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Nutritional Profile of Three Different Mushroom Varieties Consumed in Amaifeke, Orlu Local Government Area, Imo State, Nigeria

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ABSTRACT
The proximate and mineral composition of three varieties of mushroom consumed in Amaifeke, Orlu Local Government Area of Imo State were evaluated. The mushroom species include white button mushroom (*Agaricus bisporus*), oyster mushroom (*Pleurotus ostreatus*), Crimini mushroom (*Agaricus bisporus*). The mushroom varieties were harvested and dried, then taken to the laboratory for proximate, mineral and vitamin analysis. Standard assay methods were used to analyze for proximate and mineral composition. Proximate composition of the mushroom was found to be in the range of 3.29 – 5.24% for moisture content, 8.60 – 22.60% for protein, 6.85 – 7.54% for fat, 7.94 – 18.63% for fibre, 2.99 – 4.74% for ash and 59.67 – 60.60% for carbohydrate. Six mineral elements were analysed: selenium, iron, zinc, iodine, potassium and copper, having values of 3.04 -6.56mg/100g, 1.532 – 2.378mg/100g, 2.70 – 3.90mg/100g, 0.348 – 0.425mg/100g, 0.8079 – 2.4615% and 0.586 – 0.784mg/100g respectively. Based on the result the mushroom have high nutrient potentials hence it will serve as a good means of reducing the incidence and high prevalence of malnutrition in Nigeria since it is a cheap food source that is within the reach of the poor.

INTRODUCTION

Mushrooms are macro fungi with distinctive fruiting bodies, which can be hypogeous or epigeous, large enough to be seen with the naked eye and to be picked by hand (1). Wild edible mushrooms are traditionally used by many African countries as food and medicines; they are appreciated not only for texture and flavour but also for their chemical and nutritional characteristics (2 - 3). Mushrooms are valuable healthy foods, low in calories, fats, and essential fatty acids, and high in vegetable proteins as well as vitamins and minerals (4 - 5) These mushrooms have a worldwide distribution and are not only sources of nutrients but also have been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia and cancer (6 - 7); they are utilized as dried whole, powder or capsules and as tablets for promoting health in humans (8).

The focus on the nutritional value of brightly coloured fruits and vegetable has unintentionally left mushrooms in the dark. However mushrooms provide many of the nutritional attribute commonly found in meat, beans, grains or other produce. In some parts of Eastern Nigeria, the consumption of mushroom is not very popular because people are not aware of their nutritive value and they cannot identify the edible species. There is need to assess the nutrient potentials of mushrooms as they can help in the fight against micro-nutrient malnutrition. Therefore, analysis of the nutrient composition (proximate and mineral analysis) of the mushroom varieties is the focus of this study.

The use of mushrooms may contribute significantly in overcoming protein deficiency in the developing countries where good quality proteins from animal sources are either unavailable or unacceptable for religious beliefs (9 - 10). Therefore this study will help to bring home the importance and benefits of mushroom consumption.

MATERIALS AND METHODS

Sample

Three varieties of mushroom that were commonly available were freshly harvested from the farm in Amaifeke, Orlu Local Government Area of Imo State. The samples were white button mushroom, crimini and oyster mushroom with common names “ero osisi”, “ero otukwuru” and “ero ntioke”. Their botanical names being *Agaricus bisporus, Pleurotus ostreatus* and *Agaricus bisporus.*

Source of Sample

The samples used for this study were collected from logs of wood in the fields and also purchased from the old Orlu Main market.

Preparation of Sample

Non-edible portions and unwanted wastes or particles like soil, portion of compost where they were grown, spoiled portion of mushroom etc were separated and removed from the specimens. The mushrooms were then sundried by constant exposure to sunlight for 3 days while turning the mushrooms to avoid fungal growth.

