate and ash endowment required for good and quality nutritional diet. However, the *Lentinus* species mushrooms showed better nutritional composition compared to the *T. clypeatus* species. Based on the variable nutritional composition of these edible mushrooms, it can thus be inferred that the mushrooms are valuable asset with tremendous potentials in supplementing the nutritional deficiency prevalent in developing countries like Nigeria.

**AUTHORS’ CONTRIBUTIONS**

BCF conceived the study and supervised data collection, performed statistical analysis, and drafted the manuscript. VIJ also supervised data collection. CRT and OOA collected the data. All authors contributed to the writing, reading and approval of the final manuscript.

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mushroom consumed in northern part of Nigeria. 

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