# Studies on Nutritional and Anti-Nutritional Profiles of Five Species of Mushroom Found in Anambra State, South Eastern, Nigeria

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***Abstract* —** *Five species of wild mushrooms namely Termitomycesrobustus, Agaricusbisporus, Amanita phalaoides, Amanita verosa and Pleutotus tuber-regiumwere studied.* They were collected from eleven places in four local government areas of Anambra State, South-Eastern, Nigeria. *Standard analytical methods were employed in this research to obtain the proximate compositions, vitamin C content, mineral composition and anti-nutritional factors (phytic acid, hydrocyanide, and tannins). The moisture content (MC) ranged from 81.23 % to 97.10 %. MC value was highest in the Amanita phalaoides (97.10 %) and lowest in the Agaricusbisporus (81.23 %). Average crude protein (CP) ranged from 8.50 % to 24.18 % while crude fibre (CF) contents ranged from 2.20 % to 11.43 %. Carbohydrate content ranged from 21-69 % while fat content ranged from 1-6 %. Mineral composition indicated appreciable amounts of Fe ranged from154-684 mg/kg, Mg 476-191 mg/kg, Ca 83-545 mg/kg,K 167-934 mg/kg,Na152-777 mg/kg, Cu 0-1.0 mg/kg, Co 0-1.52 mg/kg, Pb 3-5 mg/kg, Zn 25-61 mg/kg, Cd3-6 mg/kg, Ni 1-16 mg/kg and Mn 8-24 mg/kg. Vitamin C content was very low (0- 0.15 mg/100g) in all the species. Phytic acid content ranged from 0.01-0.70 mg/100g, Hydrocyanic acid from 0.02– 0.21 mg/100g, and tannins ranged from 0.12 to 0.27 mg/100g, these are low to give adverse effect*

**Keywords —** *Nutrient composition, Anti-nutrients, edible and non-edible Mushrooms, Anambra State, South Eastern, Nigeria.*

## I. INTRODUCTION

Mushrooms are a special group of fungi which are saprophytic in nature, they grow in dark, damp places and produce a wide range of enzymes which progressively break-down complex substances into simpler inorganic matter. Reports have shown that mushrooms contained proteins, vitamins, fats, carbohydrates, amino acids and minerals[1, 3, 4]. Many studies gave proof of the fact that some mushroom species are useful in some combinations in treatment of headache, stomach disorders, colds, fever, asthma and high blood pressure[1,5]; some species were recommended to diabetic and anemic persons, due to their low carbohydrates and high folic acid content. Some were reported to possess anti-allergic, anti-cholesterol, anti-tumor and anti-cancer properties[1, 3, 5]. Researchers revealed high ability of mushrooms to accumulate common pollutants present in the biosphere at trace levels, mainly heavy metals [5, 6, 7]. The main course of concern is their toxicity with some being carcinogenic and mutagenic [20]. Most of the studies on mushroom species were reported in Niger Delta Region of the country [5, 7, 20]. No studies have been reported on mushrooms found in Anambra State, South-Eastern, Nigeria. We have therefore chosen to determine the physicochemical and toxicological profiles of five species of wild mushroom found in the study area with the aim of providing some baseline data of these mushrooms. The specific objectives of this study were to: (i) determine the physicochemical and toxicological profiles of five wild mushroom species found in the study area and (ii) assess the edibility of those considered non-edible.

## II. MATERIALS AND METHODS

### *Sampling*

Five species of wild mushrooms were collected from towns and villages as indicated in Fig 1, namely Uke, Abatete, Ideani, Nnobi, Nnewi, and Ozubulu,in Anambra State, South-Eastern , Nigeria during the season of availability (July-October) , between 2006 and 2012. Table 1 shows the specific sites, environment or substrate, habitat, mushroom species and their local names.

The wild mushroom samples were immediately taken to the laboratory and stored in refrigerator at 4 $^0$C to avoid dehydration and possible spoilage. Photographs of the mushroom samples are shown in Fig 2(a-e).