Chemical Analysis

Determination of Moisture Content

The moisture content was determined by the gravimetric method (11). A measured weight of each sample (5g) was weighed into a weighed moisture can. The can and its sample content were dried in the oven at 105°c for 3 hours. It was then cooled in a dessicator and reweighed. The weight was recorded while the sample was returned to the oven for further drying. The drying, cooling and weighing was done repeatedly until a constant was obtained. The moisture content was calculated as follows

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where W_1 = weight of empty moisture can

W_2 = weight of can before drying

W_3 = weight of can + sample after drying to a constant weight

Determination of Fat Content

Fat content of the samples were determined by the continuous solvent extraction method using a soxhlet apparatus. The method is described by James (11). Five grams (5.0g) of each sample was wrapped in a porous paper. The wrapped sample was put in a soxhlet enflux flask containing 200ml of petroleum ether. The upper end of the reflux flask was connected to a condenser. By heating the solvent in the flask through electro-thermal heater, it vapourized and condensed into the reflux. Soon the wrapped sample was completely immersed in the solvent and remained in contact with it until the flask filled up and siphoned over thus carrying the oil extract from the sample down to the boiling flask. This process was allowed on repeatedly for about 4 hours, before the defatted sample was removed and reserved for crude fibre analysis. The solvent was recovered and the extracting flask with its oil content was dried in the oven at 60°c for 3 minutes (that is to remove any residual solvent). After cooling in a dessicator, the flask was reweighed.

By difference, the weight of fat extraction was determined and expressed as a percentage of the sample weight and calculated thus

$$\% \text{ Fat} = \frac{W_2 - W_1}{\text{Wt of sample}} \times \frac{100}{1}$$

Where W_1 = weight of empty extraction of flask

W_2 = weight of flask and oil extract

Determination of Protein

The protein content was determined by Kjeldahl method described by James (11). The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. A total of 0.5g of each sample was mixed with 10mls of concentrated sulphoric acid AR grade (Analytical Reagant Grade) in a Kjedahl digestion flask. A tablet of selenium catalyst was added to it and the mixture was digested and heated under a fume cupboard until a clear solution was obtained in a separate flask. The acid and other regents were digested but without sample to form the blank control.

All the digests were carefully transferred to 100ml vol. flask using distilled water and made up to a mark in the flask. A 100ml portion of each digest was mixed with equal volume of 45% NaOH solution in Kjedahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% Boric acid solution containing 3 drops of mixture indication. A total of 50ml distillate was obtained and titrated against 0.02M H_2S0_4 solution. Titration was done from the initial green colour to a deep red end point. The nitrogen content was calculated as follows:

$$\% \text{ N} = \frac{14 \text{ X N X100 X VF X T}}{\text{W X 100 Va}}$$

Where W = wt of sample analysed

N = Conc. H_2S0_4 titrant

V = Total vol. of digest

Fva = volume of digest distilled

T = Titre value – bank

Determination of Total Ash

This was done using the furnace incineration gravimetric method (12). A measured weight (5g) of each fruit sample was put in a precious weighed porcelain crucible. The sample in crucible was put in a muffle furnace at 550°c and allowed to burn for 2 – 3 hours (until the sample became a gray ash). The sample in crucible was very carefully removed from the furnace (taking care not to blow air into the ash) and cooled in a dessicator. It was reweighed by difference and the weight of the ash in percentage was obtained by this formula:

$$\% \text{ Ash} = \frac{W_2 - W_2 x}{\text{wt of sample}} \times \frac{100}{1}$$

Where W_1 = weight of crucible

W_2 = weight of empty crucible

Determination of Crude Fibre

This was determined by the Weende method (11). 5grams of each sample were defatted (during fat analysis). The defatted sample was boiled in 200ml of 1.25% $H_2 50_4$ solution under refulx for 30 minutes. After that, the samples were washed with several portions of hot boiling water using a two-fold muslin cloth to trap the particle. The washed samples were carefully transferred quantitatively back to the flask and 20ml of 1.25% NaOH solution added to it. Again the samples were boiled for 30 minutes and washed as before with hot water. Then they were very carefully transferred to a weighed proclaim crucible and dried in the oven at 105°c for 2 hours (until they became ash). Again they were cooled in a dessicator and reweighed

