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Chemical composition and nutritional value of two edible mushrooms from three regions of Côte d'Ivoire

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Abstract: Wild edible mushrooms are consumed in the center regions of Côte d'Ivoire. In this study, the proximate composition, mineral element profile and amino acid profile of two selected wild edible mushrooms from three regions from center of Côte d'Ivoire including *Lentinus squarrosulus* and *Auricularia politrich* investigated. The mushrooms were harvested fresh, dried in an oven at 45°C for 48 hours, ground and analyzed according to standard procedures. showed high level of proteins (24.07±0.30–26.20±0.72%), crude fibre (12.30±0.07–20.13±0.07%), carbohydrate (52.36±1.84–64.64±0.68%), ash (9.58±0.18–16.02 ±0.10%) and fat (0.92±0.02–5.40±0.24%) in all species in the three regions. Mineral analysis of all species indicated the mushrooms were specifically rich in potassium, phosphorus, calcium and magnesium. Potassium was found to be the most abundant mineral present in all specie ranging from 1240.02±0.20 to 3414.11±0.94 mg/100g. Cadmuim and lead contents of the two species were generally very low. There were 17 amino acids, and these mushrooms were rich in essential amino acids. The ratios of essential amino acids to total amino acids were 0.40 to 0.45. The high scores of essential amino acids present in these mushrooms implied that they have a high biological protein value. These mushrooms could be considered a potential health food and may be of use to the food industry as a source of ingredients with high nutritional value.

INTRODUCTION

Mushrooms are the fleshy spore-bearing fruiting bodies of fungi, typically produced above ground on soil or on its food source (substrate) based on standard morphology, the word "mushroom" was mostly used to describe those fungi that have a stem (stipe), a cap (pileus), and gills (lamellae) or pores on the underside of the cap e.g. (Basidiomcota and Agaricomycetes). However, it generally refers to a variety of gilled fungi, with or without stems. Mushrooms are also described as macro-fungi with a distinctive fruiting body which can be either epigeous or hypogeous and large enough to be seen with the naked eyes and to be picked by hand. Only fruiting body of the mushroom can be seen whereas the rest of the mushroom remains underground as mycelium (Mattila et al., 2001; Heleno et al., 2010).

More than 2000 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 a great nutritional value since they are quite rich in protein, with an important content of essential amino acids and fiber, and poor in fat. Edible mushrooms also provide a nutritionally significant content of vitamins (B1, B2, B12, C, D and E) (Heleno et al., 2010; Mattila et al., 2001). Edible mushrooms could be a source of many different nutraceuticals such as unsaturated fatty acids, phenolic compounds, tocopherols, ascorbic acid and carotenoids. Thus, they might be used directly in diet and promote health, taking advantage of the additive and synergistic effects of all the bioactive compounds present (Barros et al., 2007a; Ferreira et al., 2009; Vaz et al., 2010). Compared with vegetables they are high in protein and have a good balance of vitamins and minerals. They contain little fat and digestible carbohydrate, making them suitable for low-calorie diets (Kurzman, 1997). However, the results of analyses vary widely for all constituents. This variation can be caused by differences in strain, substrate, and the developmental stage of the mushroom(Laborde and Delpech, 1991).

Considering the interest for wild mushrooms for human consumption and the lack of data with regard to mushroom amino and fatty acids, the objective of this study was to characterize profiles of two wild edible mushrooms, i.e. *Lentinus*

squarrosulus and *Auricularia politrich* from three regions from center of Côte d'Ivoire.

MATERIALS AND METHODS

Collection of mushrooms

The mushroom samples were picked in the wild of Central part of Côte d'Ivoire in the rainy season. This picking was carried out in the three administrative regions of central area which was region of Gbêkê. Belier and N'Zi. Taxonomic identification was achieved by Dr Souleymane Yorou Nourou (Abomé Calavy University of Benin/ Munich University of Germany) as *Lentinus squarrosulus* and *Auricularia politrich*. After picking. the samples of mushroom were immediately transferred to the laboratory and cleaned.