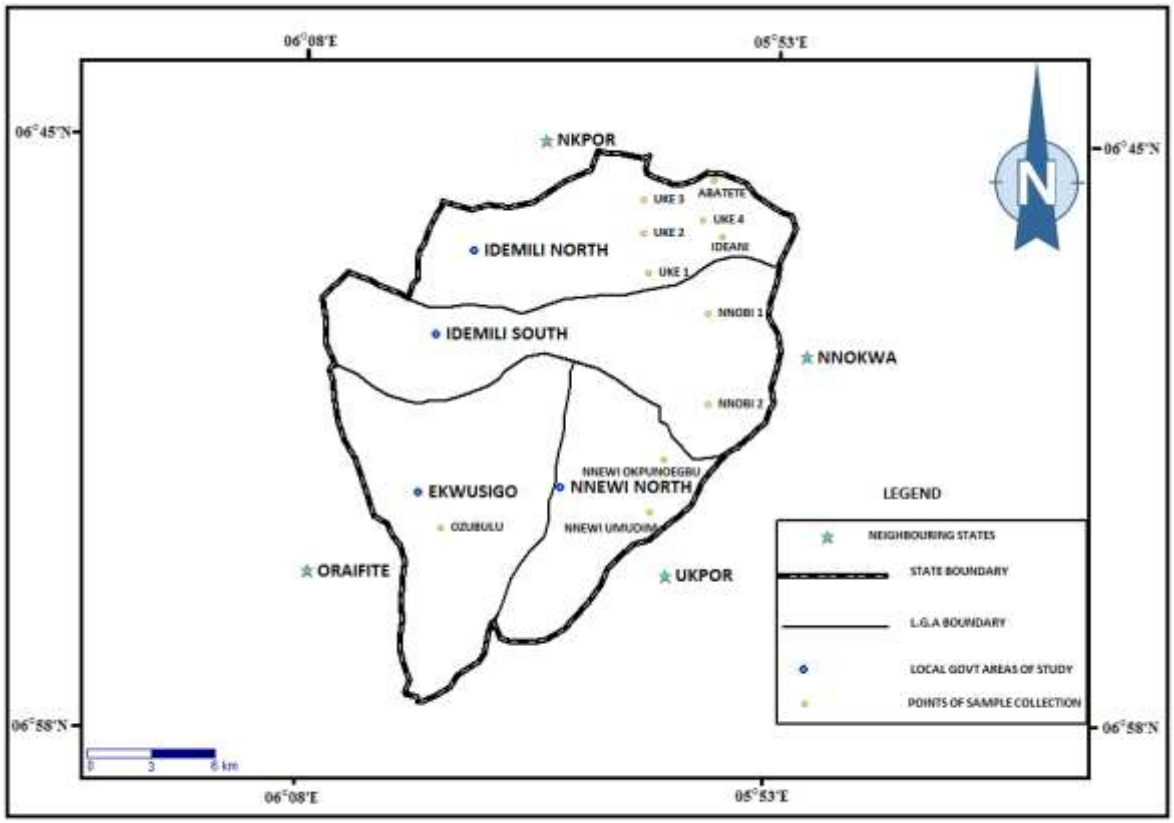


FIG 3.1: MAP OF IDEMILI NORTH & SOUTH, NNEWI NORTH & EKWUSIGO L.G.A SHOWING SAMPLING SITE.

