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Review Article

Nutrient and Mineral Contents of Wild Edible Mushrooms from the Kilum-Ijim Forest, Cameroon

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ABSTRACT

Kilum-Ijim forest is a forest in the North West Region of Cameroon. Wild edible mushrooms are mostly consumed by the communities of Kilium-Ijim as a substitute of meat to obtain protein, hence the importance on the evaluation of their nutritional and mineral composition. Eight most preferred wild edible mushroom species from ethnomycological studies; Polyporus tenuiculus, Termitomyces striatus, Termitomyces macrocarpus Auricularia polytricha, Laetiporus sulphureus, Termitomyces sp.1, Termitomyces sp.2 and Polyporus dictyopus was identified by ITS gene region. The eight species were analyzed for nutrient and mineral content using standard protocols. Significant differences in nutrient values were demonstrated among the edible mushroom species. On dry weight basis, significant differences observed in the values ranged from 43.49-64.88 for carbohydrates, 6.60-30.69 for crude protein, 7.74-14.10 for ash and 2.17-3.22 g for fat and 11.60-20.69 g per 100g for crude fibres with significant differences ($P< 0.05$) between species for each nutrient. The dry matter content ranged from 12.69-17.77g per 100g while the total calorie values ranged from 285.16-319.27Kcal per 100g. Mineral nutrient analyses also showed that these mushrooms are rich in both macro and micro nutrients. In conclusion, the study has revealed that soil mushrooms especially the Termitomyces species have nutritional values which can greatly supplement diets especially in rural communities. Domestication of these species high in nutrients and minerals needs to be encouraged not only for local consumption but also for commercial purposes since they risk extinction with the current habitat degradation.

INTRODUCTION

Edible mushrooms mostly grow in forests in association with woody parts of trees either as parasite, saprophyte, or as symbionts in the soil [1]. Macrofungi have several ecological functions in both natural and agroecosystems and are widely exploited by humans for food and medicine [2-4]. Mushrooms represent one of the world's greatest untapped resources of nutrition [5]. More than 2,000 species of mushrooms exist in nature; however, less than 25 species are widely accepted as food and only a few have attained the level of an item of commerce [6]. Macrofungi play important roles

in the lives of many people around the world. They provide two main benefits; they are a source of food and income and also have medicinal properties. The awareness of wild edible fungi and their importance to people are generally poor. The importance of wild edible fungi to people in developing countries may also have gone unremarked for the simple reason that many of the collections are for personal use [7]. The people of the West African sub-region still rely on wild edible mushrooms for their livelihood especially as a low-cost alternative for animal proteins and flavoring in diets. In addition, they represent a venerable source of subsistent income and incontrovertible raw material in local traditional medicine practice [8].

The most cultivated mushroom worldwide is Agaricus bisporus, followed by Lentinula edodes, Pleurotus spp. and Flammulina velutipes [9,10]. Newer species or varieties of wild mushrooms like Tricholoma spp. (Spain), Cantharellus spp., Hydnum spp., Lactarius spp., Xerocomus spp., Amanita spp. and Hygrophorus spp. (Greece), Lactarius spp., Tricholoma spp., Leucopaxillus spp., Sarcodon spp. and Agaricus spp. (Portugal), Ramaria spp., Psathyrella spp. and Termitomyces spp. and Agaricus spp., Amanita spp., Boletus spp., Hydnum spp., Hypholoma spp., Lactarius spp., Pleurotus spp., Russula spp. and Tricholoma spp. from various countries have been investigated for their nutritional values and antioxidant activity [11-13]. Despite the many global studies on mushroom cultivation [14], over 95% of edible mushrooms are still collected from the wild in most African countries.

Mushrooms have high nutritional value particularly as a source of protein that can enrich human diets, especially in some developing countries where animal protein may not be readily available and are expensive [15]. Many genera of edible mushrooms are also rich in carbohydrates, vitamins, mineral, fibers, and amino acids and have a low fat and oil content [16-18]. Edible mushrooms are sources of food all over the world and have high nutritional value, almost twice that of any vegetable [14] although the total nutrient contents vary significantly among species. Based on their chemical composition, mushrooms have also been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia, and cancer [19].

