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Comparative Nutritional Analysis of Three Edible Mushrooms

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ABSTRACT

Background and Objective: Edible mushrooms make a remarkable addition to the daily diet of some families in Africa. The high nutritional, medicinal, and commercial values of mushrooms make it to be of great importance in some parts of Africa. This study was carried out to compare the nutritional components of *Pleurotus plumonarius* (Oyster), *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu) mushroom. **Materials and Methods:** Oyster mushroom, *Ganoderma*, and Osu samples were collected from Eke Awka Market, Awka, Anambra State. These samples were tested for proximate and minerals using different standard methods. The proximate parameters tested include moisture, ash, fiber, protein, and fat, while minerals tested include magnesium, calcium, potassium, and iron. Data collected were analyzed and subjected to one way analysis of variance, while the treatment means were separated using Duncan's Multiple Range test at $p<0.05$. **Results:** Results of the proximate analysis revealed that *P. plumonarius* (Oyster) had the highest contents of all the parameters tested, except moisture content and carbohydrates. *Ganoderma lucidum* and *P. tuber-regium* have the highest volume of moisture and carbohydrate, respectively. The mineral components of the three mushrooms were significantly different from each other, except for iron. All three mushroom samples have comparable iron levels (not significantly different from each other), with the highest value obtained in G. *lucidum* (3.50 mg/100 g). **Conclusion:** The findings from this study revealed that *P. plumonarius*, *P. tuber-regium*, and *G. lucidum* are rich in proximate and mineral contents, although *P. plumonarius* has relatively more nutritional values than *P. tuber-regium* and *G. lucidum*.

KEYWORDS

Nutrient, mineral, proximate, fungi, comparative

INTRODUCTION

A mushroom is a fungus with a spore-bearing fruiting body. It grows in substrates above the ground. Suitable substrates for mushroom growth include soil, plants, and other food sources. Generally, the name mushroom denotes the cultivated species, *Agaricus bisporus*. Therefore, it is right to refer to a mushroom as a kind of fungi that has gills, a stem, and a cap. On the other hand, some gilled fungi without a stem are also grouped as mushrooms. A variety of other gilled fungi, with or without stems, are most times classified as mushrooms; therefore, the term is used to describe the fleshy fruiting bodies of some Ascomycota. The gills are responsible for the production of tiny spores, which are usually microscopic and help the fungus spread across the ground or its substrates[1].

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Pleurotus plumonarius, a kind of Oyster mushroom, is commonly found in most tropical countries such as Europe and North America. *Pleurotus pulmonarius* is incorrectly called *Pleurotus sajor-caju*, which is one of the most common varieties often marketed by spawn manufacturers and cultivators. *Pleurotus pulmonarius* is cultivated by transferring hyphal tips from an inoculated Petri dish onto grain and then transferring the grain spawn after the mycelium colonizes it to either nitrogen based or non-nitrogen-based substrates[2].

The importance and nutritional value of mushrooms cannot be overemphasized. *Pleurotus pulmonaris* is consumed as food and is also vital in the formulation of many drugs. A review of the extant literature on the ethno-botany of mushrooms revealed that people from South-Eastern Nigeria consume edible mushrooms as food and medicine[3]. Mushrooms are important parts of most foods sold in eateries because they are low in calories, carbohydrates, fat, and sodium; also, they are cholesterol-free[4]. Besides, mushrooms are important because of their healing capacities and valuable properties in traditional medicine. Other nutrients that are abundant in mushrooms are selenium, potassium, riboflavin, niacin, vitamin D, proteins, and fiber[5].

The importance of mushrooms in the human diet in many regions of the world cannot be overemphasized. It is on record that mushrooms is rich in rich in organoleptic and nutritional properties. There is a remarkable increase in the consumption of mushrooms over the last decades. This is as a result of empirical evidence from findings of some researchers on the potential of mushrooms and mushroom products to prevent and control several diseases. Of the over 150,000 species of mushrooms in nature, only about 2000 species are grown. Wild mushrooms are also important as food and nutraceutical because of their high nutritional and functional They are of great interest because of their economic, medicinal, and organoleptic properties[6].