The crude fibre was calculated gravimetrically as

$$\% \text{ Ash} = \frac{W_2 - W_3}{\text{wt of sample}} \times \frac{100}{1}$$

Where W_2 = wt of crucible + sample after washingand drying in oven

W_3 = weight of empty crucible

Determination of Carbohydrate

The carbohydrate content was calculated by difference as the nitrogen free extractive (NFE), a method separately described by James (11). The NFE was % NFE = 100 %(a+b+c+d+e)

Where a= protein
b = fat
c = fibre
d = ash
e = moisture

Determination of Minerals

The mineral content of the test samples were determined by the dry ash extraction method following which specific mineral element. About 2.0g of the sample was burnt to ashes in a maple in ash determination; the resulting ash was dissolved in 100ml of dilute hydrochloric acid (1ml) HCl and then diluted to 100ml in a volumetric flask using distilled water. The digest so obtained was used for the various analysis.

Determination of Potassium

Potassium in the sample was determined using the flame photometry method. The instrument, Jaway digital flame photometer, was set up according to the manufacturer's instruction. It was switched on and allowed about 10 to 15 minutes to equilibrate. Meanwhile standard potassium solution were prepared and diluted in series to contain 10, 8, 6, 4 and 2pp of K. After calibrating the instrument, 1ml of each standard was aspirated into it and sprayed over the non-luminous flame. The optical density of the resulting emission from standard solution was recorded. Before flaming, the appropriate element fitter (k) was put in place with the standards measured, the test sample extracts were measured in time and they were plotted into standard course which to extrapolate the content of each test element and calculated as shown below

$$K \text{ (mg/100g)} = \frac{x}{100} \times \frac{vf}{va} \times D \times \frac{100}{w}$$

Where x = conc. of the test element from the curve.
vf = total volume of extract
w = wt of sample used
D = Dilution sample
va = volume of sample used.

Determination of Zinc

The element was determined using (12) method. 1gram of the sample was first digested with 20ml of acid mixture (650ml) conc HNO_3, 80ml pecloric acid. About 5ml of the digest was collected and diluted to 100ml with distilled water. This now serves as sample solution for AAS reading. Also standard solution of zinc was prepared in concentration of 0.0, 0.2, 1.0.

Calculation of the concentration of the samples was obtained by extrapolating the ppm off curve.

$$\text{Zn (mg/100g)} = \frac{100}{1} \times \frac{100}{w} \times D$$

Where x = ppm off curve.
Vf = total volume of extract
D = Dilution sample
va = volume of sample used.

Determination of Iron

The element was determined using (12) method. 1gram of the sample was first digested with 20ml of acid mixture (650ml) conc, $HN0_3$, 80ml pecloric acid. About 5ml of the digest was collected and diluted to 100ml with distilled water. This now serves as sample solution for AAS reading.
Also standard solution of iron was prepared in concentration of 0.0, 0.2, 1.0. Calculations of the concentration of the samples were obtained by extrapolating the ppm off curve.

$$\text{Iron (mg/100g)} = \frac{100}{1} \times \frac{100}{w} \times D$$

Where x = ppm off curve.
Vf = total volume of extract
W = wt of sample
D = Dilution sample

Determination of Copper and Selenium

The method of AOAC (12) was used. 2grams of each sample was collected and was added into HCL for preparation of stock solution. Aliquot of the diluted clear digest was used for spectrophotometric reading. Also standard solution of the elements were prepared in concentrations of 0.0, 0.5, 1.0 and 1.5ppm.

$$\text{Cu (mg/1000)} = \frac{100}{1} \times \frac{x}{103} \times \frac{vf}{va}$$

$$\text{Se(mg/1000)} = \frac{100}{1} \times \frac{x}{103} \times \frac{vf}{va}$$

Where x = ppm off curve.
W = wt of sample
Vf = volume of total sample
Va = volume of sample used.

Statistical Analysis

The data was analysed to the determine the means and standard deviation (SD).

RESULTS

TABLE 4.1: The Proximate Composition of White Button, Oyster and Crimini Mushroom Varieties.