In Cameroon, edible and medicinal mushrooms are ubiquitous and constitute a substantial volume of internal trade especially by women in rural areas [20,21]. Wild edible mushrooms are one of the important natural resources on which the local people of all nationalities rely heavily [22] and are considered in many parts of tropical Africa as "meat" for the poor [20]. Apart from the comprehensive work of Kansci et al. [23] who revealed the nutritional contents of some mushroom species of the genus Termitomyces consumed in Cameroon, there is no other documented work on nutrient composition on mushrooms in Cameroon. Hence, the aim of this study was to determine the proximate composition and mineral content of some wild edible soil and wood-inhabiting mushroom species from the Kilum-Ijim forest, to provide information about their nutritional value with respect to consumer preference.

MATERIALS AND METHODS

Study area and sample collection

Fresh fruiting bodies for nutrient analysis were collected from five community forests in the Kilum-Ijim (Figure 1). Five community forests out of 18 were selected based on accessibility after a reconnaissance survey was carried out in the area. Fruiting bodies were dug off the soil or cut off with a knife where they were found on wood substrata. The samples were wrapped with their tags using aluminium foil and put in zip-lock bags for drying. Drying at 45°C-55°C was done in a locally designed open air oven for up to 72 hours for thick samples. The dried samples were carefully wrapped in absorbent papers and preserved over blue silica gel in zip-lock bags for analysis.

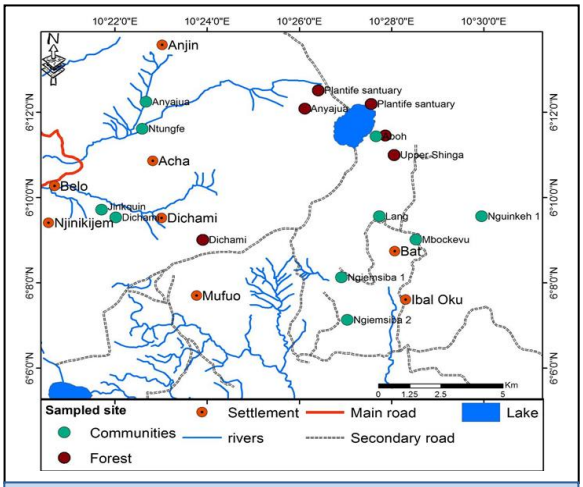

Figure 1: Field sites where samples were collected for proximate and mineral analysis in Kilum-Ijim forest.

Nutritional analysis of edible mushrooms

The eight species used for nutritional and mineral analysis were identified using DNA barcoding of the ITS regions using ITS1/ITS 4 primers [24]. The species were identified as; Termitomyces microcarpus, Laetiporus sulphureus, Auricularia polytricha, Termitomyces striatus, Polyporus tenuiculus, Polyporus dictyporus, Termitomyces sp.1 and Termitomyces sp.2. These eight mushroom species had also been identified as edible from an ethnomycological survey [22]. One kg each of dried fruiting bodies of the different samples were separately milled to powder using a blender and stored in airtight bottles at 4°C until use. The samples were then analyzed for moisture, crude protein, carbohydrates, total fat, crude fiber, ash, and mineral contents using standard protocols of Association of Official and Analytical Chemists [25].

Dry matter content determination

Dry matter content was determined by the oven drying method, in which porcelain crucibles were oven-dried at 110± 5oC until a constant weight was attained. The dishes were cooled in a vacuum desiccator for 30 minutes and weighed (W1). This operation was done until a constant weight was attained. 1g of the sample was put into the pre-weighed crucibles. The crucibles were then placed in a pre-heated oven and dried for 16 hours at 110°C. The crucibles with the samples were removed and immediately transferred into a vacuum desiccator for 30 minutes and weighed. The heating/cooling weighing procedure was repeated until a constant weight was attained (W3). The moisture content was calculated using the following equation:

$$Dry\ matter\ content\ (\%) = \frac{W_1 - W_2}{W_1}\ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where:

W1 = Weight of sample before drying

W2 = Weight of sample after drying

Determination of crude protein

Crude protein content was determined using a modified Folin-Lowry's method [25]. 100mg of dried sample was weighed in duplicates into 25mL falcon tubes. 5mL of 5% SDS was added and allowed to stand for 2hours at room temperature and vortexed every 30 minutes. After two hours the tubes were placed in the centrifuge and centrifuged at 2000rpm for 10 minutes. 50µL aliquot of the sample was diluted into 950µL of distilled water. 100µL aliquot of the diluted sample was then extracted for analysis (using Folin-Lowry's method). The tubes were allowed to stand for 30 mins for color development. Using a UV-Visible spectrophotometer, the absorbance of the standards and samples versus the blank was measured at 750nm. A calibration curve was prepared by plotting the absorbance values of the standards against their corresponding protein concentrations. This was used to determine the protein concentrations of the samples.