Wild-growing mushrooms have a worldwide distribution and have been a popular delicacy in many countries, They can be grouped as a functional group since their dietary component provides cardiovascular and antioxidant properties which are beyond basic nutrition. Fruiting bodies of mushrooms are consumed as a delicacy for their texture and flavor, and also for their nutritional properties that make them more attractable[7]. *Pleurotus pulmonarius*, also known as the "Phoenix Oyster mushroom", is an edible species of mushroom belonging to the Pleurotaceae family. It is closely related to *Pleurotus ostreatus* (Oyster mushroom) and is commonly found growing on dead wood, such as logs or tree trunks. This mushroom has a mild flavor and is popular in various culinary dishes. It is also cultivated for its nutritional benefits, being rich in proteins, vitamins, and minerals. *Pleurotus pulmonarius* is studied for its medicinal properties, including its antioxidant, antimicrobial, and immune-boosting effects.

Ganoderma lucidum, commonly known as the "Reishi mushroom" or "Lingzhi", is a well-known medicinal fungus that has been used for centuries in traditional Chinese medicine. It grows primarily on decaying hardwood trees. *Ganoderma lucidum* is renowned for its immune-modulating and anti-inflammatory properties. It contains bioactive compounds like polysaccharides, triterpenoids, and peptides, which contribute to its potential benefits in boosting immunity, reducing stress, improving sleep, and possibly fighting cancer and other chronic diseases. Reishi is often consumed as tea, tincture, or powder.

Pleurotus tuber-regium, also known as the "King tuber mushroom" or "Tuberous Oyster mushroom," is unique because it produces both a mushroom and a large underground sclerotium (tuber), which is also edible. This mushroom is native to Africa and Asia and is highly valued for its nutritional content, including proteins, fibers, and essential amino acids. Both the sclerotium and the fruiting body are used in traditional dishes. *Pleurotus tuber-regium* is also investigated for its potential in biotechnology, particularly in bioremediation and as a sustainable food source due to its ability to grow on agricultural waste. This study evaluates the nutritional differences among three edible mushrooms by assessing their protein, carbohydrate, fat, fiber, vitamins, and mineral content, providing insights into their dietary benefits and potential applications in nutrition and food industries.

MATERIALS AND METHODS

Study area: This research was conducted between April to August, 2024 at the Nnamdi Azikiwe University, Awka, Anambra State. The research area is located in the Eastern part of Nigeria and lies between Latitudes 6.20732, Longitudes 7.06947'E.

Sample collection: A 3 kg bag of Oyster mushrooms (*Pleurotus plumonarius*), *Ganoderma* mushrooms (*Ganoderma lucidum*), and Osu mushrooms (*Pleurotus tuber-regium*) were collected from Eke Awka market, Awka, Anambra State, Nigeria.

Proximate content

Moisture content determination: Moisture content was determined according to the standard method of AOAC *et al.*[8]. A Petri dish was washed and dried in the oven. Exactly 2 g of the sample was weighed into a Petri dish. The weight of the Petri dish and sample is noted before drying. The Petri dish and sample were put in the oven and heated at 100°C for 1 hr, the result noted, and then heated another 1 hr until a steady result was obtained and the weight was noted. The drying procedure is continued until a constant weight is obtained[9]:

$$\text{Moisture content (\%)} = \frac{\text{W1 - W2}}{\text{Wt of sample}} \times 100$$

Where:

W1 = Weight of the Petri dish and sample before drying
W2 = Weight of Petri dish

Ash content determination: Ash content was determined according to the standard method of AOAC *et al.*[8]. An empty platinum crucible was washed, dried, and the weight was noted. Exactly 2 g of wet sample was weighed into the platinum crucible and placed in a muffle furnace at 500°C for 3 hrs. The sample was cooled in desiccators after burning and weighed:

$$\text{Ash content (\%)} = \frac{\text{W3 - W1}}{\text{W2 - W1}} \times 100$$

Where:

W1 = Weight of empty platinum crucible
W2 = Weight of platinum crucible and sample before burning
W3 = Weight of platinum and ash

Fiber content determination: Fiber content was determined according to the standard method of AOAC *et al.*[8]. About 2 g of material with petroleum ether (if the fat content is more than 10%). Boil under reflux for 30 min with 100 mL of a solution containing 1.25% of H_2SO_4 per 100 mL of solution. Filter the solution through linen or several layers of cheesecloth on a fluted funnel, wash with boiling water until the washings are no longer acidic. Transfer the residue to a beaker and boil for 30 min with 100 mL of a solution containing 1.25 M NaOH per 100 mL. Filter the final residue through a thin but close pad of washed and ignited asbestos in a Gooch crucible, dry in an electric oven, and weigh. Incinerate, cool, and weigh.

The loss in weight after incineration×100 is the percentage of crude fiber[9]:

$$\text{Crude fiber (\%)} = \frac{\text{Weight of fiber}}{\text{Weight of sample}} \times 100$$

Protein content determination: Protein content was determined according to the standard method of AOAC *et al.*[8]. Exactly 0.5 g of sample was weighed into a 30 mL Kjeldahl flask (gently to prevent the sample from touching the walls of the flask of each and then the flask was stoppered, and shaken. Then, 0.5 g of the Kjeldahl catalyst mixture was added. The mixture was heated cautiously in a digestion rack over the fire until a clear solution appeared. The clear solution was then allowed to stand for 30 min and to cool. After cooling, about 100 mL of distilled water is added to avoid caking, and then 50 mL is transferred to the Kjeldahl distillation apparatus. A 100 mL receiver flask containing 5 mL of 2% boric acid and an indicator mixture containing 5 drops of Bromocresol blue and 1 drop of methylene blue is placed under a condenser of the distillation apparatus so that the tap is about 2 cm inside the solution. The 5 mL of 40% sodium hydroxide was added to the digested sample in the apparatus, and distillation commenced immediately until 50 drops were obtained in the receiver flask, after which it was titrated to pink colour using 0.01 N Hydrochloric acid[9]:

$$\text{Nitrogen (\%)} = \frac{\text{Titre value} \times 0.01 \times 14}{\text{Weight of sample}} \times 100$$

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

Fat content determination: Fat content was determined according to the standard method of AOAC *et al.*[8]. Dry 250 mL clean flasks in oven at 105 to 110°C for about 30 min. Transfer into a desiccator and allow to cool. Weigh correspondingly labeled, cooled flasks. Fill the flasks with about 300 mL of petroleum ether (boiling point 60°C), plug the extraction thimble lightly with cotton wool and assemble the Soxhlet apparatus, and allow to reflux for about 6 hrs. Remove the thimble with care and collect the petroleum ether in the top container of the setup and drain into a container for re-use. When the flask was almost free of petroleum ether, remove and dry at 105 to 110°C for 1 hr. Transfer from the oven into a desiccator and allow cooling and weighing[10]:

$$\text{Fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Carbohydrate content determination: Carbohydrate content was determined according to the standard method of AOAC *et al.*[8] and Hooper *et al.*[10]:

$$\text{Carbohydrate (\%)} = 100\text{-(Protein+Moisture+Ash+Fat+Fibre) (\%)}$$

Mineral analysis

Sample digestion for mineral analysis: One milliliter of each sample was weighed into 50 mL of Hydrogen Peroxide (H_2O_2) and 5 mL of Perchloric Acid ($HClO_4$). The entire content was heated in an oven at a temperature of 95°C until a clear solution was observed in the beaker. Thereafter, the digest was filtered with Whatman No. 42 filter paper into a 250 mL volumetric flask. Two 5 mL portions of distilled water were used to rinse the beaker, and the content was filtered into a 250 mL volumetric flask. The filtrate was allowed to cool to room temperature before dilution was made to the 250 mL mark with distilled water. The digest was analyzed for Ca, and zinc, respectively, on a Buck Scientific 210 VGP atomic absorption spectrophotometer.