Samples	Moisture %	Protein %	Fat %	Carbohydrate %	Ash %	Fibre %
A	5.24±0.15	11.91±0.03	6.90±0.17	60.04±0.15	3.27±0.09	12.65±0.17
B	3.29± 0.07	8.60±0.10	6.85±0.08	59.67±0.14	2.99±0.02	18.63±0.44
C	4.14±0.07	22.60±0.06	7.54±0.07	60.60±0.11	4.47±0.06	7.94±0.18

Mean ± standard Deviation of Three Replication.

A = white button mushroom
B = oyster mushroom
C = crimini mushroom.

Moisture Content
White button mushroom had the highest moisture content, (5.24 ± 0.15%) while oyster mushroom had the lowest moisture content (3.29 ± 0.07%).

Ash
The mushroom with the highest ash content was the crimini mushroom with a percentage of 4.74 ± 0.06 followed by the white button mushroom with a percentage of 3.27 ± 0.09 and oyster mushroom with lowest content of 2.99 ± 0.02%.

Fat
Fat content was highest in the crimini mushroom (7.54 ± 0.07%) and lowest in oyster mushroom (6.85 ± 0.08%) while the white button variety had a fat content of 6.90 ± 0.17%.

Protein
Sample C had the highest protein content of 22.60 ± 0.06%, followed by Sample A with a value of 11.91 ± 0.03% and Sample B with the lowest content of 8.60 ± 0.1%.

Fibre
The content of fibre in the mushrooms was seen in the descending order B>A>C having the value of 18.63 ± 0.44%, 12.65 ± 0.17% and 7.94 ± 0.18% respectively.

Carbohydrate
The carbohydrate content was highest in sample C with the value of 60.60 ± 0.11%, followed by sample A (60.04 ± 0.15%) and sample C (59.67 ± 0.14%).

Table 4.2: The Mineral Content of White Button, Oyster and Crimini Mushroom Varieties mg/100g

Samples	Selenium	Iron	Zinc	Iodine	Potassium	Copper
A	6.480±0.11	1.531±0.03	3.40±0.4	0.376±0.05	1.615±0.08	0.769±0.08
B	3.040±0.08	2.378±0.03	2.70±0.02	0.425±0.07	0.8079±0.3	0.586±0.09
C	6.560±0.09	2.188±0.06	3.90±0.3	0.348±0.02	2.4615±0.05	0.784±0.04

Mean ± SD of three replications

KEY A = White button mushroom
B = Oyster mushroom
C = Crimini mushroom

Selenium
The selenium content was highest in sample C (Crimini mushroom) (6.56 ± 0.09), followed by the white button mushroom (6.48 ± 0.11) and the lowest content in the oyster mushroom (3.64 ± 0.08mg/100g).

Iron
Sample B (oyster mushroom) had the highest iron content (2.378 ± 0.03mg/100g) while sample C (crimini mushroom) followed it with a content of (2.188 ± 0.06mg/100g) and sample A had the lowest content 1.531 ± 0.03mg/100g.

Zinc
The highest zinc content was seen in sample C (the crimini mushroom) with a value of 3.90mg/100g, sample A followed it with a value of 3.40 ± 0.4mg/100g and sample B having the lowest content of 2.70 ± 0.02mg/100g.

Iodine
The iodine content of the mushrooms was seen in the descending order of B>A>C having the values of 0.425mg/100g, 0.376 ± 0.05mg/100g and 0.348 ± 0.02mg/100g respectively.

Potassium
The potassium content of the mushroom was obtained in percentages. Sample C had the highest percentage (2.4615 ± 0.05), sample A had the second highest percentage (1.615 ± 0.08) and sample B had the lowest percentage of 0.8079 ± 0.3.

Copper
Sample C had the highest content of copper (0.784± 0.04mg/100g), followed by sample A with 0.769 ± 0.08mg/100g and sample B had the lowest content of 0.586 ± 0.09mg/100g.

DISCUSSION

Proximate Composition
The proximate composition values for the studied mushroom species are shown in Table 1. It is known that the moisture content of mushrooms depends on their harvesting time, maturation period and environmental conditions such as humidity and temperature in growing period, and storage conditions (5). The moisture content of all studied mushroom species ranged from 3.29% to 5.24%, which is similar to the study made by Okechukwu *et al*., (13) on eight mushrooms species having a moisture content range of 3.0 – 10.55%.