The crude protein content of the samples was calculated using the formulae:

$$Total\ protein\ \left(\frac{g}{100g}\right) = \frac{C\ x\ 100\ x\ DF}{10^6\ x\ W} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

Where:

C = Concentration obtained from calibration curve in µg/ml

100 = Conversion factor to express protein in g/100g

DF = Total dilution factor (100)

10^6 = Conversion from µg to g

W = Weight of the sample taken

Determination of total fat

The total fat was determined using the Chloroform/Methanol gravimetric method. Two grams of ground mushroom sample were weighed into 50mL falcon tubes (W1). To each tube, 32mL of Clarase solution was added and the tube was gently shaken until the sample was well mixed with the enzyme solution. The sample was incubated in a 50°C water bath for 1hour, with gentle inversion every 15 minutes. The digest was quantitatively transferred to a blender assembly with 80mL methanol and 40mL chloroform in a fume hood and blended for 2 minutes. The solution was centrifuged at 2000rpm for 15 minutes to clarify the chloroform. The top aqueous phase was carefully discarded using a tap aspirator pump, leaving a 4mm thick layer of the top phase on the chloroform. A hole was broken into the surface crust using a glass rod and 20mL of the chloroform extract was pipetted into a pre-weighed dried 50mL beaker (W2). The solution was evaporated to dryness by allowing it to stand for three days in a fume hood after which the beaker plus fat residue was weighed (W3).

The fat in the residue was calculated using the formulae:

$$Total\ fat\ \left(\frac{g}{100}\ g\right) = \frac{(W_3 - W_2)}{W_3}\ X\ 100\ x\ 4 \ldots\ldots\ldots\ldots [3]$$

Where;

W3 = Weight of the beaker plus fat residue after drying

W2 = Weight of the beaker

W1 = Weight of the sample.

100 = Conversion factor to report results in g/100g dry weight

4 = Factor of volume extract in chloroform taken for evaporation

Determination of total ash

Crucibles were heated for 3hours in a muffle furnace at 500°C, removed, cooled in a desiccator, and weighed (W1). One gram of mushroom sample was weighed into the crucible and the weight taken (W2). The crucible was placed over a hot plate at 90°C until the entire sample was completely charred. The charred samples were incinerated in a muffle furnace at 550°C for 5hours (until residue was completely white or nearly white in color. The crucibles were then cooled in a desiccator and weighed (W3). The total ash was calculated as follows;

$$Ash\ content\ \left(\frac{g}{100}g\right) = \frac{(W_3 - W_2)}{W_2 - W_1} X\ 100 \text{.....[4]}$$

Where:

W3 = Weight of crucible + ash sample

W1 = Weight of crucible

W2 = Weight of crucible + dried sample

100 = Conversion factor to report results in g/100g

Determination of crude fiber

2 grams of moisture and a fat free sample was weighed, treated with 0.255N sulphuric acid and 0.313N sodium hydroxide and washed with ethanol and ether, boiled for 30 minutes, filtered, and washed again with boiling 1.25% sulphuric acid, water, and alcohol. The residue was then transferred to a preweighed crucible (W1), dried overnight at 80-1000C, and weighed (W2). The crucible containing the ash was incinerated in a muffle furnace at 6000Cfor 6 hours, cooled and weighed again (W3) and crude fiber content calculated thus:

$$Crude\ fibre\ \left(\frac{g}{100}g\right) = \frac{(Wt\ of\ crucible\ before\ ashing - Wt\ of\ crucible\ after\ ashing)}{Weight\ of\ sample} \text{.....[5]}$$

Determination of available carbohydrate

The content of the available carbohydrate was determined indirectly as previously described in this paper [28].

$$Available\ Carbohydrate = 100 - (Total\ Lipid + Total\ Protein + Ash + Crude\ Fibre) \text{.....[6]}$$

