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Nutrient and mineral components of wild edible mushrooms from the Kilum-Ijim forest, Cameroon

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Kilum-Ijim forest is a montane forest in the North West Region of Cameroon. Wild edible mushrooms are mostly consumed by the communities of Kilum-Ijim as substitute of meat to obtain protein, hence the need to evaluate the nutrient and mineral components of the species consumed in these communities. The most eight preferred wild mushroom species from ethnomycological studies are: *Polyporus tenuiculus, Termitomyces striatus, Termitomyces macrocarpus, Auricularia polytricha, Laetiporus sulphureus, Termitomyces* sp.1, *Termitomyces* sp.2 and *Polyporus dictyopus* were identified by ITS gene region. These species were analysed for nutrient and mineral contents using standard protocols. Significant differences in nutrient values were demonstrated among these mushroom species. The study results on dry weight basis range from 43.49 to 64.88 for carbohydrates, 6.60 to 30.69 for crude protein, 7.74 to 14.10 for ash, 2.17-3.22 g for fat and 11.60 to 20.69 g per 100 g for crude fibres with significant differences (P< 0.05) between species for each nutrient. The dry matter content ranged from 12.69-17.77 g per 100 g while the total calorie values ranged from 285.16-319.27 Kcal per 100 g. Mineral nutrient analyses also showed that these mushrooms are rich in both macro and micro nutrients. In conclusion, the study revealed that soil inhabiting mushrooms especially the *Termitomyces* species have nutritional values which can greatly supplement diets especially in rural communities.

Key words: Cameroon, Kilum-Ijim Forest, Macrofungi, Mineral content, nutritional analysis.

INTRODUCTION

Edible mushrooms are mostly growing in forests in association with woody parts of trees either as parasite, saprophyte or as symbionts in the soil (Chamberlain et al., 1998). Macrofungi have several ecological functions

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in both natural and agroecosystems, and are widely exploited by humans for food and medicinal purposes (Mueller et al., 2007; Osemwegie et al., 2006; Boa, 2004). Mushrooms represent one of the world's greatest untapped resources of nutrition (Wani et al., 2010). 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 (Lindequist et al., 2005). Mushrooms have probably been a part of the human omnivore diet ever since humans have evolved as a species. Actually, it is quite possible that many fungal species developed the highly nutritious sporocarps concurrently with the evolution of omnivores, as a very small number of animal species has been reported to be strictly mycophagous (Witte and Maschwitz, 2008).

Macrofungi play important roles in the lives of many people around the world. They provide two main benefits; they are a source of food, income and also have medicinal properties. The awareness of wild edible fungi and their importance to people are generally poor. Subsistence uses in developing countries have often been ignored. 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 (Yorou and Kesel, 2002).

The most cultivated mushroom worldwide is *Agaricus bisporus*, followed by *Lentinula edodes*, *Pleurotus* spp. and *Flammulina velutipes* (Aida et al., 2009; Chang and Miles, 2004). 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 (Aletor, 1995; Barros et al., 2007; Ouzouni et al., 2007). Despite these advances in mushroom cultivation (Manjunathan and Kaviyarasan, 2011), over 95% of edible mushrooms are still collected from the wild in most African countries.

The people of West African sub-region still rely on wild edible mushrooms for their livelihood especially as a low-cost alternative for animal proteins and flavouring in diets. In addition, they represent a venerable source of subsistent income and incontrovertible raw material in local traditional medicine practice (Osarenkhoe et al., 2014).

In Cameroon, edible and medicinal mushrooms are ubiquitous and constitute a substantial volume of internal trade especially by women in rural areas (Kinge et al., 2014; Teke et al., 2018). Mushrooms have good 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 (Heleno et al., 2010). Edible mushrooms have high nutritional values since they are quite rich in protein, vitamins, mineral, fibers and various amino acids (Hyde et al., 2010; Luangharn et al., 2014; Bandara et al., 2015), with an important content of essential amino acids, and low in fat contents. Edible mushrooms also provide a nutritionally significant content of vitamins (B_1, B_2, B_{12}, C, D and E) and have high antioxidant abilities (Manjunathan and Kaviyarasan, 2011; Mattila et al., 2001), although the total nutrient contents vary significantly among species. Hence, due to their high content of nutritional values, edible wild mushrooms are considered in many parts of tropical Africa as "meat" for the poor communities (Kinge et al., 2014). Based on their chemical composition, mushrooms have also been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia, and cancer (Shashirekha and Rajarathnam, 2011).

