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Nutrients value of some edible mushrooms in Côte d'Ivoire

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ABSTRACT

In order to promote consumption of edible mushrooms in Côte d'Ivoire, a chemical study was conducted. The composition of six species of edible mushrooms (*Volvariella volvacea, Termitomyces letestui, Psathyrella tuberculata, Lentinus brunneofloccosus, Hirneola auricula-judae, Pleurotus ostreatus*) was determined. The results showed that *V. volvacea* is the richest (P≤0.05) in fat (3.24 ± 0.24 % DM), sodium (67.41 ± 0.01 mg/100 g DM), phosphorus (2137.20 ± 0.10 mg/100 g DM), chlorine (889.13 ± 0.23 mg/100 g DM), flavonoids (3.15 ± 0.03 mg/100 g DM), tannins (17.59 ± 0.09 mg/100 g DM) and oxalates (253.93 ± 1.78 mg/100 g DM). *T. letestui* has a higher content (P≤0.05) of crude proteins (19.48 ± 0.65 % DM), digestible proteins (13.65 ± 0.46 % DM), ash (21.44 ± 0.34 % DM), magnesium (351.61 ± 0.07 mg/100 g DM), iron (1076.28 ± 0.17 mg/100 g DM) and copper (85.76 ± 0.02 mg/100 g DM). Reducing sugars (740.99 ± 3.94 mg/100 g DM), total sugars (1654.06 ± 0.00 mg DM) and potassium (8042.77 ± 0.31 mg DM) concentrations are greater (P≤0.05) in *P. tuberculata*. *L. brunneofloccosus* has a higher content (P≤0.05) of fibers (42.74 ± 0.07 % DM), calcium (337.89 ± 0.05 mg/100 g DM) and zinc (17.30 ± 0.00 mg/100 g DM). The highest content (P≤0.05) of digestible carbohydrates (57.60 ± 0.65 % DM), manganese (4.26 ± 0.00 mg/100 g DM), phytates (109.88 ± 0.13 mg/100 g DM) and a stronger (P≤0.05) anti-radical activity (51.75 ± 0.34 mg/100 g DM) were recorded in *H. auricula-judae*. *P. ostreatus* is richer (P≤0.05) in moisture (92.05 ± 0.55 % FM), energy (246.61 ± 1.41 kcal/100 g DM) and polyphenols (112.97 ± 0.28 mg/100 g DM). These results clearly show that mushrooms are rich in nutrients.

Keywords: Côte d'Ivoire, edible mushrooms, nutrient value, polyphenols, antioxidant activity, antinutrients,

INTRODUCTION

There are over 2,000 species of mushrooms in the nature. Only less than 25 wild species are considered as edible in nutrition. Very few of them have a commercial status (Lindequist *et al.,* 2005). Edible mushrooms are better known in Central Africa and East Africa. No recent work dealing with them in West Africa is available. This lack of data is not due to an absence of mushrooms in this part of Africa. As a fact, mushrooms are regularly mentioned in the diets of local people, without any data on the species, origins and cooking methods (Ducousso *et al.,* 2003). Edible mushrooms, vegetables and meat have a very similar nutritional value, and are increasingly considered as essential for healthy and balanced diet (Courtecuisse and Duhem, 1994; De Kessel *et al.,* 2001). However, edible mushrooms have, so far, attracted little interest in commercial transactions. Yet, these products contribute significantly to the livelihoods of African populations, especially, in the south of the Sahara (Degreef *et al.,* 1997; Yorou and De Kessel, 2001). Johnsy *et al.* (2011) showed that some wild edible mushrooms are rich in carbohydrates, proteins, vitamins, minerals, fat and fibers. As a consequence, they can help solve the problem of malnutrition in the world (Baros *et al.,* 2008). The goal of this work is to conduct the proximate analysis of six mushrooms, in order to promote their consumption in Côte d'Ivoire, since it's well known that these mushrooms can contribute to alleviate malnutrition and prevent metabolic diseases in rural populations.

MATERIALS AND METHODS

Plant material: The plant material is composed of species of edible mushrooms, including five wild species (*Volvariella volvacea, Termitomyces letestui, Psathyrella tuberculata, Lentinus brunneofloccosus,*

Hirneola auricula-judae) and one cultivated specy (*Pleurotus ostreatus*). They were bought at the food markets in the District of Abidjan (Côte d'Ivoire).