Determination of energy value

Energy value was determined using the Atwater factor method described by Onyeike et al. (1995).

$$Energy\ Value\ \left(\frac{\text{kcal}}{100\text{g sample}}\right) = 4X(Protein) + 9X(fat) + 4X(carbohydrate) \text{.....[7]}$$

DETERMINATION OF MINERAL CONTENTS

Sample preparation

One gram of oven-dried sample was weighed and put into a digestion tube. 5mL of concentrated HNO_3 and 1mL 30% hydrogen peroxide was added into the tube. The tube was allowed to stand overnight in a fume hood. The digestion tube was then placed into a block digester and digested. Complete digestion was attained when the residue was clear or colorless. The tube was then removed from the digester and allowed to cool. The digest was transferred into a 50mL volumetric flask. Distilled water was used to dilute the digest to the 50mL mark.

Mineral content

The minerals were determined using Atomic Absorption Spectrometer (AAS). Aliquots of the solution were aspirated to the AAS for determination of calcium (Ca), zinc (Zn), magnesium (Mg), sodium (Na), Potassium (K), Iron (Fe) and copper (Cu). Calibration of the AAS was done using working standards prepared from commercially available standard solutions. The most appropriate wavelength, hallow cathode lamb current, flow rate, and other AAS instrument parameters for minerals were selected as given in the instrument user's manual for each mineral. Each value was the mean of three replicate determinations ± standard deviation.

Phosphorus was determined by the spectrophotometric method in which phosphorus reacts with molybdovanadate reagent [26]. The yellow coloration formed from this reaction is directly related to the amount of phosphorus in the sample and the absorbance measured at 400nm. To each flask, 10mL of 6 $NHNO_3$ was added followed by 10mL each of 0.25% ammonium monovadate and 2.5% sodium molybdate and diluted with distilled water to the mark. The flasks were well

mixed and allowed to stand for 15 minutes for color development. The absorbance of the resulting yellow solution measured at 400nm. The content of phosphorus present in the sample was calculated using the formula:

$$P\left(\frac{g}{100g}\right) = \frac{C \times V \times 100}{V1 \times W} \quad \text{.....[8]}$$

Where:

C = Concentration of phosphorus obtained from standard curve in µg/mL

V = Final volume of the extracted solution in mL

V1 = Volume of solution taken in mL

100 = Conversion factor to report results in g/100g

W = Weight of sample

STATISTICAL ANALYSIS

All nutrient analyses for the mushrooms studied were performed in triplicates. All data were subjected to one-way analysis of variance (ANOVA). Results are expressed as mean values and standard deviation (SD) using Minitab software version 16, followed by the Tukey method to compare treatment means at $P<0.05$.

RESULTS

Nutrient contents of edible mushrooms

Table 1 and Figure 2 show the properties and photos of the eight mushroom species reported as edible from ethnomycological survey which was used in analyzing for the proximate and mineral compositions.

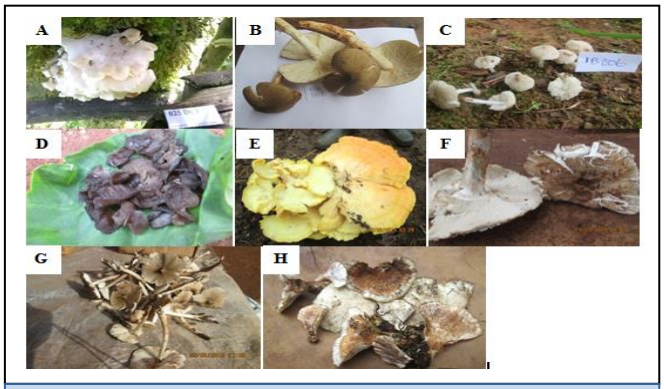

Figure 2: Fruiting bodies of edible mushroom species collected from the Kilum-Ijim forest of the Northwest Region of Cameroon (A) Polyporus tenuiculus (B) Termitomyces striatus (C) Termitomyces microcarpus (D) Auricularia polytricha (E) Laetiporus sulphureus (F) Termitomyces sp.1 (G) Termitomyces sp.2 (H) Polyporus dictyopus

Table 1: Some properties of analyzed mushroom species.