SOURCE: MINISTRY OF LAND AND SURVEY ANAMBRA STATE MODIFIED FROM FIELD TRIP 2012

**TABLE 1**

**SAMPLING SITES, HABITAT, MUSHROOM SPECIES, THEIR LOCAL NAMES AND EDIBILITY**

| S/N | SITE | HABITAT | SPECIE OF MUSHROOM | LOCAL NAME | EDIBILITY |
|---|---|---|---|---|---|
| 1 | Uke | Termite nest behind family house | *Termitomycesrobustus* | ERO-MKPU | Edible |
| 2 | Uke | Dead bread fruit tree by road side | *Agaricusbisporus* | ERO-OSISI | Edible |
| 3 | Uke | Rotten wood on farm land | *Agaricusbisporus* | ERO-OSISI | Edible |
| 4 | Uke | Soil in farm land | *Amanita verosa* | ERO-OHIA | Non- edible |
| 5 | Abatete | Rotten plant leaves inside bush | *AmanitaPhalaoides* | ERO-AGBUGBO | Non-edible |
| 6 | Ideani | Dead wood inside bush | *Pleurotus Tuber-regium* | ERO-OSU | Edible |
| 7 | Nnobi | Dead wood in farm land | *Agaricusbisporus* | ERO-OSISI | Edible |
| 8 | Nnobi | Forest soil | *Amanita verosa* | ERO-OSISI | Edible |
| 9 | Nnewi okpuno | Refuse dump | *Agaricusbisporus* | ERO-OSISI | Edible |
| 10 | Nnewi Umudim | On soil inside bush near disused battery in the bush | *Amanita verosa* | ERO-OHIA | Non-edible |
| 11 | Ozubulu | Near termite nest on farmland | *Termitomycesrobustus* | ERO-MKPU | Edible |

*a)Agaricusbisporus*

*b)Termitomyces robust*

*c)AmanitaAphAphphalaiodes*

*d) Amanitaverosa*

*e) AvAV*

*f)* Agaricusbisporus

g) Pleurotustrrrregium

## III. PROXIMATE ANALYSES

***Sample Preparation*:**

Mushroom samples were oven dried at 75 $^0$C, ground and kept in polythene bottles. Soil/substrate samples were oven dried at 105 $^0$C until constant weights were obtained. The dried samples were pulverized and kept in treated polyethylene containers.

**MOISTURE CONTENT AND DRY MATTER[12]**

Three dried porcelain crucibles were weighed and kept in a desiccator. 5.0 g of fresh ground mushroom samples were weighed in the porcelain crucibles and put into the oven (Gen. Lab JENNY WAY, MODEL MINO/30 England) and dried at 75 $^0$C for 6 hr. Further drying and weighing were conducted until constant weights were obtained[12]. The weight obtained after further drying for 6 hr at the same temperature (75 $^0$C) represented the dry matter, also expressed in percentage[12].

**ASH CONTENT[12]**

5.0 g oven–dried mushroom samples were weighed in a previously dried and weighed porcelain crucibles. The crucibles and their contents were placed in a muffle furnace (Vecstar F EF3,Jennyway, Chesterfield, U.K) and ashed at 450 $^0$C for 4 hr. The furnace was switched off and the crucibles were left to cool, before being transferred into a dessicator and weighed later after attaining room temperature. The loss on ignition and the % ash contents were calculated.

**CRUDE PROTEIN CONTENT[12]**

Crude protein was determined by the micro Kjeldahl method[12]. 5.0 g of dried finely ground mushroom samples were weighed into 500 mL round bottom Kjeldahl flask. 2.0 g of digestion catalyst

($K_2SO_4$) mixed with $H_2O$ were added followed by 20 mL of concentrated $H_2SO_4$. The flask was gently heated until frothing subsided.The heat was increased until a colourless or pale green digest was obtained. The digest was allowed to cool and then diluted to 25 mL with distilled water. 20 mL of the diluted digest was placed in a distillation flask with addition of 25 mL of 4M NaOH solution followed by distillation. The distillate was collected in a receiver containing 10 mL of 0.1M boric acid solution. After distillation,0.1M HCl solution was used to titrate excess boric acid to violet end point(just before the solution goes back to pink).Amount of $NH_3$ liberated was obtained by difference. The crude protein was calculated using a conversion factor of 6.25

**TOTAL LIPIDS[12]**

5.0 g of dried and ground mushroom sample was weighed in a 10 mm thimble, and put in a soxhlet extractor having a 60 mL flask.. A clean dry 25 mL round –bottom flask containing black beads to serve as boiling chips to ensure smooth boiling was accurately weighed. 20 mL of ether was added to the flask which was connected to the extractor and extraction was carried out for 4-6 hr[12]. At the end of extraction, the flask was removed and put in the oven at 40 $^0$C for 30 min. Later cooled in a desiccator and reweighed. The total lipid was then calculated and expressed in %.