METHODS

The fresh mushrooms bought in the markets were dried in an oven (MERMERT 854 Schwabach W, Germany) at 50 °C and were reduced to powder with micromill hammer (Culatti Type MFC, Germany) with a sieve of 10 microns mesh. Moisture, crude proteins, lipids and ash levels were determined according to the methods of AOAC (1975). Moisture content was determined by dehydration of 10 g of a sample of fresh mushrooms in an oven (MERMERT 854 Schwabach W, Germany) at 105 °C until a constant weight. Crude proteins content (% N x 6.25) was determined by Kheldjahl method, using 1 g of mushrooms powder. But, since mushrooms proteins are part of chitin which is not digestible, digestible proteins (% N x 4.38) were calculated using the adjustment factor 4.38 (Shashireha, 2002). Mushrooms lipids content was determined by extracting 5 g of mushrooms powder in a Soxhlet apparatus for 5 hours, using hexane as extractant. Ash was determined by incineration of 1 g of mushrooms powder in a muffle furnace (MAKER, 5 EL STATOP-2MG, France), maintained at 550 °C for 6 hours. Content of mushrooms crude fibers was determined by the method of Van Soest (1963). The digestible carbohydrate (DC) and the energy value were determined on dry matter (DM) basis by calculation (FAO, 1998) as following:

DC (% DM) = 100 - [proteins (% DM) + lipids (% DM) + fibers (% DM) + ash (% DM)]

Energy (kcal / 100 g DM) = 2.44 x proteins (% DM) + 8.37 x lipids (% DM) + 3.57 x carbohydrates (% DM)

Quantification of reducing sugars was performed according to the method of Bernfeld (1955). The total sugar content was determined by the phenol-sulfuric method, as described by Dubois *et al.* (1956). Minerals composition is determined with a scanning electron microscope coupled with an energy scattering spectrometer (Zeiss Supra 40 VP, Germany). Two grams of sample were taken, burned on benzene spout and put in the oven at 750 °C. After six hours, the sample was removed and cooled in a desiccator. Ten milligrams of ash residue were collected. The polyphenols were determined by the method of Singleton *et al.* (1999). The flavonoid content was determined according to the method of Meda *et al.* (2005). Tannins were determined by the method of Bainbridge *et al.* (1996). The antioxidant activity *in vitro* was measured by the method of Choi *et al.* (2002). Phytates have been quantified according to the method of Latta and Eskin (1980). Oxalates were quantified according to the method of Day and Underwood (1986).

The analyses were carried out in triplicate and data were expressed as mean ± standard deviation. Analysis of variance (ANOVA) followed by Newman-Keuls range test to show, at the level of 5 %, was used to compare means followed by standard deviation (STATISTICA 7.1 software).

RESULTS AND DISCUSSION

The results of the analyses of the nutrients composition of the edible mushrooms are shown in Table I. Except for to the moisture and dry matter (DM) values; other values are expressed relative to the dry matter. Mushrooms moisture values are between 89.62 ± 1.42 % and 92.05 ± 0.55 %. The *Pleurotus ostreatus* has the highest humidity value (P≤0.05). These results are comparable to those of Bernas *et al.* (2006), Adedayo *et al.* (2010) and Johnsy *et al.* (2011). The values of crude proteins are between 7.58 ± 0.28 % and 19.48 ± 0.65 %, while the digestible proteins ones are between 5.31 ± 0.15 % and 13.65 ± 0.46 %. *Termitomyces letestui* presents the greatest rate (P≤0.05) of crude proteins and digestible proteins. These values are lower than those of Johnsy *et al.* (2011), Manjunathan and Kaviyarasan (2011), and Adejumo *et al.* (2015). Lipids values are between 0.55 ± 0.01 % and 3.24 ± 0.24 %. *Volvariella volvacea* contains the greatest level (P≤0.05) of lipids. This result is comparable to those of Barros *et al.* (2007), Manjunathan and Kaviyarasan (2011), and Sahore *et al.* (2011). The values of ash are between 4.26 ± 0.29 % and 21.44 ± 0.34 %. *Termitomyces letestui* has the highest value (P≤0.05) of ashes. This level is higher than that found by Johnsy *et al.* (2011). The values of the fibers are between 21.87 ± 0.80 % and 42.74 ± 0.07 %.