S/N	Name	Family	Substrates	Edibility
1	*Termitomyces sp. 1*	Lyophyllacceae	Soil	Edible
2	*Termitomyces microcarpus*	Lyophyllacceae	Soil	Edible/Medicinal
3	*Termitomyces sp.2*	Lyophyllacceae	Soil	Edible
4	*Laetiporus sulphureus*	Polyporaceae	Deadwood	Edible/Medicinal
5	*Auricularia polytricha*	Auriculariaceae	Deadwood	Edible/Medicinal
6	*Termitomyces striatus*	Lyophyllacceae	Soil	Edible
7	*Polyporus tenuiculus*	Polyporaceae	Deadwood	Edible
8	*Polyporus dictyopus*	Polyporaceae	Deadwood	Edible

Nutrient contents of edible mushrooms

The nutrient content and calculated energy value of edible mushroom species from the Kilum-Ijim forest are shown in Table 2. Dry matter content ranged from 12.69% in Auricularia polytricha to 17.77% in Polyporus dictyopus. Except for Polyporus dictyopus which showed a significant difference in dry matter content of the species studied, no significant differences were observed in the dry matter contents amongst the other species. The Crude protein content of studied mushrooms ranged from 6.6g/100g in Polyporus dictyopus to 30.69g/100g in Termitomyces microcarpus. Carbohydrate content calculated by difference was also an abundant compound in mushrooms and ranged from 43.49g/100g in Termitomyces sp. to 64.88g/100g in Laetiporus sulphureus. Crude fat content ranged from 2.17g/100g in Termitomyces microcarpus to 3.22g/100g in Polyporus tenuiculus. Ash content varied between 7.74g/100g in Auricularia polytricha and 14.10g/100g in Polyporus dictyopus while crude fiber content ranged from 11.60g/100g in Termitomyces microcarpus to 18.17g/100g in Polyporus dictyopus. It was observed that the Termitomyces species differed significantly in crude protein content from all the other species. The mean content of crude fat showed no significant difference amongst all the species. However, significant differences were observed amongst species in ash and crude fiber contents. The studied mushroom species proved to be high in energy content ranging from 285.16Kcal/100g in Polyporus dictyopus to 321.67Kcal/100g in Laetiporus sulphureus.

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Table 2: Nutrient content of wild edible mushroom species from the Kilum-Ijim forest (g/100g dw).

Mushroom species	Dry matter content	Carbohydrate	Crude Protein	Crude Fat	Ash	Crude Fibre	Energy (Kcal/100g dw)
Termitomyces sp. 1	16.97^{a,b}±0.58	43.49^{d}±2.70	28.24^{a}±0.75	2.38^{a}±0.32	12.26^{a,b}±1.45	13.63^{c,d}±0.76	308.32^{a,b}±5.57
Termitomyces microcarpus	15.56^{a,b,c}±0.51	44.23^{d}±1.83	30.69^{a}±0.71	2.17^{a}±0.36	11.30^{a,b,c}±0.38	11.60^{d}±1.60	319.27^{a}±8.19
Termitomyces sp. 2	16.09^{a,b}±0.88	48.54^{c,d}±1.38	21.26^{b}±0.56	2.23^{a}±0.28	11.03^{a,b,c}±1.36	15.94^{b,c}±1.13	308.30^{a,b}±8.46
Laetiporus sulphureus	16.40^{a,b}±1.53	64.88^{a}±0.66	8.62^{d,e}±0.57	3.07^{a}±0.31	8.19^{b,c}±0.74	15.24^{b,c,d}±1.50	321.67^{a}±4.08
Auricularia polytricha	12.69^{a}±0.74	51.23^{c}±1.12	17.44^{c}±1.65	2.91^{a}±0.61	7.74^{c}±1.20	20.69^{a}±1.20	301.51^{a,b}±12.90
Termitomyces striatus	14.41^{a,b}±1.13	46.82^{c,d}±2.84	21.76^{b}±1.45	2.40^{a}±0.37	12.33^{a,b}±1.50	16.70^{b,c}±0.55	295.88^{a,b}±3.63
Polyporus tenuiculus	17.02^{a,b}±0.97	58.84^{a,b}±1.72	10.89^{d}±0.62	3.22^{a}±0.17	11.57^{a,b,c}±1.83	15.48^{b,c}±0.59	299.49^{a,b}±18.02
Polyporus dictyopus	17.77^{c}±0.20	58.29^{b}±1.62	6.60^{e}±0.95	2.84^{a}±0.31	14.10^{a}±1.28	18.17^{a,b}±0.92	285.16^{b}±7.38

Data are means (±S.D) of triplicate values; means along a column with the same letters are not significantly different from each other at P<0.05.

