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Proximate Composition, Mineral Element Profile and Antioxidant Properties of the Edible Kenyan Mushroom, *Auricularia polytricha*

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Abstract

The indigenous Kenyan *Auricularia polytricha* is a known delicacy to the communities residing around Kakamega forest in Western Kenya. The objective of the present study was to carry out proximate analysis, determine selected mineral element levels and radical scavenging capacity of the fruiting bodies of *Auricularia polytricha*. Proximate analysis which included determination of total carbohydrates, crude protein, crude fibre, crude fat, ash and moisture contents was done according to the Association of Official Analytical Chemists (AOAC) methods. The minerals (Ca, Mg, Fe, Zn, Mn, Pd, Cd) in the dried mushroom sample were determined using an Atomic Absorption Spectrophotometer (AAS) while Na and K were determined by flame emission photometry. Phosphorus was estimated by spectrophotometric method. The antioxidant activity of the crude mushroom extracts was evaluated by measuring their scavenging capacity on the stable radical, DPPH (2,2-Diphenyl-1-Picrylhydrazyl) using UV-Vi's spectrophotometer at 517 nm. The mushroom was found to contain 64.53% total carbohydrates, 43.12% crude fibre, 11.67% crude proteins, 4.75% crude fat and 4.69% ash content on dry matter basis. The moisture content of the mushroom was found to be 80.33% of the fresh weight, which is typical of fresh foods and vegetables. A methanol extract of the mushroom exhibited antiradical activity against DPPH in a dose dependent manner with the highest radical scavenging capacity (40.84%) obtained at a concentration 500 µg/mL. For the mineral profile, the variations and concentrations of the essential and trace elements under study decreased in the order K>Na>Mg>Ca>Fe>P>Zn>Mn. The selected hazardous heavy metals Cd and Pb were not detected in the mushroom sample. Implications of the mineral concentrations on the nutritional value of the mushroom have been highlighted. In conclusion, the obtained results suggest that the mushroom, which has good amounts of the required proximate components, minerals and antiradical constituents, is a potentially healthy, safe and functional food.

Keywords: *Auricularia polytricha*, Mushrooms, Proximate, Anti-oxidant, Mineral Element.

INTRODUCTION

Auricularia polytricha is one of the edible mushrooms that belongs to the order Auriculariales, in the Auriculariaceae family. Auricularia spp are commonly referred to as the wood ear fungus, due to their morphological similarities with human ear [1]. *Auricularia polytricha* is widely distributed in tropical and temperate regions where it grows as a saprophyte on wood logs. It can also be easily cultivated in an effort to boost its production for medicinal and nutritional application [2]. The mushroom is reported to be highly valued in most countries for their numerous nutritional and medicinal properties stemming from them having low calorie content, richness in dietary fiber, proteins, minerals and biologically active polysaccharides [3]. Previous research has also reported the mushroom's potential for application in anticancer, anti-diabetic, anti-oxidant and lowering cholesterol therapy [4-8].

Auricularia polytricha, along with some species of the same family have been reported in Kakamega forest of western Kenya. These species, famously known to the local communities as "matere", are a known delicacy to these communities residing around Kakamega forest [9]. Many other Kenyan communities do not, however, consume these mushrooms for several reasons including, lack of information about them, non-availability and/or probably due to their rubbery-gelatinous nature with no distinctive taste. These limitations do not change the fact that Auricularia mushrooms are full of health benefits [10].

The chemical composition of these species is also likely to vary with different ecological systems [11]. and thus, determining the nutritional composition of the indigenous Kenyan *Auricularia polytricha* would provide the most accurate information on its constitution. The objective of this study was to carry out proximate analysis, determine the mineral element levels and radical scavenging capacity of the edible Kenyan mushroom, *Auricularia polytricha*.

MATERIALS AND METHODS

Sample Collection and preparation

The fresh fruiting bodies of *Auricularia polytricha* were collected from Isecheno forest reserve of Kakamega forest. Kakamega forest reserves are located between longitudes of 34032′0″E and 34057′0″W and latitudes of 0007′30″N, 0010′15″S.