Sample analysis: The atomic absorption spectrophotometric (ASS) method was used for the analysis. A Buck Scientific 210VGp atomic absorption spectrophotometer was used for the quantification of metal ions. The instrument was set up according to the manufacturer's instructions and allowed to equilibrate for about 15 min. It was then flushed to zero readings with distilled water. Depending on the element

being ionized, the appropriate hollow cathode lamp was put in place, and monochromatic light was adjusted at the appropriate wavelength. The standard solutions of the test element were first aspirated into the instrument, and thereafter, their respective absorbance was recorded. The readings were aspirated into the instrument one after the other, three consecutive times, and their absorbance was recorded. The respective composition of samples concerning the test element was calculated with the formulae, while the statistical method employed was the Student t-test[8]:

$$E\ (mg/100\ g) = 100/W\ N/10^3 \times D$$

Where:

W = Weight of the sample used;
M = Concentration in ppm derived from the standard curve
E = Test element
D = Dilution factor

Magnesium determination: About 100 mL of HCl was added to the samples (Oyster, Osu, and *Ganoderma* mushroom). It was filtered, and 10 mL of the already-filtered sample was obtained. Then, 25 mL of ammonium was dissolved and added. A pinch of Eriochrome T black was also added and then titrated with EDTA (Ethylenediaminetetraacetic Acid). It was titrated with 10 mL each. This was carried out three times, and the readings were taken[11].

Calcium determination: As 100 mL of HCl was added to the sample and filtered to get 10 mL of the filtrate. About 25 mL of KOH (Potassium Hydroxide) was added. Then three drops of Ferrochrome indicator were also added, and then titrated with EDTA (Ethylenediaminetetraacetic Acid). This was titrated with 10 mL each, which was carried out three consecutive times, and the readings were taken.

Potassium determination: After dissolving the ash sample in 10 mL of HCl, the solution was transferred to a 100 mL volumetric flask and diluted with distilled water to the 100 mL mark. The potassium content was measured using a potassium-specific ion-selective electrode. The content was calculated in the original sample based on the calibration curve or standard solution used[11].

Iron determination: After dissolving the ash sample in 10 mL of HCl, the solution was transferred to a 100 mL volumetric flask and diluted with distilled water to the 100 mL mark. The iron content was measured using an iron-specific colorimetric assay (Ferrozine method)[11]. The content was calculated in the original sample based on the calibration curve or standard solution used.

Statistical analysis: Statistical analysis was carried out using SAS software (20.0). One-way Analysis of Variance (ANOVA) was used to compare the means of various parameters. The means were separated using Duncan's Multiple Range Test, while Pearson's correlation was used to test the relationship between various parameters at a $p<0.05$ significance level.

RESULTS

Proximate and mineral contents of the three mushrooms [*Pleurotus plumonarius* (Oyster), *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu)]: From the results of the proximate and mineral analysis of the three edible mushrooms (*Pleurotus plumonarius*, *Pleurotus tuber-regium*, and *Ganoderma* mushrooms) recorded in this research, observe and compare their nutritional properties. The proximate contents tested are moisture, ash, fats, crude fibre, crude protein, and carbohydrate, while minerals tested include calcium, magnesium, iron, and potassium.

Proximate analysis findings: There is a significant ($p<0.05$) difference in the moisture contents of *Pleurotus plumonarius* (Oyster), *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu). *Ganoderma* mushroom has the highest moisture content (23.69%), which was significantly ($p<0.05$) higher than 21.60% obtained from Osu, while Oyster mushroom gave the least moisture content (18.90%). A lower moisture level in Oyster makes it relatively more shelf-stable (Table 1).

The findings of this study showed that Oyster mushroom has the highest ash content (5.33%), which is significantly ($p<0.05$) higher than 4.73 and 4.10% recorded from Osu and *Ganoderma*, respectively. There is also a significant difference between the values obtained from Osu and *Ganoderma*.

