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Proximate and Mineral Element Compositions of Five Edible Wild Grown Mushroom Species in Abakaliki, Southeast Nigeria

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ABSTRACT

The proximate and mineral element compositions of five wild growing mushrooms species in Abakaliki area of Nigeria were investigated. The mushroom species include coral mushroom, *Pleurotus ostreatus, Agaricus bisporus, Auricularia polytrichia,* and *Lentinus sajor*. The aim of the study was to assess the nutritional qualities of the mushrooms. The results of the analysis indicated that the mushrooms are good sources of crude protein (11.85%), carbohydrate (56.77%), fats (17.61%), crude fibre (15.61%) and ash (8.33%). The result also showed that the mushrooms are also good sources of nutritionally important mineral elements including potassium (221.13), phosphorus (86.89), calcium (28.86), magnesium (14.08) and sodium (7.53), but low in iron (1.12), zinc (0.77) and manganese (0.012) all in mg/100g on dry weight basis. The mushrooms did not contain toxic levels of Cd and Pb. There mean concentrations were 0.01 and 0.003 mg/100g respectively. These nutrients varied widely among the mushroom species. Based on the results of this study, we report here that these mushroom species are nutritionally good and need to be popularized in the study area through artificial cultivation to reduce shortage of nutrient supply in the region.

Keywords: Mushrooms, proximate composition, mineral composition, nutrient supply.

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INTRODUCTION

Mushrooms are the fleshy spore-bearing fruiting bodies of fungi, typically produced above ground on soil or on its food source (substrate). Based on standard morphology, the word "mushroom" was mostly used to describe those fungi that have a stem (stipe), a cap (pileus), and gills (lamellae) or pores on the underside of the cap e.g. (*Basidiomycota* and *Agaricomycetes*). However, it generally refers to a variety of gilled fungi, with or without stems. Mushrooms are also described as macro-fungi with a distinctive fruiting body which can be either epigeous or hypogeous and large enough to be seen with the naked eyes and to be picked by hand. Only fruiting body of the mushroom can be seen whereas the rest of the mushroom remains underground as mycelium.

During the early days of civilization, mushrooms were consumed mainly for their palatability and unique flavours. However, several research works on the chemical composition of mushrooms have revealed that mushrooms can be used as a diet to combat diseases making the present use of mushrooms to be totally different from the traditional use [20, 21]. Many research reports described the nutritional compositions of mushrooms as attractive, being good sources of dietary protein, carbohydrate, fats, vitamins, fibre and minerals [2, 8, 12, 14, 17, 23, 26, 36).

In terms of the amount of crude protein, Chang and Miles (1989) noted that mushrooms rank only below animal meats, but well above most other foods, including milk, which is an animal product. According to these authors, mushroom protein contains all the essential amino acids required by man. Owing to its high protein content, the Food and Agricultural Organization (FAO) has recommended mushroom foods to reduce the problem of protein malnutrition in underdeveloped countries where protein malnutrition has taken epidemic proportions [27]. Mushroom carbohydrate is dominated by mannitol (also called mushroom sugar), which constitutes about 80% of the total free sugars [28, 32]. Mushroom is low in fats dominated by polyunsaturated fatty acids [19, 34]. The nutritional composition of mushroom varies according to the species, age, type of substratum and environment [11]. In addition to nutritional value, mushrooms have some unique colour, taste, aroma, and texture characteristics, which stimulate their preference by humans.

Mushrooms have also been recognized as highly medicinal. Medicinal properties, such as antifungal, antibacterial, antioxidant, antiviral antihypotensive, renal protective, immunomodulatory, and anticancer activities of mushroom extracts have been reported [7, 13]. Bahl reported that mushrooms cure epilepsy, wounds, skin diseases, heart ailments, rheumatoid arthritis, Cholera, fevers, diaphoretic, diarrhea, dysentery, cold, anesthesia, liver disease, gall bladder diseases and can be used as vermicides. The main therapeutically active components were found to be polysaccharides, especially β-D- glucans [10, 31]. Most of these medicinal components are now available in tablet and capsule forms, which are called mushroom nutriceuticals and are used as food supplements [33]. Extracts from certain mushroom species (*Ganoderma lucidum, Ganoderma lucidium* and *Lentinus tigrinus*) have been used to lower blood pressure and serum cholesterol in hypertensive rats [15, 22].