**CRUDE FIBRE CONTENT[12]**

5.0 g of powdered mushroom sample was weighed into a porcelain crucible and ashed in a muffle furnace at 450 $^0$Cfor 4 h. 2.0 g of the ashed sample was weighed into a beaker and 100 mL of 1.25 % $H_2SO_4$ was added. The beaker was covered with a watch glass and gently heated on a hot plate for 30 min. The supernatant was decanted under suction through a pre-weighed sintered glass crucible and the residue and the supernatant were washed three times with about 50 mL of boiling water. The content was washed into the sintered glass crucible and dried in an oven for 3 hr at 105 $^0$C. It was cooled and weighed to constant weight. The difference divided by the sample weight expressed in percentage gives the % fibre content.

**ETHANOL SOLUBLE SUGAR[21]**

5.0 g of dried powdered mushroom samples were extracted with 50 mL of 80 % ethyl alcohol in a soxhlet extractor for 6 hr. The crude extract was diluted to 100 mL with 80 % ethyl alcohol. The quantity of soluble sugar in the extract was titrated using the phenol sulphonic acid method[21].

**VITAMIN C CONTENT[21]**

10 mL of 1 M ascorbic acid solution was pipetted into 50 mL conical flask and titrated with 0.1 M dicchlorophenol indophenol (DCPIP) dye. A faint pink colour that persists for at least 5 s indicated the end point. Therefore , titre value is 1 mL of 0.1 M DCPIP= w (mg) ascorbic acid=0.002mg ascorbic acid standard. 5.0 g of grounded mushroom sample was weighed in a 50 mL conical flask. 5.0 mL of water were added followed by 5 mL of 10 % ascorbic acid. The flask was carefully shaken for 30 min. The sample solution was then titrated with 0.1 M DCPIP dye solution in the burette. Thus mgVit C =titration value x 0.002 mg(ascorbic acid factor).

**DETERMINATION OF ANTI-NUTRITIONAL FACTORS IN THE MUSHROOMS SAMPLES.**

**PHYTATE CONTENT[21]**

5.0 g of finely grounded mushroom samples were extracted with 100 mL of 0.5 M HCI for 2 h. 25 mL of the extract neutralized with 0.5 M NaOH and later made slightly acidic with 0.17 M HCI. The solution was diluted to 50 mL with distilled water and 10 mL of the solution was heated, cooled and centrifuged. 25 mL of distilled water was added to the residue and heated for 3 min at 100 $^0$C.The residue was digested with 1mL 60 % HCI, 5ml 10 % $HNO_3$ and 0.5 mL 10 % $H_2SO_4$ for 15 min. The digest was cooled and diluted to 50 mL with distilled water. Stock solution of potassium hydrogen phosphate was prepared by dissolving 0.4393 g $KH_2P0_4$,dried at 105 $^0$C,in de-ionized water and diluted to 1 litre in standard flask. 25 mL of the stock solution was diluted to 500 mL to get working solution. Treat aliquots of standard solution containing 0.5,1.0 and 1.5 mg/L. Also dissolve 2.0 g $(NH_4)_6.MO_70_{24}H_20$ in 50 mL de-ionized water. Add 28.5 mL conc. $H_2S0_4$,cool and dilute to 1 litre with de-ionized water. Use this to set the absorbance at 827 nm, then plot calibration curve from the standards prepared and used that to determine mg of phosphorus in the sample aliquot.

**CYANIDE CONTENT[21]**

5.0 g of ground mushroom samples were suspended in 200 mL of water and diluted slightly with 10 % sulphuric acid and distilled with an upright condenser. The vapour was allowed to condense into a flask containing a few mililitres of 0.1 M nitric acid. Phosphorus and phosphine were oxidized to phosphoric acid which was precipitated as the yellow molybdophosphate on the addition of ammonium molybdate solution. It was Filtered and titrated against 0.2 M silver nitrate solution until a faint but permanent turbidity was obtained. The final value minus initial value expressed in % = the cyanide content of the sample.