The collected mushroom sample (except the one set aside for moisture content analysis) was washed thoroughly under running tap water to remove soil and other particles. The sample was then air dried under shade and ground into powder.

Proximate Analysis

The collected mushroom sample was subjected to proximate analysis according to the Association of Official Analytical Chemists methods [12]. The analysis included determination of crude protein (Kjeldahl method), crude fat (Soxhlet method), ash (dry ashing method), crude fiber (Weende method), total carbohydrates (phenol-sulphuric method) and moisture content (thermogravimetric analysis). Except for the moisture content, all the other calculations were carried out on the dry weight basis of the mushrooms. The moisture content was determined on the fresh mushroom sample.

The energy value of the mushroom was determined by the Atwater method which involves multiplying grams of protein, fats and carbohydrates by the factors, 4-9-4, respectively [13].

Mineral element Analysis

The mineral (Ca, Mg, Fe, Zn, Mn, Pd, Cd) in the dried mushroom sample were determined using an Atomic Absorption Spectrophotometer (AAS) [14]. The samples which were digested in a HNO_3/HCl acid mixture were passed through the AAS system using different lamps, and calibrated with related standards in different concentrations for different minerals under study. Phosphorus content of the dried mushroom samples was determined using molybdovanadate method [15]. Na and K were determined by flame emission photometry [16].

DPPH Radical Scavenging Activity

The DPPH assay was estimated according to the procedure reported by Imbenzi and co-workers (2014), with slight modification [17]. The scavenging activity was calculated using the formula;

$$\text{Scavenging rate (\%)} = [DPPH_{(Ab)} - \frac{Sample\ (Ab)}{DPPH\ (Ab)}]X\ 100$$

where $DPPH\ (_{Ab})$ is the absorbance at 517 nm, obtained for a DPPH solution prepared in methanol while $sample\ (_{Ab})$ is the absorbance of the test sample obtained at the same wavelength. The results were expressed as the IC_{50} value. The IC_{50} value was defined as an effective concentration of the extract that could scavenge 50% of the free radicals. All the determinations were performed in triplicates and averaged. The percentage scavenging activity of each of the sample dilutions was compared and ranked with reference to percentage scavenging rate of the standard (vitamin C) [18].

Statistical Analysis

All experiments were done in triplicates, and reported as mean values. The results were expressed as mean ± SE (standard error).

RESULTS AND DISCUSSION

Proximate Composition

The present study was carried out to evaluate the nutritional value, by determining the proximate composition, radical scavenging capacity and mineral levels composition of the indigenous Kenyan mushroom, *Auricularia polytricha*. The results of the proximate composition and calorific value of the studied sample are given in Table 1.

Table 1: Proximate composition of *Auricularia polytricha* (% w/w)

Parameter	Sample A	Sample B	Sample C	Mean ±SE
Moisture (%)	79.43	80.30	81.40	80.33±0.61
Total Carbohydrates (%)	63.70	64.5	65.40	64.53±0.49
Crude Proteins (%)	10.85	11.38	12.78	11.67±0.58
Fat (%)	5.00	4.50	4.75	4.75±0.14
Ash (%)	4.29	4.58	5.22	4.69±0.28
Crude Fiber (%)	43.34	42.92	43.11	43.12±0.12
Energy value (Kcal/100g)	343.2	344.02	355.47	347.56±3.96

The moisture content of the mushroom was found to be 80.33% of the fresh weight which is typical of fresh foods and vegetables. This value is in agreement with the values reported in literature [19-21]. The high levels moisture content show that *Auricularia polytrichid* is highly perishable and would therefore require proper preservation upon harvesting. Generally, high levels of moisture content make the mushroom susceptive to microbial growth and enzyme activity [22].

