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Phytochemical and Mineral Elements Composition of *Bondazewia berkeleyi, Auricularia auricula* and *Ganoderma lucidum* Fruiting Bodies.

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ABSTRACT

Fruiting bodies of wild edible medicinal mushrooms, *Bondazewia berkeleyi*, *Auricularia auricula* and *Ganoderma lucidum*, were analyzed for the presence of secondary metabolites and concentrations of toxic (Cd, Cr, Ni, Pb) and essential (Co, Cu, K, Li, Mn, Na, Zn) elements. The results revealed the presence of alkaloids, flavonoids, triterpenoids, saponins and carbohydrates in varied amounts. Tannins and phlobatannins were not detected. The levels (in ppm) of Na (156.80±310), K (246.20±6.62), Li (10.53±2.10), Zn (30.80±2.30), Cu (3.80±0.10), Mn (18.40±2.24), Co (2.98±0.17), Ni (0.024±0.080) and Cd (0.004±0.012) were highest in *G. lucidum*. *Auricularia auricula* showed the highest concentration (in ppm) of Pb (0.027±0.012) and Cr (0.005±0.100). However, the levels of the metals did not exceed the FAO/WHO stipulated dietary standards. This is the first chemical assessment of *B. berkeleyi* polypore.

Keywords: Mushroom, Polypore, Secondary metabolites, Mineral nutrients, Dietary standards.

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INTRODUCTION

Mushrooms are plant-like microorganisms, which grow like plant but are without chlorophyll. They depend on other organisms or plants for their nutrition. Information available in literature shows that mushrooms were first known to early Greeks and Romans who divided them into edible, poisonous, and medicinal mushrooms [1,2]. The fungus *B. berkeleyi* (Fr.) Bond. et singer (synonymous: *Polyporus berkeleyi*) of the family Bondarzewiaceae (Basidiomycota) grows at the base or roots of Abies and other conifers of the family Fagaceae. It is edible when young and gets tough and unappetizing with age [3]. Bernd *et al*. [4] reported a cytotoxic metabolite, montadial A, isolated from the polypore *B. montana*. Jelly ear or *A. auricula*-judae is a species of the edible Auriculariales fungus. This fungus was used in folk medicine as recently as the 19^{th} century for complaints including sore throats, sore eyes, jaundice, as astringent. Research into possible medicinal applications has variously concluded that polysaccharides from *A. auricula* have antitumor [5], hypoglycermic [6], anti-inflammatory [7] and cholesterol lowering properties [8]. Reishi mushroom, *G. lucidum* (Fr.) Krast (Polyporaceae) is used for the treatment of bronchitis, hepatitis, hypertension, tumorigenic diseases and immunological disorders [9] and as remedy for the promotion of health and longevity [10]. A number of polysaccharides have been isolated, characterized and assayed for antiturmor, antimetastatic and immunological activity [11, 12]. Usman *et al*. [13] reported on the phytochemical and elemental composition of *G.lucidum* sample from northern Nigeria.

Some investigations have also dealt with the metal contents of cultivated and wild growing mushrooms. When their composition was compared with green plants, their accumulation and uptake of heavy metals, such as Cd, Hg, or Pb, was found to be considerably much more than in green plants [14-17]. Isiloglu *et al*. [17] reported that the factors governing the accumulation of metals in mushrooms are not well-known. However, the principal factors influencing the accumulation of heavy metals in macro-fungi are environmental ones (metal concentration in soil, pH, and contamination by atmospheric deposition) and fungal ones (fungal structure, morphological portion, development stages, biochemical composition, and decomposition activities).

One of the mushrooms in this study, *Ganoderma lucidum*, is utilized as dried whole, powder or capsule and as tablets for promoting health in humans [18] and in some countries like China and Japan it is cultivated and utilized as source of feed supplement [19,20]. It is necessary to comprehend the levels of both the toxic and essential elements in their composition. Moreover, studies of modern medicine prove that the pharmacological effects of Chinese herbs is not only associated with the organic components, but also more importantly related to the synergistic action between inorganic elements and organic components [21]. Therefore, the purpose of this present work is to assess the phytochemical profiles and evaluate the concentrations of toxic (Cd, Cr, Ni, Pb) and essential (Co, Cu, K, Li, Mn, Na, Zn) elements in *B. berkeleyi*, *A. auricula* and *G. lucidum* collected from the wild. There are no reports on *B. berkeleyi* chemical constituents in the literature. This is the first chemical assessment of *B. berkeleyi* to the best of our knowledge.