Wild edible mushrooms are one of the important natural resources on which the local people of all nationalities rely heavily, and these mushrooms certainly play a role in improving the food nutrition (Yang, 2002). Most people eat mushrooms, mostly because of its flavour, meaty taste and medicinal value (Grangeia, 2011). Hence, this study set out to determine the nutrient and mineral components of some wild edible soil and wood inhabiting mushrooms in order to assess its nutritional value and enhance their cultivation. Thus the objective of this study was to evaluate and compare the nutrients and minerals from soil and wood inhabiting edible mushroom species which would increase our understanding of their nutritional potential and their possibility for cultivation using different substrates and development of new foods in the food industry.

MATERIALS AND METHODS

Study area and sample collection

Fresh fruiting bodies for proximate and nutritional analysis were collected from five community forests in the Kilum-Ijim (Figure 1). Prior to entering into the Kilum-Ijim forest, visitations were made to the various chiefs and administrative authorities within the Kom and Oku districts to sought traditional and administrative permission to use the forest. Five community forests out of 18 were selected based on accessibility after a reconnaissance survey was carried out in the study area.

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 (Teke et al., 2017). 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

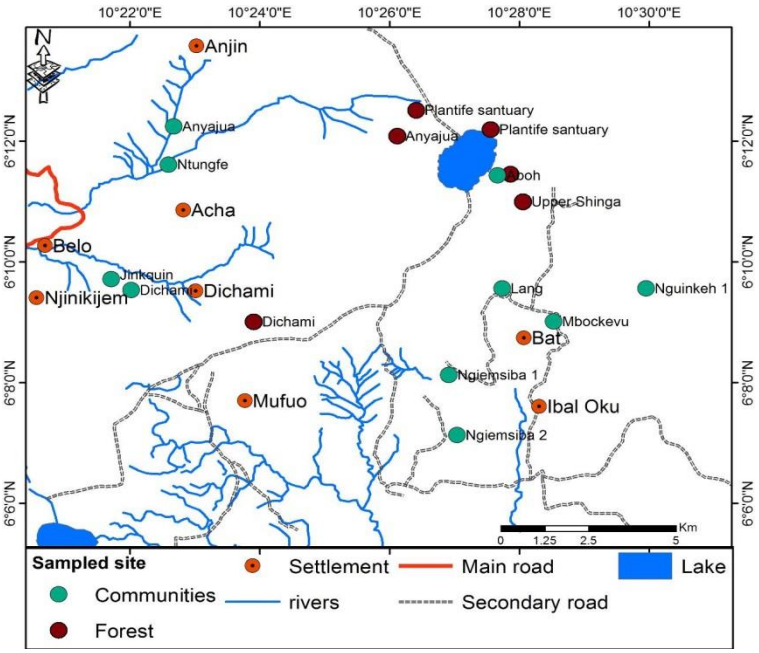

Figure 1. Field sites where samples were collected for Proximate and Mineral Analysis in Kilum-Ijim forest.

eight mushroom species had also been identified as edible from an ethnomycological survey (Teke et al., 2018). One Kg each of dried fruiting bodies of the different samples were separately milled to powder using a blender and stored in air tight bottles at 4°C until use. The samples were then analysed for dry moisture content, crude protein, carbohydrates, energy values, total fat, crude fibre, total ash and mineral contents using standard protocols of Association according to Official and Analytical Chemists (AOAC, 2005).

Dry matter content determination

Dry matter content was determined by oven drying method, in which porcelain crucibles were oven-dried at 110± 5°C until a constant weight was attained. The dishes were cooled in a vacuum desiccator for 30 min and weighed (W_1). This operation was done repeatedly until a constant weight was attained. 1 g of sample was put into the pre-weighed crucibles. The crucibles were then placed in a pre-heated oven and dried for 16 h at 110°C. The crucibles with the samples were removed and immediately transferred into a vacuum desiccator for 30 min and weighed. The heating/cooling weighing procedure was repeated until a constant weight was attained (W_3). The moisture content was calculated using the following equation:

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

Where:
W_1 = Weight of sample before drying
W_2 = Weight of sample after drying

Determination of crude protein

Crude protein content was determined using modified Folin-Lowry's method (AOAC, 2005). 100 mg of dried sample was weighed in duplicates into 25 ml falcon tubes. 5 ml of 5% Sodium Dodecyl Sulphate (SDS) was added and allowed to stand for 2hours at room temperature and vortexing every 30 min. After two hours the tubes were placed in the centrifuge and centrifuged at 2000 rpm for 10 min. 50 µl aliquot of the sample was diluted into 950 µl of distilled water. 100 µl aliquot of the diluted sample was then extracted for analysis (according to Folin-Lowry's method). The tubes were allowed to stand for 30 min for colour development. Using a UV-Visible spectrophotometer, the absorbance of the standards and samples versus the blank were measured at 750 nm. 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:

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

Where:
C=Concentration obtained from calibration curve in µg/ml
100=Conversion factor to express protein in g/100 g
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 was weighed into 50 ml falcon tubes (W_1). To each tube, 32 ml 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 1 h, with gentle inversion after every 15 min. The digest was quantitatively transferred to a

blender assembly with 80 ml methanol and 40 ml chloroform in a fume hood and blended for 2 min. The solution was centrifuged at 2000 rpm for 15 min 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 20 ml of the chloroform extract was pipetted into a pre-weighed dried 50 ml beaker (W_2). The solution was evaporated to dryness by allowing it to stand for three days in a fume hood after which the beaker and fat residue was weighed (W_3). The fat in the residue was calculated using the formulae:

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

Where;
W_3 = Weight of the beaker plus fat residue after drying
W_2 = Weight of the beaker
W_1 = Weight of the sample.
100 = Conversion factor to report results in g/100 g
4 = Factor of volume extract in chloroform taken for evaporation

Determination of total ash

Crucibles were heated for 3 h in a muffle furnace at 500°C removed from muffle furnace cooled in a desiccator and weighed (W_1). One gram of mushroom sample was weighed into the crucible and the weight taken (W_2). 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 5 h until residue was completely white or nearly white in colour. The crucibles were then cooled in a desiccator and weighed (W_3). The total ash was calculated as follows;

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

Where:
W_3 = Weight of crucible + ash sample
W_1 = Weight of crucible
W_2 = Weight of crucible + dried sample
100 = Conversion factor to report results in g/100 g

Determination of crude fibre

Two grams for moisture contents and fat free sample was weighed, treated with 0.255 N sulphuric acid and 0.313 N sodium hydroxide and washed with ethanol and ether, boiled for 30 min, filtered and washed again with boiling 1.25% sulphuric acid, water and alcohol. The residue was then transferred to a preweighed crucible (W_1), dried overnight at 80-100°C and weighed (W_2). The crucible containing the ash was incinerated in a muffle furnace at 600°C for 6 h, cooled and weighed again (W_3) and crude fibre content calculated thus:

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

Determination of available carbohydrate

The content of the available carbohydrate was determined indirectly by difference (FAO, 2003).

$$Available\ Carbohydrate = 100 - (Total\ Lipid + Total\ Protein + Ash + Crude\ Fibre) \quad (6)$$

Determination of energy value

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

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

Determination of mineral contents

Sample preparation for determination of mineral nutrients

One gram of oven dried sample was weighed and put into a digestion tube. 5 ml of concentrated HNO_3 and 1 ml of 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 colourless. 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 50 ml mark.

Mineral nutrients analyses

The mineral nutrients were determined using Atomic Absorption Spectrometer (AAS). Aliquots of the solution was 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 spectrophotometric method in which phosphorus reacts with molybdovanadate reagent (ASEAN, 2011). The yellow colouration formed from this reaction is directly related with the amount of phosphorus in the sample and the absorbance measured at 400 nm. To each flask, 10 ml of $6NHNO_3$ was added followed by 10mL each of 0.25% ammonium monovadate and 2.5% of sodium molybdate and diluted with distilled water to the mark. The flasks were well mixed and allowed to stand for 15 min for colour development. The absorbance of the resulting yellow solution was measured at 400 nm. The content of phosphorus present in the sample was calculated using the formula:

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

Where:
C= Concentration of phosphorus obtained from standard curve in µg/ml
V = Final volume of the extracted solution in ml
V_1= Volume of solution taken in ml
100 = Conversion factor to report results in g/100 g
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

Table 1. Some properties of analyzed mushroom species.