The slight difference in the moisture content of the samples when compared to the work of Emmanuel *et al*., (2013) might be attributed to the dried sample used for analysis.

The ash content observed were between 2.99 – 4.74% which indicates that the mushroom contains some nutritionally important minerals. The ash content reported by Okechukwu *et al*., (13) showed a range of 3.20 % - 25.10%. the studied mushrooms also have less amount of ash when compared to 10.98 – 29.06% obtained by Afiukwa *et al*., (14) and significantly lower than those reported by Okechukwu *et al*., (13).

The amount of fats in the mushrooms ranged from 6.85% - 7.54% with crimini mushroom having the highest value and oyster mushroom having lowest value on dry weight basis. The fat content of the mushrooms is low when compared to the content of carbohydrates and proteins. This agrees with earlier reports (15 - 17). These values are higher than those reported for mushrooms species in Turkey by Caglarlmak *et al*., (2002), higher than the values obtained for Agaricus bisporus and Plerotus ostreatus by Shah *et al*., (18) and also higher than the amount reported for four species in India by Manjunathan *et al*., (15), but a bit lower than the values obtained by Okechukwu *et al*., (13)

On dry weight basis, the protein contents of the mushrooms varied from 8.58% to 22.60%. these are appreciable amounts of protein from nutritional perspective, suggesting that some of the mushrooms are good sources of protein. Crimini mushroom had the highest content of protein (22.501). The obtained values of protein were similar to the report of Okechukwu *et al*., (13) for wood ear and oyster mushrooms (10.50 and 14.88%) respectively. In the study carried out by Afiukwu *et al*., (14), *Pleurotus ostreatus* had the highest mean concentration of 16.35% which is higher than that gotten from this study (8.58%).

The obtained values of carbohydrate indicated that the mushrooms are good energy food sources. Mushroom carbohydrates include glucans, mono-and disaccharides, sugar, alcohol, glycogen and chitin (19 - 20).

Based on dry weight, the carbohydrate concentration of the mushrooms ranged from 59.67% to 60.60%. The carbohydrate content of the mushrooms appeared similar to those reports by Ogbe and Obeka (19) and Shin *et al*., (21) for Pleurotus species (61.24 and 69.93%), A. auricular (77.74%) and G. lucidum (63.27%).

The values are also similar to that obtained for Agaricus bisporus (56.47%) by Sadiq *et al*., (22). The amounts of carbohydrate detected in these mushrooms are significantly higher than 11.98% and 14.91% obtained from wood ear and oyster mushrooms respectively by Okechukwu *et al*., (13) and also higher than 6.50 – 9.53% reported for three species in Turkey (16).

The fibre contents of the mushrooms are reasonably high, suggesting that the mushrooms would be valuable in improving human health by quickening the excretion of wastes and toxins from the body. The fibre contents ranged from 7.94% -18.63%. These values are very similar to those obtained in India by Marijunathan *et al*., (15) and are higher than those reported by Okechukwu *et al*., (13). Oyster mushroom had the highest fibre content (18.63%) while Crimini mushroom had the lowest fibre content (7.94%). The study carried out by Afiukwa *et al*., (14) revealed fibre content of (29.00%) in plerotus ostreatus which is significantly higher than the results obtained from this study. The value for Agaricus bisporus was 11.01% which is comparable to the fibre content of the studied mushrooms.

Mineral Composition

Six important minerals (copper, potassium, zinc, iodine, iron and selenium) were determined in the three mushroom varieties. The amounts are presented in Table 2, all the mineral elements were found in appreciable amounts and varied widely among the species. Among the six minerals determined in the mushrooms, the dominant ones are selenium, zinc, iron and potassium which ranged from 3.040 – 6.560mg/100g, 2.70 – 3.90mg/100g, 1.531 – 2.188mg/100g and 0.8079 -2.4615% respectively. Iodine and copper were least in concentrations with values 0.348 – 0.425mg/100g and 0.586 – 0.784mg/100g respectively.