MATERIALS AND METHODS

Samples collection and treatment

The fresh sporocarps of mature mushroom species (*B. berkeleyi, A. auricula* and *G. lucidum*) were collected from the forest in the rainy season (September to October). Specimen identifications and authentication were done by a mycologist, Dr. Joseph Essien and the voucher specimens were deposited in the School of Pharmacy herbarium, University of Uyo, Nigeria. The macroscopic descriptions, including size, shape, color, texture, and odor, were noted. The color of the carpophore, shape of the cap and stipe, color of the flesh and latex, and its smell and habitat were also noted. The mushroom samples were packed in opaque plastic bags and transferred to the analytical laboratory. The samples were carefully cleaned manually to remove any extraneous materials, cut, sun-dried and oven-dried (Gallenkamp, DV 333) at 45°C for 40 h to constant weight. Dried samples were pulverized using an agate homogenizer, and stored in pre-cleaned polyethylene bottles, prior to analyses. All reagents were of analytical grade, except otherwise stated.

Phytochemical Screening

Standard methods were employed for the phytochemical studies. Duplicate samples from each species were analysed for the presence of alkaloids, flavonoids, saponins, phlobatannins, tannins, carbohydrate, sterols and triterpenes [22-24].

Determination of Mineral Contents

The mushroom samples were wet digested according to the reported method [25]. The Na, K and Li were analyzed using flame photometer (Sheerwood 450 flame photometer). The trace metals (Cr, Cu, Pb, Co, Zn, Mn, Ni, Cd, and Mg) were determined by Pye Unicam, Model; 919 spectrometer [26]. All the experimental values are reported in mg/kg DM. Results are expressed as means ± S.D of triplicate analysis.

RESULTS AND DISCUSSION

The phytochemical analysis of the studied polypores is presented in Table 1. The results show the presence of alkaloids, flavonoids, triterpenoids, saponins and carbohydrates in varied amounts in the different samples. Tannins and phlobatannins were not detected. This result is similar to the findings on *G. lucidum* [13] whereas Ogbe and Obeka [20] quantitatively demonstrated that *G. lucidu*m contain 18.27% tannins and 1.26% saponins. Bioactive compounds found in mushroom are known to play a vital role in promoting health. Some bioactive chemical compounds (such as saponins and tannins) are known to have therapeutic effects against microbes and parasites [27]. However, carbohydrates were observed in high amounts in all samples, also abundance of triterpenes in *A. auricula*. Lam and Cheung [28] stated that *A. auricula* and *A. polytrica* water-soluble polysaccharides extracted with hot water formed viscous solutions with carbohydrate content between 75 to 79% dry weight. The extracts were particularly rich in xylose and mannose. Wasser [29] revealed that more than 100 polysaccharides are found in *G. lucidum* and these polysaccharides are considered to contribute to the bioactivity of the mushroom.

Table 1: Phytochemical analysis of wild edible mushrooms

Phytochemicals	*B. berkeleyi*	*A. auricula*	*G. lucidum*
Alkaloids	++	+	++
Flavonoids	++	++	-
Saponins	++	+	++
Steriods/triterpenes	++	+++	++
Tannins	-	-	-
Phlobatanins	-	-	-
Carbohydrate	+++	++	++

+ = low concentration; ++ = moderately present; +++ = high concentration; - = not detected.