**TANNINS CONTENT[21]**

5.0 g of finely ground mushroom sample was suspended in 50 mL distilled water and extracted by shaking continually for 60 seconds. The sample was washed and rinsed 3 times with 50 mL distilled water. The final volume of filtrate was made up to 60 mL, 3 mL of O.1 M $FeCl_3$ was added to the filtrate,

followed by 3 mL of 0.008 M $K_3Fe(CN)$. The solution was allowed to stand at ambient temperature for 10 min and then filtered. The absorbance of the blank and test sample were read at 720 nm using a UV/VIS spectrophotometer JENWAY (MODEL 6715, Staffordshire, U.K). The concentration of the test sample was read and expressed as mg/g of dry sample.

**PREPARATION OF SAMPLES FOR METALS DETERMINATIONS**

**ASHING OF MUSHROOM SAMPLES[10,11]**

Porcelain crucibles with covers were cleaned and dried at 450 $^0$C for 30 min and kept inside the muffle furnace. The dishes were allowed to cool and weighed. This was repeated until constant weights were achieved.

2.0 g of dried ground mushroom samples were accurately weighed into the crucibles and 1 mL of conc.$HNO_3$ was added and left over-night. The sample was charred (carbonized) over a Bunsen burner flame for escape of gases and transferred into the muffle furnace at 450 $^0$C to ash for 4 h with periodical check for complete ashing (when a whitish residue appeared). The furnace was switched off and the residue allowed to cool. The ashed samples were later removed and put in a dessicator.

**SOLUTION OF THE MUSHROOM SAMPLES:**

5 mL of 10 % HCl solution was added to the ash and heated in water bath for complete dissolution. If the ash did not totally dissolve, 5 ml of 10 % nitric acid were also added and boiled in water bath to dissolve. The sample solution was transferred quantitatively using a stirring rod and through a funnel with acid treated filter paper, into a clean dry 50 mL standard flask and made up the volume with de-ionized water, after rinsing both crucible and filter paper. The resulting solution was used for flame photometer or atomic absorption spectrophotometer.

**DETERMINATION OF SODUIM AND POTASSIUM. STANDARD SOLUTIONS OF SODIUM AND POTASSIUM[12, 21].**

2.54 g NaCl and 1.91 g KCl were each weighed out ,these were dissolved in de-ionized water in 1 litre volumetric flask and made up to mark with de-ionized water to serve as stock solutions. The solution contained 1000 mg/L Na or K. The working sodium and potassium standard solutions were prepared by diluting 0.1 mL, 0.3 mL and 0.5 mL to 100 mL to get 1, 3 and 5 mg/L solutions respectively.

**PREPARATION OF STOCK SOLUTIONS OF OTHER TRACE METALS[12, 21].**

Stock metal solutions were prepared as follows:-

**Calcium:**-To 2.49 g of calcium carbonate (analar grade) was added 10 % HCl to effect complete dissolution in a 100 ml beaker. The solution was diluted to mark in 1 litre volumetric flask with de-ionized water. This solution was 1000 mg/L calcium concentration.

***Cobalt*:** 4.76 g of cobalt sulphate was dissolved with de-ionized water and made up to 1litre to get 1000 mg/L stock solution.

***Iron***: 2.78 g of ferrous sulphate($FeSO_4$)(analar grade) was dissolved in de-ionized water containing 50 mL 0.1M sulphuric acid. The solution was standardized by titrating with 20 % potassium dichromate solution using N-phenlanthanic acid as indicator.

***Magnesium*:** 10.01 g magnesium sulphate ($MgSO_4$) was dissolved in 200 mL de-ionized water. To this was added 1.5 mL conc. nitric acid and the solution was made up to 1L mark. The solution was standardized by titrating with 0.1 M EDTA solution using eriochrome black-T as indicator. The solution was found to contain 1000 mg/L of magnesium ions.

***Manganese*:** 3.08 g manganese sulphate($MnSO_4$) was dissolved with 200 mL deionized water. To the solution 1.5 mL of conc.nitric acid was added and made up to one litre.The solution was found to contain 1000 mg/Lof manganese.