Table 3: The selected macro-element content of wild edible mushroom species from the Kilum-Ijim forest (mg/100g dw).

Mushroom Species	Ca	K	Mg	P	Na
Termitomyces sp.1	25.93^{e}±0.81	1179.63^{b}±6.17	29.11^{d}±1.10	776.82^{b}±12.51	11.19^{a,b}±0.30
Termitomyces microcarpus	37.47^{d}±0.46	1112.76^{b}±28.41	39.03^{c,d}±0.37	898.17^{a}±3.44	12.91^{a}±0.24
Termitomyces sp. 2	49.31^{c}±0.73	1200.28^{b}±31.07	50.75^{c}±1.36	925.69^{a}±11.08	11.21^{a,b}±0.82
Laetiporus sulphureus	13.04^{f}±0.11	433.62^{c}±4.28	13.85^{e}±0.79	542.88^{e}±4.26	4.20^{d}±0.58
Auricularia polytricha	88.62^{a}±1.82	294.00^{d}±7.25	83.54^{a}±4.07	623.96^{d}±11.73	10.91^{a,b}±0.28
Termitomyces striatus	26.39^{e}±0.98	1450.44^{a}±36.88	28.47^{d}±1.63	739.06^{b,c}±10.31	12.31^{a}±0.33
Polyporus tenuiculus	90.95^{a}±1.62	428.41^{c}±8.80	94.48^{a}±4.14	592.25^{d,e}±10.97	9.70^{b,c}±0.54
Polyporus dictyopus	65.31^{b}±1.89	239.45^{d}±7.03	64.47^{b}±1.16	684.21^{c}±10.54	7.95^{c}±0.19

Data are means (±SD) of triplicate values; means along a column with the same letters are not significantly different from each other at P < 0.05.

The selected minerals content of edible mushrooms

Macro mineral compositions of the edible mushrooms are presented in Table 3. Macro mineral contents were predominantly high in Potassium (K) and Phosphorus (P) when compared with Calcium (Ca), Magnesium (Mg), and Sodium (Na).

Phosphorus concentrations ranged from 542.88mg/100g in Laetiporus sulphureus to 898.17mg/100g in Termitomyces microcarpus. Calcium and Magnesium contents ranged from 13.04mg/100g and 13.85mg/100g in Laetiporus sulphureus to 90.95mg/100g and 94.48mg/100g in Polyporus tenuiculus respectively recording significant differences among the species. However, Polyporus tenuiculus and Auricularia polytricha recorded no significant differences from each other in Calcium and Magnesium contents. Potassium ranged from 239.45mg/100g in Polyporus dictyopusto 1450mg/100g in Termitomyces striatus. Termitomyces species recorded no significant differences from each other in the Potassium content, but where significantly different from the other species. Sodium content was very low in all the mushrooms studied ranging from 4.2mg/100g in Laetiporus sulphureus to 12.91 in Termitomyces microcarpus. However, Termitomyces species recorded no significant differences from each other but were significantly different from the other species. Overall, Laetiporus sulphurous is very low in macromineral concentrations while Termitomyces microcarpus is very rich in macrominerals. Our results also revealed that soil-inhabiting macrofungi species (Termitomyces sp.1, Termitomyces microcarpus, Termitomyces sp.2, and Termitomyces striatus) showed higher levels of Potassium, and Phosphorus than the wood-inhabiting species (Laetiporus sulphureus, Auricularia polytricha, Polyporus tenuiculus and Polyporus dictyopus).

