# TWO WIDELY CONSUMED WILD MUSHROOMS FROM CENTRAL CÔTE D'IVOIRE: THEIR PROXIMATE ANALYSIS, MINERAL COMPOSITION AND AMINO ACIDS PROFILE

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***Abstract***
*In central Côte d'Ivoire, wild mushrooms identified as Volvariella volvacea and Psathyrella tuberculata are collected during the rainy season and valued as a traditionally nutritious food by the population. However, their nutritional attributes have not been adequately studied. Hence, the objective of this work was to evaluate nutritive potential of these mushrooms picked in the wild in the three administrative regions of central Côte d'Ivoire through their chemical proximate composition, mineral and amino acids profiles. Moisture was estimated to 87% for samples of fresh V. volvacea and 90% for samples of fresh P. tuberculata. Carbohydrates were the predominant nutrient within all samples (52-53% for V. volvacea and around 56% of dry matter for P. tuberculata) followed by proteins (around 30% for all samples, whilst fats were the least occurring nutrient (2.27-3.20% for V. volvacea and 1.40-1.78% for P. tuberculata). Ash contents were around 11% for P. tuberculata and ranged from 13.80 to 14.70% within V. volvacea. Fibers were also analyzed with relatively high levels (around 8 % for all samples of V. volvacea and ranging in 12.97-14.04%) for samples of P. tuberculata). Suitable concentrations of biologically important minerals (microminerals: Fe, Mn, Zn, Cu and macrominerals: Ca, Mg, Na, K, P) were observed in all samples with slight variations from one sample to another. In contrast, all mushrooms samples displayed low concentrations of Pb and Cd. Amino acids profile demonstrated quality of proteins of all mushrooms since many essential amino acids (leucine, isoleucine, threonine Phenylalanine) were successfully investigated. Therefore, these species of wild mushrooms could represent great potentials in preventing protein and mineral deficiency in the regions of central Côte d'Ivoire.*

**Keywords:** *Volvariella volvaceae* ; *Psathyrella tubercula*, , proximate composition, minerals, amino acids, potential nutritive

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## 1. INTRODUCTION

In Africa as in several countries throughout the world, wild edible mushrooms are part of the human consumption since centuries. According to several authors, it dates of several years before Christ since antiquity (Cooke, 1977, Ribeiro *et al*., 2008; Ayodele *et al*., 2011, Kalogeropoulos *et al*., 2013). During the early days of civilization, mushrooms were consumed mainly for their palatability and unique flavors (Rai, 1994; Parashare *et al*., 2013). But today not only the mushrooms dealing a prominent place in the diet and even health in several countries in Africa, Europe, Asia, America, but they also play a real economic role. Of the point of food view, edible mushrooms constitute valuable healthy and nutritious foods, low in calories and high in vegetable proteins, vitamins and minerals (Okwulehie & Odunze., 2004**;** Adedayo *et al*., 2010; Giri *et al*., 2013). In recognition of this fact, the Food and Agricultural Organization (FAO) had recommended mushrooms for reduction of protein malnutrition in some developing countries (Pedneault *et al*., 2006). Of the point of economic view, nowadays, edible mushrooms are able to be cultivated and marketed in large commercial surfaces (Chang & Miles 1991; Mattila *et al*. 2001). Additionally, of the point of medical and pharmacological view, it well known that the mushrooms contain many substances which could have some biological activities, including antioxidant (Puttaraju et al., 2006, Ferreira et al. 2009), antitumor/anticancer (Moradali *et al*., 2007), antimicrobial (Barros *et al*., 2007),

immunomodulatory (Borchers *et al*., 2004), anti-inflammatory (Padilha *et al*, 2009; Moro *et al*.; 2012); antiatherogenic (Mori *et al*.,2008) and hypoglycemic actions (Hu *et al*., 2006).
In tropical Africa including Côte d'Ivoire, particularly in central part, wild edible mushrooms are very sought-after by the population. Two mushrooms species identified as *Volvariella volvacea* and *Psathyrella tuberculata* are widely consumed by local population (Boa, 2006). V. volvacea locally called "*boyôfè"*, is commonly found on oil palm frustums decaying. As to *p. tuberculata*, it is locally called "*ndré blé"* and grows usually on the decaying woods (frustums and roots). The harvest period is during the rainy season and mushrooms are consumed locally or marketed in villages or the surrounding towns. Sometimes they are dried in the sun for a good conservation. Despite the high consumption of these mushroom species by rural and urban populations, very few studies about their proximate, mineral and amino acids composition were carried out on samples of Côte d'Ivoire and particularly, samples from in the central region. Some data on *V. volvacea* from are available, but they are focused on samples sold in Abidjan markets (Sahoré *et al*., 2011). Therefore, the objective of this investigation was to evaluate nutritive potential of these mushrooms picked in the wild in the three administrative regions of central Côte d'Ivoire through their chemical proximate composition, mineral and amino acids profiles.
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## 2. MATERIAL 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 Bélier and N'Zi. Taxonomic identification was achieved by Dr Souleymane Yorou Nourou (Abomé Calavy University of Benin/ Munich University of Germany), as *Volvariella volvacea* and *psathyrella tuberculata*. After picking, the samples of mushroom were immediately transferred to the laboratory and cleaned.