***Zinc*:** 4.40 g of zinc sulphate ($ZnSO_4$) was dissolved in de-ionized water and made up in a 1litre flask. The solution was standardized with 0.1M EDTA using eriochrome black-T as indicator. The solution was found to contain 1000 mg/L $Zn^{2+}$.

NB: At least five serially diluted standard solutions of each metal were prepared by diluting the stock solution with 0.1 M HCl.

***Chroniumstock solution***:1000 µgCr/mL:

Dissolve 0.1923 g $CrO_3$ in mixture of 10 mL reagent water and 1 mL $HNO_3$. Dilute to 100 mL with de-ionized water.

***Nickel stock solution:(1000µg Ni/mL)*:** Dissolve 0.100 g Ni powder in 5 mL $HNO_3$ by heating at 75 $^O$C-80 $^O$C, cool to room temperature and dilute to100 mL mark with de-ionized water.

***Copper stock solution:(1000 µg Cu/mL)***Pickle Cu metal in(1+9)$HNO_3$ solution to 0.100 g. Dissolve in 5 mL (1+1) $HNO_3$ Solution by heating at 75 $^0$ -80 $^0$C ,cool to room temperature and dilute to 100 mL mark with de-ionized water.

***Lead standard solutions:Stock solution-1 mg/mL***

Dissolve 1.000 g Pb powder in 20 mL $HNO_3$ (1+1) in 1 L volumetric flask and dilute to volume with de-ionized water.(2) Working solution: 5 µg/mL

Pipet 1 mL stock solution into 200 mL volumetric flask and dilute to volume with de-ionized water.

***Cadmium standard solutions: Stock solution-1 mg/mL.***Dissolve 1.000g Cd powder in 20 mL $HNO_3$ (1+1) in 1 L volumetric flask,and dilute to volume with water. (2) Working solution-1 µg/mL Pipet 10 mL stock solution into 100 mL volumetric flask, and dilute to volume with de-ionized water. Pipet 2 mL of diluted solution into 100 mL volumetric flask and dilute to volume with de-ionized water.

**DETERMINATION OF TRACE METALS BY AAS[10, 11, 21].**

**PREPARATION OF MUSHROOM SAMPLE SOLUTIONS:**

2.0 g of dried and ground mushroom samples were ashed in glazed crucible after pre-burning(charring) over a Bunsen flame in a fume chamber. The ashing was done at 450 $^0$C for 4 h in a muffle furnace. After cooling, the ash was transferred into a 50 mL beaker by dissolving in 10 mL conc. $HNO_3$ and rinsing with 10mL conc. HCl. The solution was covered with watch glass and warmed gently for 10 mins, the solution was then cooled, decanted into 100 mL volumetric flask, and made up to the mark with de-ionized water.

**OPERATION OF ATOMIC ABORPTION SPECTROPHOTOMETER.**

The hollow cathode lamp of the desired metal was installed in the instrument. The slit width was set according to the manufacturer's guide for the element to be measured. The instrument was turned on and the current was set according to the manufacturer's guide. The instrument was allowed to warm up until the energy source stabilized. The process took 10 to 20 min. The current was re-adjusted after warming up. The burner head was then installed and lighted using air-acetylene mixture. The atomizer was rinsed by aspirating the blank (de-ionized water), and the instrument was zeroed. Each metal standards and sample solutions were atomized using air-acetylene flame.

The absorbance were recorded and printed- out. Average of three readings were taken per sample.
Table2: Shows the resonance lines of the elements.