Volvariella volvacea presents the greatest content (P≤0.05) of fibers. These values are greater than those found by Mensah *et al.* (2008), Kirlag and Akyüz (2010), Johnsy *et al*. (2011), and Okwelehie and Ogoke (2013). The values of digestible carbohydrates are between 30.20 ± 0.67 % and 57.06 ± 0.65 %. *Hirneola auricula-judae* contains the greatest value (P≤0.05) of digestible carbohydrates. These results are comparable to those reported by Babita *et al*. (2014). Values of reducing sugars (mg per 100 g of dry matter) are between 232.55 ± 0.00 and 740.99 ± 3.94. *Pleurotus ostreatus* has the greatest level (P≤0.05) of reducing sugars. These values are lower than those obtained by Barros *et al.,* (2008). Total sugar values (mg per 100 g of dry matter) are between 811.21 ± 27.39 and 1654.06 ± 0.00. *Psathyrella tuberculata* has the greatest value (P≤0.05) of total sugars. The values of the energy (in kcal per 100 g of dry matter) are between 176.65 ± 0.74 and 246.61 ± 1.41. *Pleurotus ostreatus* contains the highest energy level (P≤0.05). These results are in agreement with those obtained by Barros *et al.* (2007), Sahore *et al.,* (2011) and Babita *et al.* (2014).

Table I: chemical composition of six species of edible mushrooms

Parameters	Mushrooms					
	Volvariella volvacea	*Termitomyces letestui*	*Psathyrella tuberculata*	*Lentinus brunneofloccosus*	*Hirneola auricula-judae*	*Pleurotus ostreatus*
Moisture (%)	90.41±0.39^{ab}	89.62±1.42^{a}	91.94±0.11^{b}	90.86±0.64^{ab}	90.64±1.13^{ab}	92.05±0.55^{b}
DM (%)	9.58±0.39	10.37±1.42	8.05±0.11	9.13±0.64	9.35±1.13	7.94±0.55
CP (% N x 6,25)	17.07±0.43^{e}	19.48±0.65^{f}	15.76±0.87^{d}	11.60±0.21^{b}	7.58±0.21^{a}	13.65±0.21^{c}
DP (% N x 4,38)	11.96±0.30	13.65±0.46	11.04±0.61	8.13±0.15	5.31±0.15	9.56±0.15
Lipids (%DM)	3.24±0.24^{d}	2.89±0.99^{d}	1.50±0.01^{b}	2.33±0.36^{cd}	0.55±0.01^{a}	1.98±0.25^{cd}
ashes (% DM)	18.22±0.11^{c}	21.44±0.34^{d}	17.30±1.22^{c}	7.22±0.14^{b}	4.26±0.29^{a}	7.39±0.00^{b}
Fibres (% DM)	31.25±0.13^{e}	24.16±0.04^{b}	26.70±0.24^{c}	42.74±0.07^{f}	29.98±0.13^{d}	21.87±0.80^{a}
DC (% DM)	30.20±0.67^{a}	32.01±0.73^{b}	38.72±1.83^{d}	36.09±0.07^{c}	57.60±0.65^{f}	55.08±0.85^{e}
RS (mg/100 g DM)	665.75±3.94^{c}	677.15±0.00^{d}	740.99±3.94^{f}	232.55±0.00^{a}	351.11±3.94^{b}	697.67±0.00^{e}
TS (mg/100 g DM)	1004.25±0.00^{b}	1535.91±0.00^{e}	1654.06±0.00^{f}	1398.07±34.10^{d}	811.21±27.39^{a}	1054.06±0.00^{e}
Energy (kcal/100 g DM)	176.65±0.74^{a}	186.09±4.12^{b}	189.33±4.56^{b}	176.70±2.77^{a}	228.82±1.72^{c}	246.61±1.41^{d}

Tests were performed in triplicate; Values are means ± STD; CP: Crude proteins; DM: Dry Matter;
DP: Digestible Proteins; DC: Digestible Carbohydrates; RS: Reducing sugars; TS: Total Sugars;
Means ± STD with different small letters within a row are significantly different (P≤0.05).