### Proximate analysis

All the analyses were conducted on a dry weight basis. Moisture and dry matter were determined by drying fresh samples of whole mushrooms (Pileus + stipe) in an oven at 105ºC during 24 h until constant weight (AOAC, 1990).
For proteins, fat, fibers, carbohydrates and ash, samples of whole mushrooms were previously 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). Then, the ash, fats (hexane extract), crude fiber, crude protein (N x 6.25) and carbohydrate (by difference) were determined in accordance with AOAC methods (AOAC, 1995). All proximate analysis of the mushroom flours were carried out in triplicate and reported in percent.

### Mineral analysis

Flour of mushroom sample (1g) with a mixture of concentrated nitric acid (14.44 mol/L), sulfuric acid (18.01 mol/L) and perchloric acid (11.80 mol/L). After proper dilution, content of Zn, Cu, Fe, Ca, Mg, Mn, Na and K were determined by measuring atomic absorption (Milner & Whitside, 1981). Estimation of phosphorus was done colorimetrically using the method of Fiske & Subbarow (1925).

### Amino acid analysis

The amino acid composition of each sample was determined using a high-performance liquid chromatograph (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). Before injection, proteins of each sample were previously hydrolyzed by 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 obtained were eluted on HPLC. Sodium acetate (45 mM, pH 5.9) and sodium acetate (105 mM, pH 4.6; 30%), and acetonitrile (70%) were used as buffers. A calibration chromatogram was established for 15 known amino acids.

**Statistical analysis**
All analyses were carried out in triplicate. Results were expressed as mean values ± standard deviation (SD). Analysis of variance (ANOVA) followed by Duncan's test was performed to test for differences between means by employing Kyplot (version 2.0 beta 15, ©1997-2001, Koichi Yoshioka) statistical software. Significance of differences was defined at the 5% level ($p < 0.05$).

## 3. RESULTS AND DISCUSSION

**Proximate composition**
Table 1 and 2 present the proximate composition (% of dry matter, except moisture) of *V. volvacea* and *P. tuberculata* from the three administrative regions from central Côte d'Ivoire, respectively. Values of moisture and dry matter contents of *V. volvacea* ranging between 86.98±0.67 to 87.63±1.07% and 13.02±0.05 to 12.37%, respectively were statistically identical for the three administrative regions (Table 1). According to Okoro & Achuba (2012), *V. volvacea* from Nigeria had moisture content of 92.02%. Samples of *P. tuberculata* from three regions displayed also statistically identical values of moisture content around 90% (Table 2). These results are consistent with those reported by several authors (Chang *et al*., 1981; Akyüz & Kirbağ, 2010, Sumathy et al., 2015). In these studies most fresh mushrooms contained about 90% moisture and 10% dry matter. These high values of moisture content indicate that *V. volvacea* and *P. tuberculata* are highly perishable. Indeed, it is well established that high moisture of food products promotes susceptibility to microbial growth and enzyme activity which accelerates spoilage. Ash content was estimated in *V. volvacea* to 14.02 ±0.17, 13.02±0.05 and 14.70±0.03% of dry matter, respectively for regions of Gbêkê, Bélier and N'Zi. For ash contents, there were significant differences between *V. volvacea* samples of the three regions ($p < 0.05$). These ash contents were lower than those reported by Haq *et al*. (2011) and Hung & Nhi (2012) for samples of this mushroom from Pakistan and Vietnam, respectively. These differences could be explained by the fact that the ash represent the total amount of minerals in this mushroom and it is well established that minerals content is related to collecting site of the sample (Isildak *et al*., 2004; Colak *et al*., 2009) and also affected by acidic and organic matter content of his substrate (Mendil *et al*., 2004; Türkekul *et al*., 2004; Wang *et al*., 2015; Sumathy *et al*., 2015). In contrast, ash contents of *P. tuberculata* samples were statistically identical for the three regions (around 11% dry weigh). Another mushroom of genus psathyrella (*P. atroumbonata*) from Southern Nigeria was investigated with a lower ash content of 9.0% of Dry Weight (Gbolagade *et al*., 2006). In the literature, the reported ash contents ranged from 5.4 to 27.6% of dry matter (Manzi *et al*., 1999; Sanmee *et al*., 2003; Agrahar-Murugkar & Subbulakshmi., 2005). Major compounds of the samples of *V. volvacea* and *P. tuberculata* from the three regions of central Côte d'Ivoire were proteins and carbohydrates. Indeed, samples of *V. volvacea* were investigated with statistically identical values of carbohydrate contents (estimated by difference and including the fibers) in the three regions about 52-53% of dry matter. These values were comparable to that reported by Mshandete & Cuif (2007) for *V. volvacea* from Tanzania (50±3.15% of dry weight). With regard to *P. tuberculata* samples, despite, the significant differences observed ($p < 0.05$) for the three regions, carbohydrate contents value were around 56% of dry matter. These carbohydrate contents were higher than that estimated in sample *P. atroumbonata* from Nigeria (23.40% for carbohydrates content and 19.75 for fibers) (Ayodele *et al*., 2011). It is well established that mushroom carbohydrates comprise various groups including monosaccharides and their derivatives, oligosaccharides and reserve and construction polysaccharides (glycans) (Kalac, 2012; Sumathy *et al*., 2015). According to Kalac