Fats and oils were also relatively higher in Oyster mushroom (1.78%), compared to those of Osu (1.04%) and *Ganoderma* (1.53%). The fat and oil contents in Oyster mushroom are significantly ($p<0.05$) higher than those of Osu and *Ganoderma*. For crude fibre, the relatively highest value (2.27%) was recorded from the Oyster mushroom. This was significantly ($p<0.05$) higher than the 2.06% obtained from Osu, which was also significantly $p<0.05$ higher than the 1.53% recorded from *Ganoderma*. The crude protein content of oysters (37.15%) was the highest and significantly ($p<0.05$) higher than 24.10 and 24.80% observed from Osu and *Ganoderma*, respectively. The carbohydrate content of Osu (46.47%) was the highest value recorded. This is significantly ($p<0.05$) higher than the values obtained from other mushrooms. The lowest in carbohydrate was Oyster (34.57%) (Table 1).

Mineral composition of the three mushrooms (*Pleurotus plumonarius*, *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu)): The mineral components of the three mushrooms were significantly different from each other, except for iron (Table 2).

For calcium, *P. tuber-regium* (Osu) has the highest content (8.72 mg/100 g). This was significantly ($p<0.05$) higher than 5.87 and 5.11 mg/100 g obtained from *P. plumonarius* and *G. lucidum,* respectively.

For magnesium, 12.30 mg/100 g. As 9.76 and 7.14 mg/100 g were recorded in *P. plumonarius*, *P. tuber-regium*, and *G. lucidum*, respectively. These values are significantly ($p<0.05$) different from each other.

The potassium content of *P. plumonarius* (115.46 mg/100) was the highest and significantly ($p<0.05$) higher than 122.89 mg/100 obtained from *P. tuber-regium*, while the least was 112.00 mg/100 g recorded from *G. lucidum*.

It was observed that all three mushroom samples have comparable iron levels (not significantly different from each other), with the highest value obtained in G. *lucidum* (3.50 mg/100 g) (Table 2).

Table 1: Proximate contents of *Pleurotus plumonarius* (Oyster), *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu)

	Proximate (%)					
Mushroom	Moisture	Ash content	Fats and oil	Crude fiber	Crude protein	Carbohydrate
P. plumonarius	18.90±0.319^{c}	5.33±0.127^{a}	1.78±0.00^{a}	2.27±0.050^{a}	37.15±0.006^{a}	34.57±0.006^{c}
P. tuber-regium	21.60±0.051^{b}	4.73±0.112^{b}	1.04±0.060^{b}	2.06±0.005^{b}	24.10±0.997^{b}	46.47±0.078^{b}
G. Lucidum	23.69±0.022^{a}	4.10±0.137^{c}	1.21±0.009^{b}	1.53±0.007^{c}	24.80±0.004^{b}	44.67±0.085^{a}

*Values are mean scores±Standard deviation of three replicates and *Data in the same column bearing different superscripts differ significantly ($p<0.05$)

Table 2: Mineral contents of *Pleurotus plumonarius*, *Ganoderma lucidum*, and *Pleurotus tuber-regium* (Osu)

	Minerals (mg/100 g)			
Mushroom	Calcium	Magnesium	Iron	Potassium
P. plumonarius	5.87±0.006^{b}	12.30±0.100^{a}	3.18±0.053^{a}	115.46±0.113^{b}
P. tuber-regium	8.72±0.006^{a}	9.76±0.008^{b}	3.09±0.006^{a}	122.89±0.006^{a}
G. lucidum	5.11±0.020^{b}	7.14±0.005^{c}	3.50±0.006^{a}	112.00±0.001^{c}

*Values are mean scores±Standard deviation of three replicates and *Data in the same column bearing different superscripts differ significantly ($p<0.05$)

DISCUSSION

The findings of this study revealed that the three edible mushrooms: *P. plumonarius* (Oyster), *G. lucidum*, and *P. tuber-regium* (Osu) have different comparative nutritional properties. The result aligns with existing literature on mushrooms[12].