Sample Preparation

Mushrooms were first washed thoroughly to free from mud, ferns and other extraneous material, dried on blotting paper and cut into pieces. The mushrooms selected are normally harvested for consumption without division into pileus and stipe. Therefore, the whole mushrooms (Pileus + stipe) after washing, they were dried in an oven at 45°C for 48 hours. The dried samples were mechanically milled into powder with flat-hammer grinding mill and sifted through a 60-mesh screen and then stored in airtight containers for analysis (AOAC, 1995).

Proximate Composition Analysis

Dry matters were determined by drying in an oven at 105ºC during 24 h to constant weight (AOAC, 1990). Crude protein was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC (1990). Crude fat was determined by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent (AOAC, 1990). Total carbohydrates were calculated by difference. Total ash was determined by incinerating in a furnace at 550ºC (AOAC, 1990). Method described by Dubois et al. (1956) was used to determine total sugars while reducing sugars were analyzed according to the method of Bernfeld (1955) using 3.5 dinitrosalycilic acids (DNS). The crude fibre contents were determined according to standard method (AOAC, 1990).

Minerals analysis

Minerals were determined employing AOAC (1990) method. Flour was digested with a mixture of concentrated nitric acid (14.44 mol/L), sulfuric acid (18.01 mol/L) and perchloric acid (11.80 mol/L) and analyzed using an atomic absorption spectrophotometer. The total phosphorus was determined as orthophosphate by the ascorbic acid method after acid digestion and neutralization using phenolphthalein indicator and combined reagent (APHA, 1995).

Amino acid composition

Total amino acid composition of samples was determined after hydrolysis in 6 M HCl with phenol (1%) at 150°C for 60 min, in Pico-Tag system (Waters, Milford, Mass., U.S.A.). The phenylisothiocyanate (PITC®) amino acid derivatives were eluted on HPLC Applied Biosystems Model 172 A (Applera Corp, Foster City, Calif., U.S.A.) equipped with a PTC RP-18 column (2.1 mm × 22 cm). Sodium acetate (45 mM, pH 5.9) and sodium acetate (105 mM, pH4.6; 30%), and acetonitrile (70%) were used as buffers.

Statistical analysis

All analyses were performed in triplicates. Results are expressed as the mean ± standard deviation of several sample with Kyplot (version 2.0 beta 15, ©1997-2001, Koichi Yoshioka) statistical software. The data were statistically analyzed by one way analysis of variance (ANOVA). Means were compared by Turkey's test. Differences were considered statistically significant at $P < 0.05$.

RESULTS AND DISCUSSION

Proximate composition

The results of the proximate composition analysis of the mushroom samples were presented in Table-1. The moisture content of *L. squarrosulus* and *A. politrich* were ranged from 87.60 ± 1.46 to 87.82 ± 0.18% and 90.64± 0.73 and 9.36 ±0.01%, and dry matter were 12.40 ± 0.27 to 12.18 ± 0.72% and 9.14 ± 0.08 to 9.36 ±0.01 for the three regions respectively. The statistical analysis revealed that the regions not affected significantly ($p<0.05$) the moisture content of the mushroom samples. This high moisture content is an indication that fresh mushrooms cannot keep for long time. This is because high water activity enhances microbial growth (Brock et al., 1986). Similar observation were made by Gbolagade *et al.* (2006) for *A. polytricha* and Johnsy et al. (2011) for collected mushroom samples (*Pleurotus roseus, Pleurotus ostreatus, Pleurotus sajor caju, Termitomyces microcarpus, Termitomyces heimii, Auricularia auricular, Volvariella volvacea, Lentinus squarrosulus, Lentinus tuberegium* and *Grifola frondosa).*

Edible mushrooms are highly valued as a good source of carbohydrates and their contents usually ranged from 40.6% to 53.3% of dry weight (Khanna et al., 1992 and Ragunathan et al., 1996). Carbohydrates, calculated by difference, were also an abundant macronutrient and ranged from 63.96 ± 0.91% to 64.64 ± 0.68% and 52.36 ± 1.84 % to 53.36± 0.84 % for *L. squarrosulus* and *A. politrich* respectively (Table 1). The relatively high

carbohydrates content recorded in the samples (Table 1) is a proof of their being highly nutritious and good for human consumption. Hung and Nhi (2012) were reported that total carbohydrate content of dry weight basic in *P. ostreatus* was 61.3%, 52.5% in *V. volvacea,* 65.1% in *Lentinus edodes* respectively.