The selected trace element contents of edible mushroom species

The mean values of trace element contents of Copper, Iron, and Zinc of edible mushrooms are presented in Table 4. Trace element contents for Copper ranged from 0.14mg/100g in Auricularia polytricha to 3.90mg/100g in Termitomyces microcarpus with significant differences from each other. Iron content ranged from 6.92mg/100g in Polyporus dictyopus to 36.01 in Termitomyces sp. 2. Termitomyces sp. 2 recorded a very high Iron content with a significant difference from the other species analyzed. Zinc concentrations ranged from 1.31mg/100g in Polyporus dictyopus to 10.80mg/100g in Termitomyces sp 2. It was observed that soil- inhabiting fungi were richer in micro minerals than their wood-inhabiting counterparts.

Table 4: The content of the selected trace elements of Wild Edible Mushroom Species from the Kilum-Ijim forest (mg/100g dw).

Mushroom Species	Copper (Cu)	Iron (Fe)	Zinc (Zn)
Termitomyces sp. 1	$3.53^{a,b}$±0.36	19.09^{c}±1.09	7.24^{b}±0.04
Termitomyces microcarpus	3.90^{a}±0.22	20.86^{c}±1.24	8.13^{b}±0.14
Termitomyces sp. 2	$3.04^{a,b}$±0.35	36.01^{a}±0.15	10.80^{a}±0.36
Laetiporus sulphureus	1.15^{c}±0.06	$8.69^{d,e}$±0.46	2.66^{d}±0.18
Auricularia polytricha	0.14^{c}±0.02	17.64^{c}±0.31	1.51^{e}±0.21
Termitomyces striatus	2.41^{b}±0.24	27.77^{b}±1.10	4.90^{c}±0.04
Polyporus tenuiculus	0.86^{c}±0.07	6.92^{e}±0.05	4.82^{c}±0.20
Polyporus dictyopus	0.78^{c}±0.01	11.76^{d}±0.37	1.31^{e}±0.02

Data are means (±S.D) of triplicate values; means along a column with the same letters are not significantly different from each other at $P<0.05$

DISCUSSION

Mushrooms contribute enormously to the supply of both macro and micronutrients in our diet. They are considered to be good sources of carbohydrates, proteins, fats, and minerals. Results from our study revealed that the soil- inhabiting mushrooms were higher in nutrient content than their wood- inhabiting counterparts. The chemical composition of mushrooms varies depending on the substrate, species of mushroom, harvest time, and storage conditions after harvest [27,28]. The nutrient contents of the wild mushrooms studied were generally high. This may be because the Kilum-Ijim forest is a humid zone. This is similar to the findings of [29], who reported that mushrooms from humid zones had a high concentration of nutrients due to the high organic matter content of the soil. Different species of mushrooms had varied nutrient composition probably due to species or strain differences and their ability to bioaccumulate minerals and other nutrients into their tissues [30,31].

Dry matter content variation may have probably been caused by a series of factors such as the environmental factors during growth and storage; and the relative amount of metabolic water produced during storage [30]. Our study revealed that the dry matter contents of carbohydrate and protein of the wild mushroom studied were relatively high. Similar results have been reported by previous authors for wild mushrooms in other regions of the world [32,33].

The Protein content of mushrooms may vary according to the genetic structure of species and the physical and chemical differences in the growing medium [32,34]. Variations in protein contents in mushrooms may also be due to species/strain, stage of development, size of the pileus, and the method of analysis [35].

Results obtained revealed that the wild mushrooms studied were found to be rich in proteins but with very low- fat contents. This finding is similar to those of [36]. Who reported that wild mushrooms were richer sources of protein and had a lower amount of fat than commercial mushrooms. The protein content of Polyporus tenuiculus recorded in this study was 10.89±0.62g/100g. These results however differed from that obtained by Nakalembe et al., [37] who had protein content values for Polyporus tenuiculus species from Uganda ranging from of 11.56% for subhumid species to 16.86% for humid species. Mushroom protein is generally higher than those of green vegetables and oranges [38].

Proximate analysis of Termitomyces microcarpus revealed carbohydrate content of 44.23±1.83g/100g, the crude protein content of 30.69±0.71g/100g, the crude lipid content of 2.17±0.36, the ash content of 11.30±0.38g/100g, and the crude fibre content of 11.60±1.60g/100g. All these results are closely similar to that of [39] who studied the nutritional properties of Termitomyces microcarpus in Uganda. The values of the polypore mushroom Auricularia polytricha analyzed were compared with those carried out by Usha and Saguna [40]. Our study revealed slight variations for dry matter content, ash, and crude fiber contents while high variations were noticed for carbohydrates, protein and fat. Nevertheless,

our findings on protein and fat content were similar to those of Asaduzzaman et al., [41] on their study on the nutrient composition of Auricularia polytricha mushroom. Based on ash content, [42] reported ash content of edible fungi ranging from 5g/100g to 13g/100g. Our findings revealed that the ash contents were within this range with the exception of Polyporus dictyopus which had an ash content of 14.10g/100g.