From Table 1, there is a significant ($p<0.05$) difference in the moisture content of *P. plumonarius* (Oyster), *Ganoderma lucidum*, and *P. tuber regium* (Osu). *Ganoderma* mushroom has the highest moisture content (23.69%). This was significantly ($p<0.05$) higher than 21.60% obtained from *P. plumonarius*, while *P. tuber-regium* gave the least moisture content (18.90%). These findings is consistent with the findings of Oke *et al.*[13], who reported higher moisture content in *Ganoderma lucidum* than *P. plumonarius*, and *P. tuber-regium*. This table also showed that the Oyster mushroom has the highest ash content (5.33%). This is significantly ($p<0.05$) higher than (4.73%) and (4.10%) recorded respectively from *P. tuber-regium* and *Ganoderma*.

Fats and oils were also relatively higher in Oyster mushroom (1.78%), compared to that of Osu (1.04%) and *Ganoderma* (1.53%). For crude fiber, the relatively highest value (2.27%) was recorded from Oyster mushrooms. This was significantly ($p<0.05$) higher than (2.06%) obtained from *P. tuber regium*, which is significantly ($p<0.05$) higher than (1.535) recorded from *Ganoderma*. The crude protein content of Oysters (37.15%), was the highest and significantly ($p<0.05$) higher than 24.10 and 24.80% observed from *P. tuber-regium* and *Ganoderma*, respectively. This finding also aligns with the study of some researchers, such as Adebayo *et al.*[14], who reported higher protein content of *P. plumonarius* than that of *P. tuber-regium* and *Ganoderma lucidum*.

For Table 2, the mineral composition of the three edible mushrooms varies (potassium, calcium, magnesium, and iron). The varying mineral compositions were significantly different from each other, except for Iron. For calcium, *P. tuber-regium* (Osu) has the highest content (8.72 mg/100 g), which was significantly ($p<0.05$) higher than (5.87 mg/100 g) and (5.11 mg/100 g) obtained from *P. plumonarius* and *G. lucidium,* respectively. These findings, which report that the highest content of calcium is found in *P. tuber-regium,* respectively, are in tandem with the findings of Adebayo *et al.*[14]. For magnesium, (12.30 mg/100 g), (9.76 mg/100 g), and (7.14 mg/100 g) were recorded in *P. plumonarius*, *P. tuber-regium*, and *G. lucidum*, respectively; these values are significantly different from each other. This supports findings by Adebayo *et al.*[14], who reported high magnesium content in *P. plumonarius*.

The potassium content of *P. plumonarius* (115.46 mg/100 g) was the highest and significantly ($p<0.05$) higher than (122.89 mg/100 g) obtained from *P. tuber-regium*, while the least was (112.00 mg/100 g) recorded from *G. lucidum*. This agrees with the findings of Mattila *et al.*[15], who reported the varying content of potassium in three different edible mushrooms. The inference of this study showed that *P. plumonarius*, *P. tuber-regium*, and *G. lucidum* have very high nutritional values, with *P. plumonarius* being relatively better than the others in nutrients. Future research should explore the effects of location and substrates on the nutritional composition of the various mushrooms to ascertain the influence of these two factors on the nutritional values of cultivated mushrooms.

CONCLUSION

The findings from this study revealed that *P. plumonarius*, *P. tuber-regium*, and *G. lucidum* are rich in proximate and mineral contents, although *P. plumonarius* has relatively more nutritional values than *P. tuber-regium* and *G. lucidum*. Mushrooms are a highly nutritious food, rich in macronutrients and minerals; hence, the cultivation and consumption of the three mushrooms are encouraged.

SIGNIFICANCE STATEMENT

This study provides a comparative analysis of the nutritional value of *Pleurotus plumonarius*, *Ganoderma lucidum*, and *Pleurotus tuber-regium*, the three most commonly consumed edible mushrooms in Nigeria. While the individual nutritional compositions of these mushrooms have been previously reported, there is limited information on their comparative assessment. By bridging this knowledge gap, the findings offer valuable insights for consumers, nutritionists, and the food industry in making informed choices regarding dietary foods, food products, and additives. The study highlights the rich macronutrient and mineral content of these mushrooms and underscores the potential benefits of their cultivation and consumption, with *P. plumonarius* exhibiting relatively superior nutritional value.

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