The results of the analyses of the mineral composition of edible mushrooms are shown in Table II. The mineral contents are expressed in mg per 100 g of dry matter. The sodium levels are between 10.34 ± 0.00 mg and 67.41 ± 0.01 mg. *V. volvacea* has the highest value (P≤0.05) of sodium. This value is higher than that reported by Ahmad and Gücel (2011), and Okwulehie and Ogoke (2013). Phosphorus levels are between 334.41 ± 0.02 mg and 2137.20 ± 0.10 mg. *V. volvacea* specy has the greatest concentration (P≤0.05) of phosphorus. This result is higher than that reported by Ayodele and Okhuoya (2009). Calcium levels are between 22.90 ± 0.00 mg and 337.89 ± 0.05 mg. *L. brunneofloccosus* has the highest level (P≤0.05) of calcium. This result is higher than that reported by Ahmad and Gücel (2011), Omar *et al.* (2011), and Okwulehie and Ogoke (2013). Magnesium levels are between 103.02 ± 0.01 mg and 351.61 ± 0.07 mg. *T. letestui* presents the highest concentration (P≤0.05) of magnesium. This result is higher than that found by Akyüz and Kirbag (2010) and Adejumo *et al.* (2015). Potassium levels are between 1175.33± 0.01 mg and 8042.77 ± 0.31 mg. *P. tuberculata* has the highest value (P≤0.05) of potassium. This value is higher than that found by Ayodele and Okhuoya (2009), and

Adejumo *et al.* (2015). The chlorine levels are between 27.43 ± 0.00 mg and 889.13 ± 0.23 mg. *V. volvacea* has the greatest level (P≤0.05) of chlorine. The iron levels are between 11.82 ± 0.00 mg and 1076.28 ± 0.17 mg. *T. letestui* presents the highest content (P≤0.05) of iron. This result is higher than that found by Mensah *et al.* (2008) and Ayodele and Okhuoya (2009). Zinc and manganese were detected in *L. brunneofloccosus* with a level of 17.30 ± 0.00 mg and in *H. auricula-judae* with a level of 4.26 ± 0.00 mg. These values are higher than those reported by Bernas *et al.* (2006), and lower than those found by Akyüz and Kirbag (2010). Copper rates are between 2.21 ± 0.00 mg and 85.76 ± 0.02 mg. *T. letestui* has the highest level (P≤0.05) of copper. This result is similar to that found by Akyüz and Kirbag (2010) and Sahore *et al.,* (2011).

Table II: Mineral composition of six species of edible mushrooms

Parameters (mg / 100 g of dry matter)	**Mushrooms**					
	Volvariella volvacea	*Termitomyces letestui*	*Psathyrella tuberculata*	*Lentinus brunneofloccosus*	*Hirneola auricula-judae*	*Pleurotus ostreatus*
Na	67.41±0.01^{c}	45.02±0.02^{b}	19.03±0.00^{ab}	26.71±0.00^{ab}	17.46±0.00^{ab}	10.34±0.00^{a}
P	2137.20±0.10^{d}	1914.59±0.25^{d}	1370.16±0.62^{c}	746.54±0.01^{b}	334.41±0.02^{a}	965.13±0.04^{b}
Ca	nd	nd	330.43±0.06^{c}	337.89±0.05^{c}	247.93±0.02^{b}	22.90±0.00^{a}
Mg	185.84±0.00^{ab}	351.61±0.07^{d}	233.55±0.05^{bc}	103.96±0.01^{a}	275.62±0.00^{c}	114.54±0.01^{a}
K	7679.73±0.06^{d}	7538.30±0.58^{d}	8042.77±0.31^{d}	5010.08±0.13^{b}	1175.33±0.01^{a}	2995.16±0.08^{c}
Cl	889.13±0.23^{b}	137.21±0.08^{a}	115.91±0.06^{a}	27.43±0.00^{a}	33.22±0.00^{a}	65.03±0,03^{a}
Fe	98.38±0.01^{ab}	1076.28±0.17^{c}	262.96±0.12^{b}	56.31±0.02^{ab}	94.14±0.00^{ab}	11.82±0.00^{a}
Zn	nd	nd	nd	17.30±0.00	nd	nd
Mn	nd	nd	nd	nd	4.26±0.00	nd
Cu	nd	85.76±0.02^{b}	67.47±0.02^{b}	nd	3.83±0.00^{a}	2.21±0.00^{a}

Tests were performed in triplicate; Values are means ± STD; nd: not detected
Means ± STD with different small letters within a row are significantly different (P≤0.05).