**Table 2: Characteristic (Resonance) lines of metals determined by AAS[21]**

| Elements | Resonance lines (nm) |
|---|---|
| K | 7440.1 |
| Ca | 422.7 |
| Cd | 228.8 |
| Co | 240.7 |
| Cr | 357.9 |
| Cu | 324.7 |
| Fe | 248.3 |
| Na | 589.0 |
| Pb | 217.0 |
| Zn | 213.9 |
| Ni | 232.0 |
| Mg | 766.5 |
| Mn | 279.1 |

**STATISTICAL ANALYSIS**

The data obtained were subjected to analysis of variance (ANOVA) using SPSS version 16.0 window 2007. Significantly different means were determined using Duncan's multiple range test[13,14]

**RESULTS AND DISCUSSION**

The proximate composition anti-nutritional profiles of studied wild mushrooms are presented in table3. The moisture content (MC) ranged from 81.79 % to 97.84 %. These values were similar to values recorded by Ijeoma et al (2015)[1] when he evaluated the nutritive values of wild Nigerian edible mushrooms. Dry matter (DM) ranged from 2.63 % to 18.36 % shows an indication of high roughages contained by mushrooms. Crude protein (CP) ranged from 8.16 % to 24.67 % which compared favourably with seeds and legumes, (cowpea19.06 %, TreculiaAbrilana 19.31 %,Bean seed 20.80 %,colocycilrullus 22.00 % and ground nut 23.05 %)[1,2]. Ash contents ranged from 3.26 % to 14.33 % and these are indications of high mineral elements present in the mushroom species. Also these values agreed with some literature reports[1, 3, 4]. Low values of Lipid (fat/oil) which ranged from 1.00 % to 6.68 % is an indication that mushrooms are excellent dietary food for diabetic and coronary heart disease patients [3, 4]. Crude fibre (CF) of wild mushrooms ranged from 2.62 % to 11.37 % while the values of cultivated mushrooms ranged from 8.31% to 15.37 %. These values were close to data obtained by Gropper et al (2009)[8]. Values of Ethanol soluble sugar (ESS), carbohydrate (CHO), vitamin C were close showing no significant difference at $p>0.05$. However, low values were obtained for phytic acid, tannins and hydrocyanic acid which ranged from 0.01 to 0.27 mg/100g.These values were low to give adverse effect and compared well with 1.00 mg/100g found in standard (WHO 1995)[15] for green vegetables.

**Table 3: Proximate /Anti-nutritional Profiles of Wild Mushroom Samples (%/100g)**

| Mushroom species | Moisture Content | Dry Matter Content | Crude Protein | Crude Fibre | Ash | Lipid | Ethanol Solubl | Carbohydarte | Vitamin C | Cyanide | Tannins | Phytic acid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Termitomyc esrobustus | 88.85±0.04 | 7.55±0.03 | 23.95±0.01 | 7.95±0.08 | 13.30±0.04 | 5.45±0.14 | 11.93±0.38 | 38.45±0.37 | 0.15±0.01 | 0.04 | 0.33 | 0.01 |
| Agaricusbisporus | 81.23±0.27 | 18.78±0.17 | 24.18±0.60 | 9.05±0.09 | 11.00±0.13 | 0.70±0.14 | 11.93±0.16 | 22.38±0.22 | 0.15±0.01 | 0.21 | 0.33 | 0.35 |
| Pleuotus tuber-regium | 89.00±0.01 | 11.00±0.11 | 15.60±0.60 | 10.80±0.71 | 14.60±0.39 | 2.90±0.06 | 10.50±0.01 | 21.70±0.40 | 0.10±0.01 | 0.02 | 0.03 | 0.05 |
| Amanita pholaoides | 97.10±0.10 | 2.90±0.09 | 8.50±0.22 | 2.20±0.03 | 3.80±0.13 | 2.90±0.04 | 10.50±0.01 | 69.90±0.10 | 0.00±0.00 | 0.04 | 0.55 | 0.70 |
| Ama;ntaverosa | 84.09±0.06 | 15.93±0.47 | 10.38±0.18 | 11.43±0.59 | 13.80±0.70 | 2.20±0.70 | 7.80±0.23 | 35.40±0.09 | 0.12±0.02 | 0.04 | 0.12 | 0.15 |
| Range | 81.23 – 97.10 | 2.90 – 18.78.50 | 8.50 – 24.18 | 2.20– 11.43 | 3.80- 14.60 | 0.70– 5.45 | 7.80 – 11.93 | 21.70– 69.90 | 0.10– 0.15 | 0.02- 0.21 | 0.03- 0.55 | 0.01- 0.70 |

Table 4 contains higher nutrient metals and the data are in the line with values recorded for plants and mushrooms, by Food and Nutrition Institute of Medicine (2004)[17], although higher values were reported for green vegetables[1].