The protein content of *L. squarrosulus* and *A. politrich* were ranged from 24.07 ± 0.30 to 25.00 ± 0.21% and 25.88 ± 0.54 to 26.20 ± 0.72% for the three regions respectively. The statistical analysis revealed that the regions affected significantly ($p<0.05$) the protein content of the mushroom samples (Table 1). The protein content of mushroom was knowned to be highly variable due to strain of some species, tissue type and stage development, substrate and method analysis. Mushroom protein is generally higher than those of green vegetables and oranges (Chan, 1981; Jonathan, 2002). Hung and Nhi (2012) indicated that protein content of *V. volvacea* was 36.5%, *P. ostreatus* was 28.6%, *L. edodes* was 26.3%, *Genoderma lucidum* was 13.3% and *Auricularia polytricha* was 7.2% respectively. Hence, the mushrooms of this studied can be eaten as a protein supplement or as an alternative to fish and meat in rural areas where these items could not be affordable. Vegetarians could also eat mushrooms because it served as alternative protein supplements in their diet. Mushroom proteins are generally higher than those of green vegetables and oranges (Chan, 1981).

The crude fat content in *L. squarrosulus* and *A. politrich* investigated ranged from 0.92 ± 0.02 to 1.10 ± 0.03 % and 5.06 ± 0.14 to 5.40 ± 0.24 % respectively in the present study. These values of crude fat content of the collected mushrooms were low. This suggests those with heart or weight problems can consume wild edible mushrooms (Chan 1981). These high protein and low fat characteristics of the edible wild mushrooms have been previously reported by many workers (Die´z and Alvarez, 2001; Barros et al., 2007b; Kouassi et al., 2015).

The ash content in the present study revealed that in *L. squarrosulus* and *A. politrich* investigated ranged from 9.58 ± 0.18 to 10.61 ± 0.15 % and 15.70 ± 0.04 to 16.02 ± 0.10 % respectively. The statistical analysis revealed that the regions affected significantly ($p<0.05$) the ash content of the mushroom samples (Table 1). However, the total ash contents of *A. politrich* were higher than that *L. squarrosulus*. It appeared that ash content of *A. politrich* and *L. squarrosulus* were higher than that reported on *Auricularia polytricha* (5.2%) (Gbolagade et al., 2006) and *Lentinus sp* (8.7%) (Johnsy et al., 2011), indicating that these mushrooms contained many minerals.

Generally, mushrooms contain a relatively high amount of fibre which may be responsible for its relatively high amount of ash (Cheung, 1998). In the present study, crude fibre content in these mushrooms were ranged from 19.45±0.02 to 20.13±0.07 % and 12.30±0.07 to 12.76±0.04% in *L. squarrosulus* and *A. politrich* respectively. Fibre consumption also soften stools and lowers plasma cholesterol level in the body (Verma and Banerjee, 2010).