The results of the composition in secondary metabolites and the antioxidant activity by scavenging activity of 2.2-diphenyl-1-picrylhydrazyl (DPPH) radicals of mushrooms powder are shown in Table III. The contents of polyphenols, flavonoids and tannins are given in mg per 100 g of dry matter. The polyphenols content is between 15.04 ± 0.28 mg and 112.97 ± 0.28 mg. *P. ostreatus* has the highest polyphenols (P≤0.05) content. These values are higher than those reported by Balasundram *et al.* (2006) on fruits such as banana, mango and papaya, pineapple, and higher than those mentioned on apple, guava and higher than those reported by Babita and Narender (2014). Flavonoids concentrations are between 0.14 ± 0.03 mg and 3.15 ± 0.03 mg. *V. volvacea* has the highest concentration (P≤0.05) of flavonoids. These values are greater than those found by Babita and Narender (2014). The tannins content is between 6.90 ± 0.00 mg and 17.59 ± 0.09 mg. *V. volvacea* has the highest content (P≤0.05) of tannins. These values are higher than those reported by Okwulehie and Ogoke (2013). The antioxidant activity, by scavenging activity of 2.2-diphenyl-1-picrylhydrazyl (DPPH) radicals in mushrooms powder, is shown in Table III. The percentage of chelating in mushrooms is between 35.38 ± 0.22 % and 51.75 ± 0.34 %. *H. auricula-judae* has the highest reducing power (P≤0.05). These values are lower than those reported by Mau *et al.* (2002).

The results of the composition of antinutrients factors such as phytates and oxalates, in the 6 edible mushrooms are contained in Table IV. Their contents are given in mg per 100 g of dry matter. The phytates content is between 48.37 ± 0.06 and 109.88 ± 0.13. *H. auricula-judae* presents the greatest value (P≤0.05) of phytates. This value is lower than that reported by Russo and Reggiani (2015) on the hemp. The oxalates contents are between 45.05 ± 0.89 mg/100 g of DM and 253.93 ± 1.78 mg/100 g of DM. *V. volvacea* presents the greatest oxalates content (P≤0.05).

Table III: Phytochemical composition and antioxidant activity in six mushrooms species

Parameters (mg / 100 g of dry matter)	Mushrooms					
	Volvariella volvacea	*Termitomyces letestui*	*Psathyrella tuberculata*	*Lentinus brunneofloccosus*	*Hirneola auricula-judae*	*Pleurotus ostreatus*
Polyphenols	110.88±0.00^{e}	105.67±0.00^{d}	83.78±0.00^{c}	52.17±028^{b}	15.04±0.28^{a}	112.97±0.28^{f}
Flavonoids	3.15±0.03^{f}	1.00±0.03^{c}	1.25±0.03^{e}	1.06±0.03^{d}	0.14±0.03^{a}	0.58±0.03^{b}
Tannins	17.59±0.094^{f}	11.09±0.09^{c}	16.06±0.00^{e}	6.90±0.00^{a}	7.34±0.09^{b}	13.07±0.09^{d}
AOA (%)	40.48±0.13^{d}	39.42±0.13^{c}	40.71±0.13^{d}	36.83±0.13^{b}	51.75±0.34^{e}	35.38±0.22^{a}

Tests were performed in triplicate ; Values are means ± STD; AOA: Antioxidant Activity
Means ± STD with different small letters within a row are significantly different (P≤0.05).

Table IV: Antinutrients factors in six mushrooms species

Parameters (mg / 100 g of dry matter)	Mushrooms					
	Volvariella volvacea	*Termitomyces letestui*	*Psathyrella tuberculata*	*Lentinus brunneofloccosus*	*Hirneola auricula-judae*	*Pleurotus ostreatus*
Phytates	77.36±0.06^{c}	94.18±0.00^{d}	48.37±0.06^{a}	99.27±0.13^{e}	109.88±0.13^{f}	67.49±0.00^{b}
Oxalates	253.93±1.78^{e}	222.20±1.79^{d}	163.48±0.88^{c}	144.76±1.79^{b}	143.66±0.89^{b}	45.05±0.89^{a}

Tests were performed in triplicate; Values are means ± STD

Means±STD with different small letters within a row are significantly different (P≤0.05).

CONCLUSION

Analyses of the chemical composition of six edible mushrooms of Côte d'Ivoire show that edible mushrooms are largely composed of water. They have low energy value and low level of fats. However, they are rich in dietary fibers, minerals and polyphenols. Therefore, consumption of edible mushrooms can contribute to improve nutrition and health in rural populations.

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