Potassium is very important in the maintenance of osmotic balance between cells and the interstitial fluid in animal systems. In these mushrooms, potassium is present in 0.8079 – 2.4615% which would be an excellent food source of lowering blood pressure, reducing the risk of osteoporosis, and in maintaining bone health (17, 23). Though it is low for the range of values reported by Afiukwa *et al*., (14), which is 221.13mg/100g; the range reported by Caglarmak *et al*., (16) for L. piperatus and B. edulis species were (203.24mg/100g and 272.93mg/100g). It is also low compared to the range of 59.3 to 3634mg/100g dry weight of four mushroom species by Mailikarjuna *et al*., (15). The amount of potassium is hwever higher than those reported for leafy

vegetables (24).

Iron, which is essential for the biosynthesis of the oxygen-carrying pigment of red blood cells and the cytochromes that function in cellular respiration (17), is also present in good amounts in the mushrooms. The amount of iron found in the mushrooms (1.531 -2.378mg/100g) is within the range of values (0.74-3.38mg/100g) reported by Caglarlmak *et al*., (16) for three species in Turkey, but lower than 16.3 -85.6mg/100g reported for four species in India (15) and much lower than 2970 – 2785mg/100g reported by for two mushroom species from Owerri, Nigeria by Okechukwu *et al*., (13). It is however similar to the amounts (0.81 – 1.26mg/100g) found in mushrooms by Afiukwa *et al*., (14).

Zinc which is indispensable in numerous biochemical pathways as an important co-factor for certain enzymes was equally present in the mushroom species analysed. The zinc content is high when compared to the zinc content of mushrooms (0.104 – 1.324mg/100g) by Afiukwa *et al*., (14) and comparable with the values reported by Manjunathan *et al*., (15), (1.0 -6.2mg/100g). It is also higher than 1.10mg/100g available on the USDA Nutrient Database for mushrooms. The zinc content obtained from the study (2.70 – 3.90mg/100g) also meets about 25 – 30% of the recommended daily intake of zinc for both men and women.

Copper serves as a constituent of several enzymes. The copper-containing enzymes have diverse metabolic roles with one common characteristic: all involve reactions that consume oxygen or oxygen radicals. Copper, like iron, is needed in many of the metabolic reactions related to the release of energy.
The copper content of the mushrooms analysed gave the range of 0.586 – 0.784mg/100g. This is comparable with the content of 0.97 – 1.48mg/100g obtained from mushrooms by Mallikarjuna *et al*., (25) and also comparable with 7.43 $\pm$ 0.13ppm by Ogbe and Obeka (19) but lower than 84.25mg/kg reported by Agumuo (20).

Selenium is one of the body's antioxidant nutrients, working primarily as part of the enzyme glutathione peroxidase. Glutathione peroxidase prevents free radical formation. Selenium also helps to regulate the thyroid hormone. The selenium content of the mushrooms was found to be within the range of 3.040 – 6.560mg/100g. Selenium has the highest content of mineral compared to the other mineral element analysed. It is higher than the results of 0.048 – 0.19mg/100g reported by Mallikarjuna *et al*., (25). It is also higher than the result of 2.7mg/kg for wild Agaricus spp by Piepponen *et al*., (26).

Iodine is indispensable to life. In the GI tract, iodine from foods becomes iodide. Iodide occurs in the body in minute amounts, but its principal role in the body as an integral part of the thyroid hormones that regulate body temperature, nerve and muscle function, reproduction, growth, metabolic rate and more are well established. The iodine content of the mushrooms was found in small amounts of 0.348 – 0.425mg/100g.

Conclusion

The findings from this study revealed that mushrooms are highly nutritious foods. They are rich in macro nutrients and minerals even selenium which an anti-oxidant nutrients. Their protein content is high, offering up to 8% - 22%, higher than the protein content of most vegetables. Mushrooms are foods that can be eaten by anybody, both the old and young. It is also good food for hypertensive patients as its high potassium content can help to control blood pressure. Therefore, mushroom consumption should be encouraged in the communities and also its cultivation should be encouraged so that there will be a year-round production and availability of mushrooms.

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