Table 1:Proximate chemical composition (g/100 g) of *Lentinus squarrosulus and Auricularia politrich* from center Côte d'Ivoire (mean ± SD; n = 3)

	Lentinus squarrosulus			*Auricularia politrich*		
Region	Gbêkê	Belier	N'zi	Belier	Gbêkê	N'zi
Moisture content (%)	87.60 ± 1.46^{a}	87.69 ± 0.64^{a}	87.82 ± 0.18^{a}	90.86 ± 0.51^{b}	90.66 ± 0.51^{b}	90.64 ± 0.73^{b}
Dry matter (%)	12.40 ± 0.27^{a}	12.31 ± 0.03^{a}	12.18 ± 0.72^{a}	9.14 ± 0.08^{b}	9.34 ± 0.08^{b}	9.36 ± 0.01^{b}
Ash (%)	10.61 ± 0.15^{c}	10.19 ± 0.07^{b}	9.58 ± 0.18^{a}	16.02 ± 0.10^{e}	15.98 ± 0.04^{e}	15.70 ± 0.04^{d}
Carbohydrate (%)	63.96 ± 0.91^{c}	64.64 ± 0.68^{c}	64.46 ± 0.36^{c}	52.36 ± 1.84^{a}	52.69 ± 0.84^{a}	53.36 ± 0.84^{b}
Proteins (%)	24.51 ± 0.24^{ab}	24.07 ± 0.30^{a}	25.00 ± 0.21^{b}	26.20 ± 0.72^{c}	26.08 ± 0.54^{c}	25.88 ± 0.54^{c}
Fat (%)	0.92 ± 0.02^{a}	1.10 ± 0.03^{a}	0.96 ± 0.03^{a}	5.40 ± 0.24^{c}	5.25 ± 0.24^{c}	5.06 ± 0.14^{b}
Fiber (%)	20.13 ± 0.07^{b}	19.57 ± 0.31^{b}	19.45 ± 0.02^{b}	12.61 ± 0.04^{a}	12.76 ± 0.04^{a}	12.30 ± 0.07^{a}

Results are expressed in a dry weight basis In each line different letters mean significant differences ($p < 0.05$).

Table 2: Minerals concentrations (mg/100 g on dry weight basis) of *Lentinus squarrosulus* and *Auricularia politrich*

	Lentinus squarrosulus			*Auricularia politrich*		
	Gbêkê	Bélier	N'zi	Gbêkê	Bélier	N'zi
Mg	55.37±0.33^{a}	86.95±0.52^{e}	70.45±0.42^{c}	59.32±0.33^{b}	59.62±0.35^{b}	75.87±0.45^{d}
Na	20.55±0.14^{b}	8.90±0.07^{a}	43.65±0.28^{c}	57.99±0.07^{d}	58.13±0.37^{d}	44.95±0.29^{c}
K	6256.95±0.20^{e}	3414.11±0.94^{d}	2641.61±0.012^{c}	1240.02±0.20^{a}	1243.28±0.21^{a}	1766.61±1.32^{b}
P	319.83±0.19^{e}	99.83±0.06^{b}	209.83±0.12^{d}	94.43±0.06^{a}	94.83±0.05^{a}	111.50±0.06^{c}
Ca	95.21±0.63^{e}	84.45±0.81^{d}	71.05±0.45^{b}	59.02±0.19^{a}	59.32±0.20^{a}	75.05±0.35^{c}
Mn	0.96±0.80^{a}	0.18±0.60^{a}	0.75±0.30^{a}	0.62±0.30^{a}	0.63±0.79^{a}	1.15±0.11^{a}
Fe	52.36±0.31^{d}	13.05±0.07^{b}	14.58±0.08c	11.35±0.07^{b}	11.00±0.06^{a}	13.56±0.08^{b}
Cu	6.51±0.39^{c}	1.33±0.12^{b}	0.21±0.39^{a}	0.54±0.30^{a}	0.56±0.26^{a}	0.62±0.34^{a}
Zn	7.02±1.92^{c}	1.27±0.92^{a}	3.42±1.26^{b}	1.27±0.92^{a}	1.30±7.57^{a}	1.67±0.60^{a}
Pb	0.092±0.23^{a}	0.49±0.02^{a}	0.74±0.13^{a}	0.49±0.02^{a}	0.50±0.12^{a}	0.55±0.23^{a}
Cd	0.71±0.08^{a}	0.23±0.12^{a}	0.36±0.32^{a}	0.61±0.12^{a}	0.71±0.10^{a}	0.81±0.15^{a}
Cr	ND	ND	ND	ND	ND	ND
Co	ND	ND	ND	ND	ND	ND
Ni	ND	ND	ND	ND	ND	ND