Table 2: Mineral element composition of wild edible mushrooms

Element	*B. berkeleyi* (ppm)	*A. auricula* (ppm)	*G. lucidum* (ppm)
Na	107.50± 1.18	113.80±6.70	156.80±3.10
K	142.60±0.90	184.40±2.25	246.20±6.62
Li	4.94±0.11	10.33±0.30	10.53±2.10
Zn	15.80±1.20	26.40±1.15	30.80±2.30
Cu	2.90±0.51	2.90±1.20	3.80±0.10
Mn	13.88±1.46	12.80±2.21	18.40±2.40
Co	1.12±0.10	2.31±1.12	2.98±0.17
Pb	0.024±0.010	0.027±0.012	0.013±0.20
Cr	0.020±0.060	0.005±0.100	0.020±0.010
Ni	0.020±0.120	0.012±0.010	0.024±0.080
Cd	0.01±0.034	0.02±0.010	0.04±0.012

Data are mean values±standard deviation (SD) of triplicate results; ppm: parts per million (1mg/kg=1ppm).

The result of the elemental composition of wild edible mushrooms is shown in Table 2. Metal concentrations in the fruiting bodies of the macrofungi varied among species. This may be ascribed to differences in substrate composition as determined by the ecosystem and great differences in uptake of individual metals by the mushroom species [30]. Thatoi and Singdevsachan [31] reported that ash content of different mushrooms is usually 0.18-15.73% of dry matter. Significant quantities of Na, K, Li and Zn were detected in the studied mushrooms. Na, K Li and Zn contents ranged between 4.94±0.11-142.60±0.9 ppm in *B. berkeleyi*, 10.33±0.3-184.4±2.25 ppm in *A. auricula* and 10.53±2.1-246.2±6.62 ppm in *G. lucidum*. Higher amounts of Na, K and Zn have been reported in *G. lucidum* [13,20,32], *A. polytricha* [33], *Agaricus* sp. [34] and *A. auricula* [35]. Na is an important mineral that regulates volume flow and pressure of blood. K is an essential nutrient and has important role in synthesis of amino acids and proteins [36]. Li is an important trace element with important pharmacological activities [37]. Zn is an essential micronutrient associated with number of enzyme, especially those for synthesis of ribonucleic acids and DNA polymerases [38].

Appreciable concentration of Cu (2.9-3.8 ppm), Mn (12.8±2.21-18.4±2.24 ppm) and Co (1.12±0.10-2.98±0.17 ppm) are contained all three samples in this study. Cu plays an important role in proteins synthesis [39]. Cu and Mn play important role in enzymatic catalysis and are crucial to virtually all biochemical and physiological processes. Cobalt is essential in trace amounts for human life. It plays a key role in the body's synthesis of vitamin B-12. Cobalt has also been used as a treatment for anemia; causes red blood cells to be produced.

Bondazewia berkeleyi, A. auricula and *G. lucidum* were also found to contain trace amounts of Ni, Cr, Pb and Cd. The Ni, Cr, Pb and Cd content varied between 0.01±0.034-0.024±0.01 ppm in *B. berkeleyi*; 0.005±0.1-0.027±0.012 ppm in *A. auricula*; and 0.013±0.2-0.04±0.012 ppm in *G. lucidum*. Similarly, low levels of trace elements have been documented for *G. lucidum* [13,32], *A. polytrichia* [33] and *Agaricus* sp. [34]. Ni is also an essential element, and its daily uptake of 100 mg is recommended for good health [40]. Cr has important role in reduction of cardiovascular disease and adult diabetes [41]. Cadmium may contribute to biological processes, but have not been established as essential. Cd and Pb are best known for their toxicological properties [37]. The low levels of Cd and Pb in the studied mushrooms suggest that the samples are nontoxic with respect to metal concentration. Generally, the mineral content of wild edible mushrooms has been found to be higher than cultivated ones [42]. Gabriel *et al*. [43] has also provided data on some polypores including *G. applanatum* with relative high content of heavy and trace metals harvested from medium polluted sites in Czech Republic.

CONCLUSION

The mature and healthy fruiting bodies of the macrofungi in this study – *B. berkeleyi*, *A. auricula* and *G. lucidum* are a reservoir of some implicated medicinal phytochemicals and essential mineral elements which should be exploited for their potential health benefits and as feed supplements.

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