For edibility and safety, proper identification of mushrooms is very important as many mushroom species are poisonous. The colour of their spores (basidiospores) is most helpful in this process. The spore colours of edible mushroom species include white, brown, black, purple-brown, pink, yellow, and cream, with the white colour being the most common, but never blue, green, or red. The presence of juices upon breaking, odours, tastes, bruising reactions, habitat and season are also considered in mushroom identification. However, tasting and smelling mushrooms may be dangerous because of toxins and allergens that may be present. Chemical tests are also used, while molecular identification by professional mycologists is rapidly growing.

This study was aimed at characterizing some wild growing edible mushrooms common in Abakaliki region of Nigeria for proximate and mineral compositions as an assessment of their nutritional values. The study is important to provide useful information for selecting nutrient rich mushroom species for artificial production since rapid deforestation is almost sending these important food resources into extinction in the region and relying on natural mushroom production could place consumers at risk of buying toxic species by honest error in addition to the problem of inadequate supply.

MATERIALS AND METHODS

Determination of Proximate Composition

The five mushrooms species used in this study were harvested from Abakaliki, Southeast Nigeria. Prior to the proximate analysis, the mushroom samples were washed clean with distilled water. Moisture and ash contents were determined by the method described Onwuka (2005). Fat was determined on wet weight basis by the method of Suzanne (2003). Crude fibre was determined in each of the samples by a method described by James (1995). The protein content of the sample was determined by the semi-micro kjeldahl method reported by AOAC (1990). The total nitrogen was determined and multiplied by the factors crude 6.25 to obtain the protein content. The carbohydrate content of the samples was determined by estimation using the arithmetic difference method described by James (1995).

Determination of Mineral Element Composition

Prior to the mineral analysis, ashing and digestion of ground mushroom samples were done according to methods described by AOAC (1990) and the digestates were used for mineral element determinations. Phosphorus concentration was determined by the vonadomolybdate spectrophotometric method described by James (1995); calcium and magnesium were determined by EDTA complexiometric titration method of Udoh (1986); sodium and potassium by flame photometric method described in AOAC (1990), whereas manganese, zinc, lead and cadmium levels were determined by AAS according to James (1995).

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RESULTS AND DISCUSSION

Proximate Composition

Proximate analysis was carried out on five wild grown edible mushroom varieties consumed in Abakaliki region of Nigeria; coral mushroom, *Pleurotus ostreatus*, *Agaricus bisporus*, *Auricularia polytrichia*, and *Lentinus sajor*. Results of the proximate compositions are presented in Table 1. The moisture, protein, carbohydrate, fat, fibre and ash contents all varied widely among the mushroom species (P<0.0001).

Table 1: Proximate Composition (%) of Five Wild Growing Edible Mushrooms in Abakaliki, Nigeria (n = 3)

Mushroom species	Protein	Fibre	Moisture	Ash	Fat	Carbohydrate
coral mushroom	16.05±0.50[a]	11.53±0.04[d]	30.43±0.95[e]	8.05±0.06[c]	16.04±0.34[c]	62.86±0.35[b]
Pleurotus ostreatus	16.35±0.50[a]	29.00±0.06[a]	46.95±0.17[d]	4.05±0.07[d]	21.00±0.04[b]	44.41±0.11[e]
Agaricus bisporus	15.45±0.50[b]	11.01±0.0[d]	67.73±1.00[b]	16.13±0.05[a]	24.00±0.30[a]	45.77±0.30[d]
Auricularia polytrichia	3.75±0.55[d]	14.01±0.14[b]	82.17±0.25[a]	2.39±0.03[e]	2.01±0.04[d]	80.85±0.24[a]
Lentinus sajor	7.70±0.15[c]	12.49±0.04[c]	56.13±0.26[c]	11.02±0.03[b]	25.00±0.04[a]	49.95±0.06[c]
Grand Average	11.85±5.35	15.61±7.01	56.68±18.27	8.33±5.11	17.61±0.04	56.77±14.17

*Means with the same letters in each column are not significantly different at 0.05 probability level.