**Table 4: Concentrations of nutrient metals in five wild mushrooms (mg/kg).**

| Mushroom**species** | **Wild** | | | | |
|---|---|---|---|---|---|
| | Na | K | Ca | Mg | Fe |
| Tr | 370.99 | 886.32 | 83.64 | 686.76 | 213.09 |
| Ab | 474.64 | 714.88 | 252.67 | 476.57 | 268.11 |
| Ptr | 152.36 | 678.39 | 399.76 | 601.83 | 154.68 |
| Aph | 777.42 | 933.81 | 545.00 | 1,191.00 | 404.32 |
| Av | 669.59 | 166.88 | 111.40 | 1,178.00 | 684.74 |
| Range | 152.36-777.42 | 167.39-933.81 | 83.64-545.00 | 476.57-1,191.00 | 154.68-684.74 |
| SEM | 0.0±4 | ± 0.27 | ±0.14 | ±0.04 | ±0.15 |

Tr-TermitomycesRobustusAb -AgarcusBisporusPtr-Plenrotus- RegiumAph-AmamitaPhalaiodes Av-AmamitaVerosa SEM-Standard Error of Mean.

Cu, Pb, Mn and Cr showed lower trace metals concentrations. Co, Zn, Cd, and Ni showed no significant differences at ($p>0.05$) when compared with WHO 1995 permissible levels for vegetables.

**Table** 5: Concentrations of Trace Metals in five species of mushroom (mg/kg)

| Mush room species | WILD | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cu | Co | Pb | Zn | Cd | Ni | Mn | Cr |
| Tr | 0.12 | 0.59 | 5.03 | 50.88 | 4.48 | 16.85 | 24.42 | <0.001 |
| Ab | 0.39 | 1.21 | 4.56 | 28.72 | 4.41 | 1.40 | 15.20 | <0.001 |
| Ptr | 0.22 | 0.48 | 3.60 | 25.00 | 4.30 | 3.04 | 13.60 | <0.001 |
| Aph | 0.72 | 1.52 | 4.62 | 34.02 | 3.88 | 4.77 | 16.60 | <0.001 |
| Av | 0.66 | 0.63 | 3.83 | 61.17 | 6.68 | 15.07 | 8.25 | <0.001 |
| Range | 0.12-0.72 | 0.59-1.52 | 3.60-5.03 | 25.00-61.17 | 3.88-6.68 | 1.40-16.85 | 8.25-24.42 | <0.001 |
| SEM | ±0.01 | ±0.01 | ±0.07 | ±0.09 | ±0.11 | ±0.09 | ±0.27 | ±0.01 |
| WHO1995 vegetables | 10.00 | 0.01 | 10.12 | 15.63-78.00 | 0.30 | 4.75 | 5.00-140 | 0.10 |

## CONCLUSION

From the present analytical information, it is conceivable that a number of these wild mushrooms hold tremendous promise in narrowing the protein and mineral supply deficits prevalent in several developing countries of Africa. Till date, virtually all the mushrooms are harvested in the wild, with no information about their husbandry. For their full nutritional potentials to be realized, intensive efforts must be geared towards the husbandry and popularization of these nutritious mushroom species. This investigation also revealed the need for public awareness on mushrooms and their bioaccumulation ability especially in areas with frequent pollution like crude oil pollution in the Niger Delta area of Nigeria. Further research is needed to find out the variations in metal uptake by different mushroom species, and the site-specific risk assessment guidelines to highlight and minimize the potential health risks of ingesting mushrooms containing high levels of heavy metals.

## ACKNOWLEDGMENT

The authors wish to acknowledge the Quality Control Laboratory, Technology Incubation Centre, Nnewi Anambra State Nigeria and Energy Research Laboratory, University of Nigeria, Nsukka, Enugu State, Nigeria.

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