Name	Family	Substrate	Edibility
Termitomyces sp. 1	Lyophyllacceae	Soil	Edible
Termitomyces microcarpus	Lyophyllacceae	Soil	Edible/Medicinal
Termitomyces sp.2	Lyophyllacceae	Soil	Edible
Laetiporus sulphureus	Polyporaceae	Deadwood	Edible/Medicinal
Auricularia polytricha	Auriculariaceae	Deadwood	Edible/Medicinal
Termitomyces striatus	Lyophyllacceae	Soil	Edible
Polyporus tenuiculus	Polyporaceae	Deadwood	Edible
Polyporus dictyopus	Polyporaceae	Deadwood	Edible

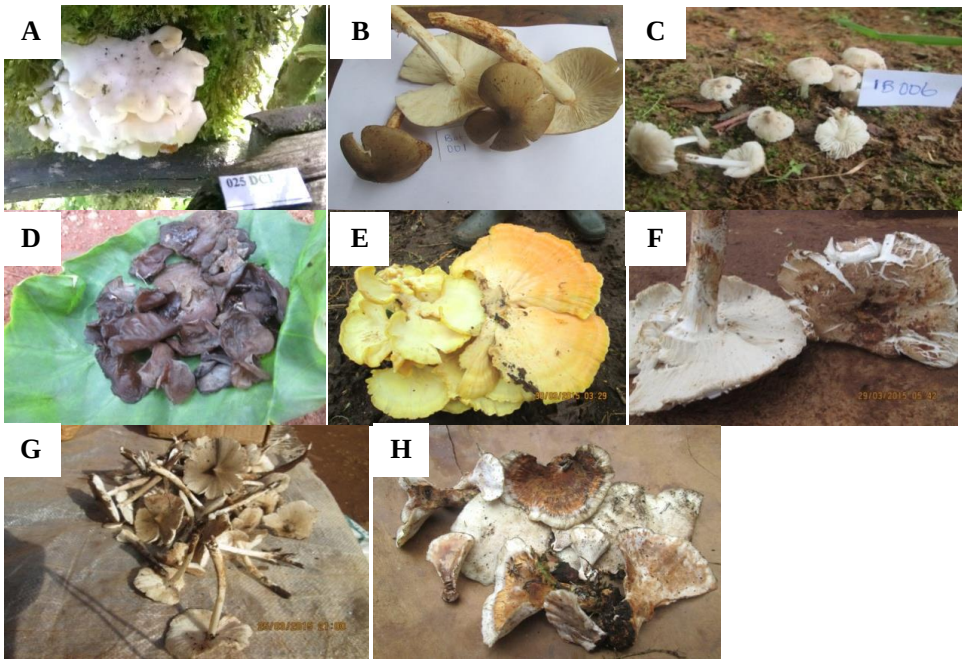

Figure 2. Fruiting bodies of edible mushroom species collected from the Kilum-Ijim forest of the Northwest Region of Cameroon. **(A)** *Polyporus tenuiculus* **(B)** *Termitomyces striatus* **(C)** *Termitomyces microcarpus.* **(D)** *Auricularia polytricha* **(E)** *Laetiporus sulphureus* **(F)** *Termitomyces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

deviation (SD) using Minitab software version 16, followed by Tukey method to compare treatment means at $p<0.05$.

RESULTS

Nutrient contents of edible mushrooms

Table 1 and Figure 2 shows the properties and pictures of the eight mushroom species reported as edible from ethnomycological survey which were used in analysing for the proximate and mineral compositions.

Proximate contents of edible mushrooms

The proximate composition and calculated energy value of edible mushroom species from the Kilum-Ijim forest are shown in Table 2. Dry matter content ranged from 17.77% in *P. dictyopus* to 12.69% in *A. polytricha.* With the exception of *P. dictyopus* which showed significant difference in dry matter content of the species studied, no significant differences were observed in the dry matter contents amongst the other species. Crude protein content of studied mushrooms ranged from 6.6 g/100 g in *P. dictyopus* to 30.69 g/100 g in *T. microcarpus.* Carbohydrate content ranged from 43.49 g/100 g in *Termitomyces sp.* to 64.88 g/100 g in *L. sulphureus.* Crude fat content ranged from 2.17 g/100 g in *T. microcarpus* to 3.22 g/10 0g in *P. tenuiculus.* Ash content varied between 7.74 g/100 g in *A. polytricha* and 14.10 g/100 g in *P. dictyopus* while crude fibre content ranged

Table 2. Proximate composition of wild edible mushroom species from the Kilum-Ijim forest.