The total carbohydrates, crude proteins, crude fat and ash values obtained for *Auricularia polytricha* are also in agreement with values reported in literature [14,21]. The mushroom contains 64.53% total carbohydrates, 43.12% crude fiber, 11.67% crude proteins, 4.75% crude fat and 4.69% ash content. Carbohydrates, proteins and fats are macronutrients required by the body for growth, provision of energy and maintenance of other body functions. Proteins are needed for growth and body building while carbohydrates and fats mainly provide the energy needed to maintain body functions [23]. Consumption of excessive amounts of fats in a diet has, however, been acknowledged as a very important dietary factor aiding increased levels of cholesterol in the body [24]. *Auricularia polytricha* notably contains low fat of 4.75%, a diet which may be beneficial in helping maintain weight loss and lower the risk of coronary heart diseases and some forms of cancer.

The mushroom also contains high levels of crude fiber, ideal for improved digestive health, regular bowel movements and regulation of cholesterol and blood sugar levels. These roles played by the fiber-rich mushroom are likely to lower risk of metabolic disorders such as diabetes, cardiovascular diseases and bowel cancer [25]. The present study also recorded low levels of ash content (4.69%). Ash content provides insights into the amounts of the nutritionally important inorganic minerals present in the mushroom [26]. *Auricularia polytricha* mushroom can therefore be said to be nutritionally sound, rich in carbohydrates and fibers with low levels of fat, medium source of protein and calories.

Mineral element Composition

The mineral composition of the mushroom reflects on its growth conditions. Mineral elements are a very important component of the nutritional value, which the human body requires in small quantities to be able to perform different functions. The results of the mineral element contents, the macro and microelements, of the mushroom sample are given in Table 2. The concentrations of the reported elements were determined on a dry weight basis.

Table 2: Mineral ion content of *Auricularia polytrichid* (mg/kg of dry weight)

Macro elements		Microelements	
Element	Content (mg/kg)	Element	Content (mg/kg)
Na	1.75×10^4	Fe	1933
K	2.34×10^4	Zn	430
Ca	0.87×10^4	Mn	138
Mg	1.26×10^4	Cd	ND
P Ca/P** Na/K**	0.0802×10^4 10.85 0.75	Pb	ND

**Calculated values; ND= Not Detected.

The Variations and concentrations of the metal elements under study decreased in the order K>Na>Mg>Ca>Fe>P>Zn>Mn. Although mineral elements are required in trace quantities, macro elements (K, Na, Mg, Ca, and P) are required by the body in relatively high amounts to enable the body perform important roles such as transport, homeostasis, storage, absorption, excretion among other functions. They work together with vitamins to initiate hormone production and promote metabolic processes [27]. Human body also requires varying levels of microelements, most of which are heavy metals. In the present study, Iron, Zinc and Manganese are required by humans for various roles, but excessive levels can be damaging to the organism [28]. Other heavy metals such as lead and cadmium are toxic whose accumulation in body tissues over time can cause serious illnesses [29].

Potassium and sodium play an important role in maintaining osmotic balance between the cells and interstitial fluids (homeostasis) [30]. From the results in Table 2, *Auricularia polytricha* contains relatively higher amounts of potassium (2.34× 104 mg/kg) than sodium (1.75× 104 mg/kg). A high potassium and low sodium diet has been reported to be beneficial in preventing high blood pressure. A high potassium diet has also been reported to have a protective effect against excessive sodium intake. A diet intake with Na/K ratio of less than 1 is recommended for the prevention of high blood pressure [15,31]. Hence in the present study, the Na/K ratio (0.75) shown in Table 2, therefore suggests that the mushroom would be good in lowering blood pressure.