On dry weight basis, the protein contents of the mushrooms varied from 3.45-16.65% with a mean value of 11.85±5.35%. These are appreciable amounts of protein from nutritional perspective, suggesting that some of the mushrooms are good sources of protein. *Pleurotus ostreatus* had the highest mean concentration of protein (16.35%) followed by coral mushroom (16.05%), while *Auricularia polytrichia* had the least amount (3.77%). The obtained values of protein in the mushrooms compare well with 10.50% and 14.88% reported by Okechukwu *et al.* (2011) for wood ear and oyster mushrooms, respectively, in Owerri, Nigeria. The values are however significantly higher than 2.5% available on the United States Department of Agriculture (USDA) Nutrient Database for mushrooms and higher than 2.67-7.39% reported for three species of mushroom in Turkey [5], but low when compared with 18.07-37.00% reported for four species in India by Manjunathan *et al* [6].

The obtained values of carbohydrate indicate that the mushrooms are good energy food resources. The carbohydrate concentration of the mushrooms varied from 44.28-81.13% with an average value of 56.77±14.17%. *Auricularia polytrichia* (which had the least value of protein) had the highest amount of carbohydrate (80.85%) followed by coral mushroom (62.86%), while *Pleurotus ostreatus* that had the highest concentration of protein had the least carbohydrate value (44.41%). This results suggests a negative correlation between protein and carbohydrate contents in the mushrooms (r=-0.67). 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.* [18] in Owerri, Nigeria; higher than 38.48-60% reported for four species in India [16]; and also higher than 6.50-9.53% reported for three species in Turkey [5].

The amounts of fat in the mushrooms spanned from 1.89-5.33% with a mean concentration of 3.61±1.72% on dry weight basis. The highest concentration of fat was detected in *Lentinus sajor*, while the least value was found in *Auricularia polytrichia*. The fat content of the mushrooms is very low when compared to carbohydrates and proteins. This agrees with earlier reports by Wani *et al*. (2010), Okwuchukwu *et al*. (2011), Manjunathan *et al*. (2011) and Caglarlmak *et al.* (2001). These values are higher than those reported for three mushroom species in Turkey by Caglarlmak *et al.* (2002), higher than the values obtained for *Agaricus bisporus* and *Pleurotus ostreatus* by Shah *et al*. (1997) and also higher than the amounts reported for four species in India by Manjunathan *et al*. (2011), but lower than the values obtained from two species in Owerri Nigeria by Okechukwu *et al*. (2011).

The fibre contents of the mushrooms are appreciably 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 and ash contents ranged from 10.98-29.06% with a mean of 15.61±7.01% and 2.36-16.18% with a mean value of 8.33±5.11% respectively. These values are very similar to those obtained in India by Manjunathan *et al*. (2011) and are significantly lower than those reported by Okechukwu *et al*. (2011). *Pleurotus ostreatus* had the highest crude fibre content (29.00%), while *Agaricus bisporus* had the least value (11.01%). *Agaricus bisporus* showed the highest value for ash (16.13%) followed by *Lentinus sajor* (11.02%), while *Auricularia polytrichia* showed the lowest value (2.39%).

The results of the moisture contents of the mushrooms indicate that most of them are highly perishable. High moisture content promotes susceptibility to microbial growth and enzyme activity (Manjunathan *et al*., 2011; Adeyeye and Ayejuyo, 1994). The moisture contents of the mushrooms varied widely from 29.34-82.42% with mean value of 56.68±18.27%. The result shows that coral mushroom and *Pleurotus ostreatus* with lower moisture contents would have longer shelf life than the other species.