Mushroom species	Dry matter content	Dry weight basis(g/100 g)					
		Carbohydrate	Crude Protein	Crude Fat	Ash	Crude Fibre	Energy Kcal/100 g
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. Macro mineral composition of wild edible mushroom species from the Kilum-Ijim forest.

Mushroom species	Dry weight basis(mg/100 g)				
	Calcium (Ca)	Potassium (K)	Magnesium (Mg)	Phosphorus (P)	Sodium (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.

from 11.60 g/100 g in *T. microcarpus* to 18.17g/100g in *P. 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 fibre contents. The studied mushroom species proved to be high in energy content ranging from 285.16 Kcal/100 g in *P. dictyopus* to 321.67 Kcal/100 g in *L. sulphureus.*

Some macro mineral nutrient contents of edible mushrooms

Macro mineral compositions of the edible mushrooms are presented in Table 3. Macro mineral contents were predominantly high in

Table 4. Some trace element composition of wild edible mushroom species from the Kilum-Ijim forest.

Mushroom species	Dry weight basis(mg/100 g)		
	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.

potassium and phosphorus when compared with Calcium, Magnesium and Sodium.

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

Some micromineral nutrient contents of edible mushroom species

The mean values of micro mineral contents of Copper, Iron and Zinc of edible mushrooms are presented in Table 4. Micromineral contents for copper ranged from 0.14 mg/100 g in *A.polytricha* to 3.90 mg/100 g in *Termitomyces microcarpus* with significant differences from each other. Iron content ranged from 6.92 mg/100 g in *P. dictyopus* to 36.01 in *Termitomyces* sp. 2. *Termitomyces* sp. 2 recorded a very high iron content with significant difference from the other species analysed. Zinc concentrations ranged from 1.31 mg/100 g in *P. 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.

DISCUSSION

Mushrooms contribute enormously to the supply of nutrients 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 (Adejumo and Awosanya, 2005; Guillamón et al., 2010). The nutrient contents of the wild mushrooms studied were generally high. This may be due to the fact that the Kilum-Ijim forest is a humid zone. This is similar to the findings of (Colak et al., 2009), who reported that mushrooms from humid zones had high concentration of nutrients due to the high organic matter content of the soil. Different species of wild mushrooms had varied nutrient composition probably due to species or strain differences (Mattila et al., 2001; Mshandete and Cuff, 2007).

Dry matter content ranged from 17.77% in *P. dictyopus* to 12.69% in *A. polytricha.* This difference may have probably been caused by fluctuations in environmental factors during growth and storage therefore affecting metabolism (Mattila et al., 2001). Our study revealed that the dry matter contents of the wild mushroom studied were relatively high. Similar results in wild mushrooms have been reported by previous authors in other parts of the world (Sanmee et al., 2003; Saiqa et al., 2008). The protein content of wild mushrooms in this study ranged from 6.6 g/100 g in *P. dictyopus* to 30.69 g/100 g in *T.*

microcarpus. Protein content of mushrooms may vary according to the genetic structure of species, the physical and chemical differences in the growing medium (Sanmee et al., 2003; Ragunathan and Swaminathan, 2003). 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 (Bernas et al., 2006).

Results obtained from this study 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 Barros et al. (2008) who reported that wild mushrooms were richer sources of protein and had a lower amount of fat than commercial mushrooms. The protein content of *P. tenuiculus* recorded in this study was 10.89±0.62 g/100 g. This results however differed from that obtained by Nakalembe et al. (2015) who had protein content values for *P. 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 (Jonathan, 2002).