Mushrooms are generally considered as low- calorie diets. Calculated energy values of edible wild mushrooms studied varied from 285.16kcal/100g to 321.67kcal/100g on dry matter basis confirming them as low- calorie source. The energy values fall slightly below that of cereals (millet; 341kcal and maize 349kcal) [43]. Other studies from literature reported from different parts of the world revealed high energy values of mushrooms ranging from 367.9-450.2 kcal/100g [32-33]. Though Polyporus dictyopus has relatively low crude protein content of 6.6g/100g, it is relatively rich in carbohydrate; 58.29g/100g; ash 14.1g/100g and crude fiber 18.17g/100g. It is also a poor source of fat 2.84g/100g and energy 285.16Kcal/100g. Polyporus dictyopus was highly cherished as meat by the Kilum-Ijim inhabitants due to its taste and tender nature.

The wild mushrooms reported in this study were predominantly rich in potassium and phosphorus compared to the other macro minerals. This is in agreement with studies reported by different authors on mushrooms [29,30,36,44]. Potassium is an important electrolyte in the body and is the major cation within cells. It functions in reducing the effect of salt on blood pressure. All the Termitomyces species studied showed high concentrations of mineral nutrients. This is in agreement with [30] who reported that Termitomyces species were generally rich in minerals such as potassium, calcium magnesium, and iron. Manzi et al. [45] reported that calcium levels are not so high in mushrooms. Calcium level in this study, varied from 13.04mg/100g to 90.95mg/100mg. However, reported literature range for calcium in mushrooms varies from 1.8mg/100g to 59.0mg/100g [46]. Magnesium levels in this study ranged from 13.85mg/100g to 94.48mg/100g. These results differ with those of [37] who reported magnesium values ranging from 7.14-31.9mg/100g in some wild mushroom species from Uganda. However, the reported literature ranges magnesium contents in mushrooms from 60mg/100g to 250mg/100g [47].

Sodium concentrations were relatively low in this study ranging from 4.2mg/100g to 12.91mg/100g. This supports previous findings that sodium is relatively less in mushroom species and therefore of great benefit to patients with hypertension [48].

Among the trace elements studied, Fe content was higher (6.92mg/100g -36.01mg/100g) than other trace elements. Nevertheless, the range of reported literature values varies between 1.46mg/100g-83.5mg/100g [49]. Copper functions in the body to protect the cardiovascular, skeletal, and nervous systems. It is the third most abundant trace element in the body. The copper range in our study varied from 0.14mg/100g to 3.9mg/100g. The recommended daily intake of copper is 2mg/day. However, this is adequate for all age groups except for pregnant and lactating mothers who require 1mg/100g of copper [50]. Copper contents in mushrooms might vary due to the habitat and substrate of the mushrooms. Very low copper contents were reported [37]. On the contrary, various studies from different parts of the world have reported high copper contents in mushrooms [29,39]. Zinc content in this study varied from 1.3mg/100g to 10.8mg/100g. Zinc is an important element in cellular metabolism involving cell division, wound healing, and protein synthesis [51]. The recommended daily intake of zinc for all age groups is 15mg/day [50]. The Reported literature range of Zinc contents in mushrooms is between 2.98-15.8mg [52]. Nevertheless, [37] reported the zinc content values of studied mushrooms in Uganda as low as 0.56 to 1.1mg/100g.

CONCLUSION

The results obtained from this studyrevealed that mushrooms are rich sources of nutrients and can be used to upgrade the diet of local commuities . Mushrooms are essential foods for vegetarians as they are rich sources of proteins. Therefore, mushroom consumption should be encouraged in these communties. These high nutritional quality and unique flavor of the studied mushrooms are likely to be poorly known and to be lost if they are not documented, so it is imperative that a nutritional database of these mushrooms is set up to collect and improve the characteristics of these unique species.

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