Results are expressed in a dry weight basis in each line different letters mean significant differences ($p < 0.05$).
ND: Not Detected

Mineral composition

Mineral elements are essential for human health. The concentration of elements has an important physiological effect on different organs and cellular mechanisms (Vetter, 2003); therefore, it is necessary to know the levels of toxic and essential elements in mushrooms before using them. High accumulation of Cd, Co, Ni, Cr, Pb, and Hg in some edible mushrooms is of a great importance when considering human health. The mineral composition of these mushrooms shown in Table 2. This study indicates that the mushrooms were specifically rich in potassium, phosphorus, calcium and magnesium. Significant differences were observed between the two mushrooms concerning mineral contents and varied according to growth region ($p<0.05$). This may be ascribed to differences in substrate composition, as determined by the ecosystem and great differences in uptake of individual metals by mushrooms species (Isiloglu et al., 2001; Vetter, 2003; Isildak et al., 2004). This indicates that these mushroom species are good sources of these mineral elements and may provide more than 50% of the recommended daily allowance for these elements. The values were also higher than those reported for cowpea species (Aletor and Aladetimi, 1989). The low sodium concentration and the presence of a great quantity of potassium suggest the utilization of mushrooms in an anti-hypertensive diet; in fact, potassium from fruit and vegetables lowers blood pressure, as stated by Manzi et al. (1999). Levels of Cr, Ni, and Co were not detected in *L. squarrosulus and A. Politrich* (Table 2). In the present study, Pb, and Cd values in these mushrooms not varied according to growth region. Cadmium and lead are known as principal toxic elements since they inhibit many vital processes. They can be taken up directly from water and, to some extent, from air and dietary food. These elements also have a tendency to accumulate in both plants and animals (Demirbaş, 2001). From these concentrations of toxic minerals presented in this work, we could assert that these mushrooms do not pose health risks to populations, since these concentrations may be considered rather low compared with the limits set by to WHO (World Health Organization) in raw plant materials which are of 0.30 mg/kg for Cd, and 10.0 mg/kg for Pb (Zhu *et al*., 2011). It is worth clarifying here in that our results are expressed on a dry basis. Falandysz et al. (2008) reported that Cd and Pb could be considered limiting metals in edible mushrooms. In other words, the Cd and Pb concentrations of the samples were below the tolerance limits established by the FAO/WHO.

Amino acid composition

In order to evaluate the quality of proteins within our samples of mushroom. it appears also fundamental to determine their amino acid profile. Table 3 showed the amino acids found in each sample with their levels. Of the twenty aminoacids biologically active for humans. Seventeen were tested in our samples (serin, glutamic acid, lysin, histidine, arginine, aspartic acid. Threonin, prolin, glycin, alanin, valin, methionine, isoleucine, leucin, tyrosin, phenylalanine and tryptophan). In general. there appears to be significant differences between mushroom samples for amino acid profiles of each species and for each region. The results presented suggest that these mushrooms were rich in essential amino acids. The ratios of essential amino acids to total amino acids were 0.40 to 0.45 and may well meet the minimum daily requirements (WHO, 1975). The quality of a food protein depends largely on its amino acid content. The cells, in making their own protein, need a full array of amino acids from food. Cells can synthesize non-essential amino acids when they are unavailable from food, but essential amino acids can only be obtained from foods (Sizer and Whitney 2000). The high scores of essential amino

acids present in these mushrooms implied that they have a high biological protein value. This is particularly important as there is a need for novel protein sources owning to the increasing cost of conventional sources of protein in the third world. In addition, the cereal based diets common in developing countries could receive a boost with the inclusion of these mushrooms in their diet.