The present study reported significant amounts of Calcium (0.87 × 104 mg/kg) in *Auricularia polytricha*. Calcium is known for formation and maintenance of bones, blood clotting and transmission of nerve impulses to the muscles [32]. Phosphorus also plays an important role in bone and teeth health in addition to its role in energy metabolism and maintaining structural integrity of cells [32]. The amount of phosphorus recorded in the present study was 0.0802×104 mg/kg, relatively lower than that of calcium. Diets with higher amounts of phosphorus than calcium (low Ca/P ratio) may promote the loss of calcium in the urine, leading to decrease of calcium levels in bones. Good food is recommended to have the Ca/P ratio which is above 1 and while poor food has less than 0.5 [15]. The Ca/P ratio in the present study was 10.85 making *Auricularia polytricha* mushroom a valuable food for formation and maintenance of bone, normal function of nerves and muscles in humans, among other benefits.

Previous studies have also investigated the impact of diets with unregulated Ca/P and Na/K ratios on lipid metabolism. The finding of the studies recommends that diet with high Ca/P ratio and low Na/K ratio could effective in reducing lipid and cholesterol levels in blood [33]. In the present study, *Auricularia polytricha* mushroom records high Ca/P ratio and low Na/K ratio, indicating that the mushroom could be a valuable diet in enhancing lipid metabolism and management of cholesterol levels.

Manganese and magnesium minerals, which are essential in numerous pathways as important co-factors for numerous enzymatic reactions were equally present in good amounts. Manganese acts as an enzyme activator and as an important component of metalloenzymes [34]. Manganese was present in concentrations of 138 mg/kg, a value which is below the toxicity limit of 400-1000 mg/kg set by WHO [34]. Magnesium which plays a pivotal role in energy production and nucleic acid synthesis, among other functions [35]. recorded dry weight concentration of 1.26 × 104 mg/kg.

Iron performs numerous roles in the human body including biosynthesis of hemoglobin for oxygen transport, enzymatic processes, and immune response among other functions [36]. In the present study, the indigenous Kenyan *Auricularia polytricha* recorded 1933 mg/kg of iron, a value which by far exceeds the set limit of 15 mg/kg by WHO [34]. Previous studies estimate that up to 90% of the iron present in *Auricularia polytricha* is bioavailable and can be absorbed since mushrooms do not contain phytates, which reduce the body's ability to absorb iron [37]. The mushroom is therefore a better source of iron than some vegetable sources which contain phytates.

Zinc is an important microelement for human metabolism which catalyzes a variety of different enzymes, aids protein folding and regulates gene expression [38]. In the present study, the concentration of zinc determined in the mushroom sample was 430 mg/kg, a value which is also higher than the permissible limit of 60mg/kg set by WHO [34]. The hazardous heavy metals, cadmium and lead were not detected in the mushroom sample.

DPPH Radical Scavenging Activity

The methanol (MeOH) extract of *Auricularia polytricha*showed DPPH radical scavenging capacity in a dose-dependent manner with an IC_{50} of 548 µg/mL (Table 3).

Table 3: DPPH radical scavenging activity of *Auricularia polytricha* (MeOH extract) compared to that of the reference standard

Concentration (µg/mL)	**% Scavenging Activity**	
	MeOH extract (*A. polytricha*) Mean±SEM	**Vitamin C (reference standard) Mean±SEM**
500	40.84±0.78	97.95±0.09
250	32.09±1.56	97.36±0.09
125	23.19±1.61	97.05±0.09
62.5	13.72±1.44	92.4±0.22
31.25	7.66±0.37	89.65±0.60
15.625	3.00±0.19	87.47±0.60
7.813	1.66±0.23	84.94±0.41
3.906	0.83±0.23	82.71±0.42
IC_{50} (µg/mL)	548.32	0.30

The highest antiradical activity of the extract (40.84%) against DPPH noted for the extracts was obtained at a concentration of 500 µg/mL while the lowest antiradical activity (0.83%) against DPPH˙ was obtained at a concentration of 3.906 µg/mL (Table 3). The mushroom sample extract exhibited significant antiradical activity against DPPH even the though the values were lower than those posted by the standard (Figure 1 and Table 3). Antiradical scavenging activity is an indicator that the mushrooms could be a good source of antioxidants, compounds which are appreciated for their ability to slow down ageing and fight oxidative stress [39].