Proximate analysis of *T. microcarpus* revealed carbohydrate content of 44.23±1.83 g/100 g, crude protein content of 30.69±0.71 g/100 g, crude lipid content of 2.17±0.36, ash content of 11.30±0.38 g/100 g and crude fibre content of 11.60±1.60 g/100 g. All these results are closely similar with that of Nabubuya et al. (2010) who studied the nutritional properties of *T. microcarpus* in Uganda. The values of the polypore mushroom *A. polytricha* analyzed were compared with those carried out by Usha and Saguna (2014). Our study revealed slight variations for dry matter content, ash and crude fibre 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. (2009) on their study on nutrient composition of *A. polytricha* mushroom. Based on ash content, (Varo et al., 1980) reported ash content of edible fungi ranging from 5 g/100 g to 13 g/100 g. Our findings revealed that the ash contents were within this range with the exception of *P. dictyopus* which had an ash content of 14.10 g/100 g.

Mushrooms are generally considered as low calorie diets. Calculated energy values of edible wild mushrooms studied varied from 285.16 kcal/100 g to 321.67 kcal/100 g on dry matter basis confirming them as low calorie source. These values fall slightly below that of cereals (millet; 341 kcal and maize 349 kcal) (FAO, 1972). Similar studies from different parts of the world have also revealed high energy values in mushrooms ranging from 367.9-450.2 kcal/100 g (32-33). Though *P. dictyopus* has relatively low crude protein content of 6.6 g/100 g, it is relatively rich in carbohydrate; 58.29 g/100 g; ash 14.1 g/100 g and crude fibre 18.17 g/100 g. It is also a very low source of fat 2.84 g/100 g and energy 285.16 Kcal/100 g. *P. 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 (Mattila et al., 2001; Colak et al., 2009; Barros et al., 2008; Palazzolo et al., 2012). 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 (Mattila et al., 2001) who reported that *Termitomyces* species were generally rich in minerals such as potassium, calcium magnesium and iron. Manzi et al. (1999) reported that calcium levels are not so high in mushrooms. Calcium level in this study, varied from 13.04 mg/100 g to 90.95 mg/100 mg. However, reported literature range for calcium in mushrooms varies from 1.8 mg/100 g to 59.0 mg/100 g (Falandysz et al., 2001). Magnesium levels in this study ranged from 13.85 mg/100 g to 94.48 mg/100 g. These results differ with those of Nakalembe et al. (2015) who reported magnesium values ranging from 7.14-31.9 mg/100 g in some wild mushroom species from Uganga. However, reported literature ranges magnesium contents in mushrooms from 60 mg/100 g to 250 mg/100 g (Bakken and Oslen, 1990). Sodium concentrations were relatively low in this study ranging from 4.2 mg/100 g to 12.91 mg/100 g. This supports previous findings that sodium is relatively less in mushroom species and therefore of great benefit to patients with hypertension (Feldman et al., 1986).

Among the trace elements studied, Fe content was higher (6.92 mg/100 g -36.01 mg/100 g) than other trace elements. Nevertheless, range of reported literature values vary between 1.46 mg/100 g-83.5 mg/100 g (Tuzen, 2003). Copper is the third most abundant trace element in the body and plays a role in protecting the cardiovascular, skeletal and nervous systems. The copper range in our study varied from 0.14 mg/100 g to 3.9 mg/100 g. The recommended daily intake of copper for all age groups is 2 mg/day. However, pregnant and lactating mothers need 1 mg/100 g of copper daily (Food and Nutrition Board, 2001). Copper contents in mushrooms might vary due to the habitat and substrate of the mushrooms. Very low copper contents were reported (Nakalembe et al., 2015). On the contrary, various studies from different parts of the world have reported high copper contents in mushrooms (Colak et al., 2009; Nabubuya et al., 2010). Zinc content in this study varied from 1.3 mg/100 g to 10.8 mg/100 g. Zinc is an important element in cellular metabolism involving cell division, wound healing and protein synthesis (Heyneman, 1996). The recommended daily intake of zinc is 15 mg/day (Food and Nutrition Board, 2001). Reported literature range of Zinc contents in mushrooms

is between 2.98 and 15.8 mg (Islolu et al., 2001). Nevertheless, (Nakalembe et al., 2015) reported zinc content values of studied mushrooms in Uganda as low as 0.56 to 1.1 mg/100 g.

Conclusion

From the results obtained, it can be seen that all the mushroom species can be used as nutrient sources to upgrade the diet of the communities. These high nutritional qualities and unique flavors 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 and for their eventual domestication.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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