CONCLUSION

Results from the present study indicate that the two wild edible mushrooms species from a three regions of center (Côte d'Ivoire) are rich in nutrients including protein, carbohydrates, fibre, especially essential amino acids and minerals. Therefore, these mushrooms could be considered a potential health food and may be of use to the food industry as a source of ingredients with high nutritional value.

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Table 3: Contents of amino acid (g/100 g protein dry weight basis) of *Lentinus squarrosulus* and *Auricularia politrich*

Amino acids (g/100 de proteins)	*Lentinus squarrosulus*			*Auricularia politrich*		
	Gbêkê	Belier	N'zi	Gbêkê	Belier	N'zi
Leucin*	3.20±0.42^{a}	4.55±0.35^{b}	4.85±0.35^{b}	6.20±0.14^{c}	6.00±0.14^{c}	5.25±0.21^{bc}
Isoleucin *	5.30±0.14^{b}	4.35±0.07^{a}	3.85±0.49^{a}	3.55±0.35^{a}	3.95±0.21^{a}	6.05±0.35^{b}
Valin*	4.60±0.14^{b}	2.30±0.28^{a}	2.70±0.42^{a}	5.08±0.14^{b}	5.20±0.14^{b}	4.70±0.28^{b}
Tryptophan*	0.15±0.07^{a}	nd	2.50±0.28^{c}	1.24±0.21^{b}	1.10±0.14^{b}	2.45±0.21^{c}
Lysin*	9.55±0.21^{d}	7.45±0.07^{c}	7.05±0.35^{c}	5.64±0.14^{b}	5.55±0.07^{b}	3.90±0.14^{a}
Thréonine*	4.95±0.07^{c}	6.40±0.21e	5.60±0.28^{d}	2.33±0.14^{b}	2.40±0.14^{b}	1.35±0.07^{a}
Phénylalanin*	3.30±2.26^{a}	5.45±0.35^{b}	7.05±0.21^{c}	3.36±2.26^{a}	3.50±0.07^{a}	4.50±0.21^{b}
Méthionin*	1.90±0.14^{bc}	2.20±0.14^{c}	1.70±0.14^{b}	1.10±0.14^{a}	1.15±0.07^{a}	1.60±0.14^{b}
Histidin*	2.60±0.14^{b}	2.95±0.21^{b}	3.15±0.07^{c}	3.51±0.14^{b}	3.60±0.14^{b}	2.05±0.07^{a}
Arginin	0.20±0.21^{a}	1.15±0.07d	1.45±0.21c	0.79±0.07^{b}	0.90±0.14bc	0.65±0.07^{b}
Alanine	4.90±0.14^{e}	4.10±0.28^{ab}	3.35±0.35^{a}	1.47±0.07^{b}	1.60±0.14^{b}	0.35±0.07^{a}
Proline	5.85±0.21^{a}	6.35±0.07^{b}	7.30±0.21^{c}	nd	nd	nd
aspartic acid	8.00±0.28^{d}	6.00±0.14^{c}	5.95±0.21^{c}	2.82±0.14^{a}	2.90±0.14^{a}	5.20±0.14^{b}
Glycin	3.05±0.21^{c}	4.60±0.14^{d}	2.35±0.35^{b}	1.33±0.21^{a}	1.65±0.07^{a}	2.20±0.14^{b}
Tyrosin	2.70±0.70^{a}	5.25±0.07^{c}	5.25±0.21^{c}	5.18±0.21^{c}	4.95±0.07^{c}	4.05±0.21^{b}
Serin	3.35±0.35^{b}	4.60±0.28^{d}	2.90±0.07^{c}	4.23±0.35^{c}	4.30±0.14^{c}	3.55±0.14^{b}
Glutamic acid	5.35±0.35^{a}	13.90±0.21^{e}	12.70±0.07^{d}	8.89±0.35^{b}	9.00±0.14^{b}	10.00±0,07^{c}
Total essential amino acids	35.55	35.65	38.45	32.01	32.45	31.85

* essential amino acid

Results are expressed in a dry weight basis in each line different letters mean significant differences ($p < 0.05$).

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