Mineral Composition

Eight important mineral elements (Ca, P, Fe, Na, K, Mg, Mn, Zn, Cd and Pb) were determined in the five mushroom varieties. The amounts of the mineral elements in the mushrooms are presented in Table 2. With the exception of the heavy metals, all the mineral elements were found in appreciable amounts in all the mushroom species and varied widely among the species. Of the eight minerals determined in the mushrooms, the dominant ones in descending order were K, P and Ca which ranged from 107-394, 35.10-127.30 and 4.01-52.10 mg/100 g. Cd, Pb, Mn and Zn were the least in concentrations with values ranging from 0.00-0.024, 0.00-0.012, 0.004-0.020 and 0.104-1.324 mg/100g respectively.

Table 2: Mineral Element Composition (mg/100g) of Five Wild Growing Edible Mushrooms in Abakaliki, Nigeria (n = 3)

Mineral Element	coral mushroom	Pleurotus ostreatus	Agaricus bisporus	Auricularia polytrichia	Lentinus sajor	Grand average
Calcium	50.77±2.32	37.41±1.69	13.36±2.51	5.35±1.13	37.41±2.32	28.86±17.55
Phosphorus	68.28±0.46	122.28±0.49	81.07±0.23	35.63±0.46	127.17±0.23	86.89±35.50
Potassium	243.67±0.01	266.67±1.15	331.33±2.52	114.33±0.58	392.33±1.53	221.13±148.86
Sodium	6.17±0.06	7.53±0.12	13.17±0.06	2.33±0.12	8.43±0.12	7.53±3.63
Magnesium	11.20±1.39	13.60±1.32	12.80±1.85	17.60±1.36	15.20±1.54	14.08±2.54
Iron	1.25±0.005	1.15±0.03	1.185±0.01	1.20±0.04	0.82±0.01	1.12±0.16
Manganese	0.02±0.00	0.02±0.00	0.004±0.00	0.004±0.00	0.02±0.00	0.01±0.01
Zinc	0.10 ±0.00	1.10±0.00	1.32±0.00	0.21±0.00	1.10±0.00	0.77±0.52
Cadmium	0.024±0.00	0.012±0.00	0.004±0.00	0.00±0.00	0.012±0.00	0.01±0.008
Lead	0.004±0.00	0.00±0.00	0.012±0.00	0.00±0.00	0.000±0.00	0.003±0.005

*Means with the same letters in each column are not significantly different at 0.05 probability level.

The presence of calcium in significant amounts in these mushrooms makes it a valuable food for formation and maintenance of bone and normal function of nerves and muscles in humans and other vertebrates (Wani *et al.,* 2010). The values of calcium detected in these mushrooms (4.01-52.10 mg/100 g) are significantly higher than 11.95-29.79 ppm (equivalent to 1.195-2.979 mg/100g) reported for three edible mushrooms in Turkey by Caglarlmak *et al.,* (2002), but much lower than the values reported for oyster mushroom (*Pleurotus ostreatlis*-1590 mg/100g) and wood ear mushroom (*Auricularia polytrida*-1303 mg/100g) in Owerri Nigeria by Okwuchukwu *et al.* (2011). The values are also very low when compared with (195-607 mg/100g) obtained from four mushroom species in India by (Manjunathan *et al*., 2011). Three of these mushroom species (coral mushroom, *Pleurotus ostreatus* and *Lentinus sajor*) contained amounts of Ca significantly higher than 18 mg/100g available on the USDA Nutrient Database for mushrooms.