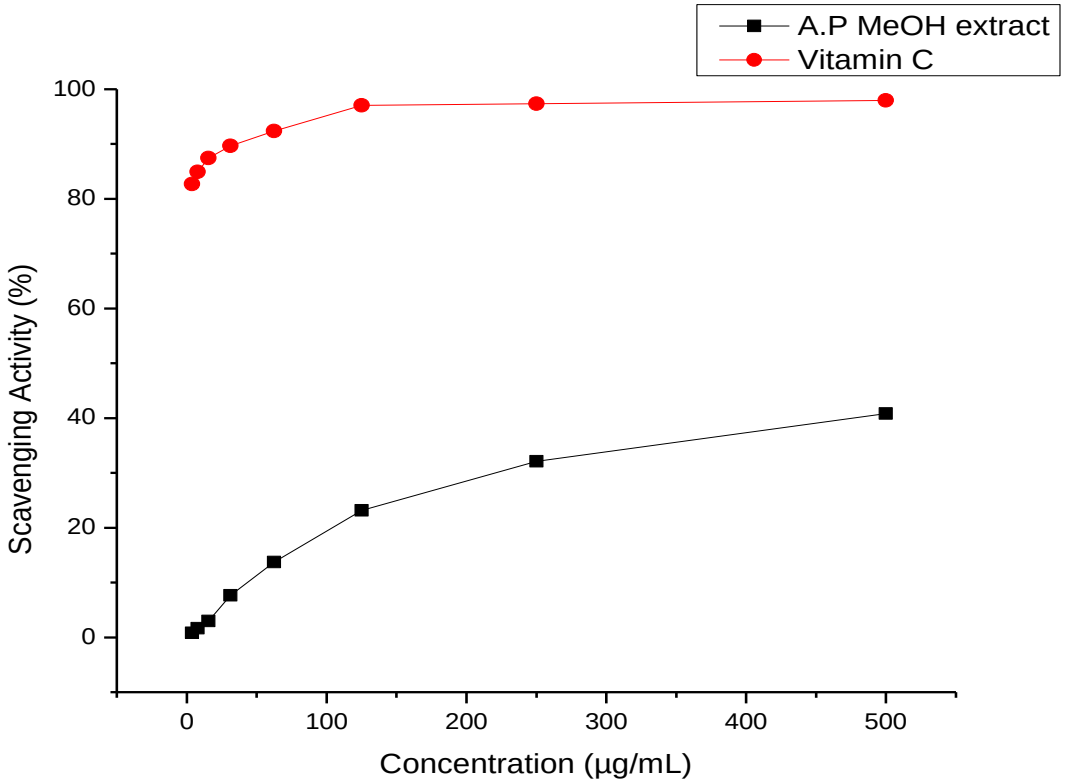

Figure 1: DPPH scavenging activity of *A. polytricha* MeOH extract and vitamin C (reference standard)

CONCLUSION

In the present study, the indigenous Kenyan *Auricularia polytricha* mushrooms contain high carbohydrate and crude fiber contents, intermediate protein and calorific values and low-fat content. The high crude fiber and low fat contents make the mushroom beneficial in helping maintain weight loss, lower the risk of cardiovascular diseases, diabetes and bowel cancer. The mushroom also contained good number of mineral elements required in the human diet. The mushroom also exhibited antiradical activity against DPPH in a dose dependent manner with its methanol extract recording highest radical scavenging capacity (40.84%) at a concentration 500µg/mL. The essential minerals, Na, K, Ca, Mg and P were present in good amounts as there were trace elements such as Fe, Zn and Mn. Fe and Zn, were however found to be higher than the permissible limits of 15mg/kg and 60mg/kg set by WHO. The toxic elements, Cd and Pb were not detected and the mushroom can therefore be said to be safe for human consumption. In conclusion, the obtained results suggest that the mushroom, which has good amounts of the required proximate components, minerals and antiradical constituents, is a potentially healthy, safe and functional food.

Conflict of Interest

The authors of this study declare no conflict of interest.

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