Phosphorus, an important constituent of nucleic acids and essential for bone and tooth formation and for acid-base balance, is one of the dominant minerals in the mushroom species. The amounts of P detected in this study (35.10-127.30 mg/100g) compared well with 120 mg/100g available on the USDA Nutrient Database for mushrooms, 10.793-136.39 mg/100g reported for three species of mushroom in Turkey (*C. cibarius, L.piperatus and B. edulis*) by Caglarlmak *et al.,* (2002) and accommodated the value reported for *A. bisporus* (75 mg P/100g) by Varo *et al*. (1980).

Na and K are important in the maintenance of osmotic balance between cells and the interstitial fluid in animal systems. In these mushrooms, K is present in exceedingly higher amount (221.13 mg/100g) than Na (7.53 mg/100g). This suggests that these mushrooms would be excellent in lowering blood pressure, reducing the risk of osteoporosis and in maintaining bone health (Yusuf *et al*., 2007; Wani et al., 2010). The range of values of K found in the mushrooms (107-394 mg/100g) compared well with the values reported for *L. piperatus*

(272.93 mg/100g) and *B. edulis* (203.24 mg/100g) by Caglarlmak *et al.,* (2002), but is significantly lower than the value available on the USDA Nutrient Database for mushroom (448 mg/100g). The mean concentration of Na (7.53 mg/100g) found in these mushrooms is very close to the value available on the USDA Nutrient Database (6 mg/100g). The values are low relative to those reported by Caglarlmak *et al.,* (2002) for three species of mushrooms in Turkey (15.03-38.8 mg/100g) and much lower than values determined in four species in India (37.3-858.4 mg/100g) (Manjunathan *et al*., 2011). The amounts of Na and K found in these mushrooms are much higher than those reported for leafy vegetables (3.5-5.2 mg/100g for Na and 5.3-8.7 mg/100g for K) by **(**Saidu and Jideobi, 2009)

Fe, which is essential for the biosynthesis of the oxygen-carrying pigment of red blood cells (haemoglobin) and the cytochromes that function in cellular respiration [31], is also present in good amounts in the mushrooms. The amounts of Fe found in the mushrooms (0.81 - 1.26 mg/100g) is within the range of values (0.74-3.38 mg/100g) reported by Caglarlmak *et al.,* (2002) for three species in Turkey, but lower than 16.3-85.6 mg/100g reported for four species in India [16] and much lower than 2970-2785 mg/100g reported by for two mushroom species from Owerri, Nigeria by Okechukwu *et al*. (2011).

Mg, Mn and Zn, which are indispensable in numerous biochemical pathways as important co-factors for certain enzymes were equally present in the mushroom species analysed. However, the concentrations of Mg detected in these mushrooms (9.60 - 19.20 mg/100g) are low when compared to values reported for four species in India (14-250 mg/100g) [16] and considerably lower than 2510 and 2819 mg/100g reported for two species in Owerri Nigeria by Okechukwu *et al*. (2011). It does appear that the values reported for all these minerals in mushrooms by Okechukwu *et al*. (2011) are exceedingly high. Mn and Zn were least in abundance in these mushrooms, 0.004-0.020 and 0.104-1.324 mg/100g respectively. The detected values are quite low compared to those obtained by Manjunathan *et al*. (2011), 0.6-3.4 mg/100g for Mn and 1.0-6.2 mg/100g for Zn. However, our values for Zn compares favourably with 1.10 mg/100g available on the USDA Nutrient Database for mushrooms.

The toxic heavy metals, cadmium and lead, were present in very insignificant amounts in the mushrooms (0.00-0.024 and 0.00-0.012 mg/100g respectively). It may be that the mushrooms are not hyper-accumulators or that the environment is not heavily polluted with the heavy metals.

CONCLUSION

The observed levels of the proximate and mineral element compositions of these mushrooms indicate that the mushrooms would be very good in complementing the nutrient supply deficits prevalent in developing countries. However, their availability is not adequate because of total reliance on wild growth rather than artificial cultivation of mushrooms in the area. For the full realization of the nutritional potentials of mushrooms, efforts must be made to cultivate them artificially and popularization of the more nutritious species is important.

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