(2012), mannitol and α,α-trehalose are the main representatives of the polyols and oligosaccharides in European wild mushrooms, respectively and glycogen constitute their reserve polysaccharide. With respect to proteins, our findings showed clearly that the contents were statistically identical for the three regions, both for *V. volvacea* and *P. tuberculata.* Proteins contents values were around 30% of dry matter. Several authors reported that mushrooms constitute a truly good source of vegetable proteins with contents generally ranging between 14.0 to 44.3 % of dry weight (Agrahar-Murugkar & Subbulakshmi, 2005; Akyüz & Kirbağ, 2010; Kouassi *et al*., 2015). Samples of *V. volvacea* and *P. tuberculata* from central Côte d'Ivoire displayed protein content registered within this range. Therefore, these mushrooms could be considered as the well-recognized sources of proteins for local population. Fiber contents were found to be statistically identical in the three samples of *V. volvacea* with values of around 7-8% of dry matter which were slightly lower than that reported in this mushroom species from Tanzania (Mshandete & Cuff, 2007). However, this parameter presented significant differences ($p < 0.05$) in the three *P. tuberculata* samples with values ranging in 12-14% of dry matter which was comparable to that reported in nigerian *P. atroumbonata* (12.6% of dry weight) (Gbolagade *et al*., 2006). As regards fats, it is well known that wild mushrooms are characterized by low content (Diéz & Alvarez, 2001; Barros *et al*., 2007). Fat contents in both mushrooms investigated in the present work express this characteristic since values were in range 2.17 to 3.27 and 1.40 to 1.78% of dry matter, respectively for *V. volvacea* and *P. tuberculata*.

**Table 1:** Proximate chemical composition (g/100 g) of *V. volvacea* from central Côte d'Ivoire (mean ± SD; n = 3)

| | Regions | | |
|---|---|---|---|
| Parameters | Gbêkê | Bélier | N'zi |
| Moisture (%) | 87.36± 0.34$^{a}$ | 86.98± 0.67$^{a}$ | 87.63± 1.07$^{a}$ |
| Dry matter (%) | 12.64± 0.41$^{a}$ | 13.02± 0.05$^{a}$ | 12.37±0.60$^{a}$ |
| Ash (%) | 14.02 ±0.17$^{b}$ | 13.80± 0.04$^{a}$ | 14.70± 0.03$^{c}$ |
| Carbohydrate (%) | 53.61± 1.21$^{a}$ | 52.66± 0,62$^{a}$ | 52.20± 2.84$^{a}$ |
| Proteins (%) | 30.10± 0.85$^{a}$ | 30.34± 0.30$^{a}$ | 30.03± 0.46$^{a}$ |
| Fats (%) | 2.27± 0.20$^{a}$ | 3.20± 0.03$^{b}$ | 3.07± 0.08$^{b}$ |
| Fiber (%) | 7.72±0.19$^{a}$ | 7.99±0.06$^{a}$ | 7.97±0.21$^{a}$ |

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

**Table 2:** Proximate chemical composition (g/100 g) of *P. tuberculata* from central Côte d'Ivoire (mean ± SD; n = 3)

| | Regions | | |
|---|---|---|---|
| Parameters | Gbêkê | Bélier | N'zi |
| Moisture (%) | 89.98± 0.72$^{a}$ | 90.79± 0.27$^{a}$ | 90.43± 0.68$^{a}$ |
| Dry matter (%) | 10.02± 0.02$^{a}$ | 9.21± 0.14$^{a}$ | 9.57± 0.12$^{a}$ |
| Ash (%) | 11.57± 0.25$^{a}$ | 11.21± 0.28$^{a}$ | 11.37± 0.18$^{a}$ |
| Carbohydrates (%) | 56.07± 0,90$^{a}$ | 56.49± 0,52$^{c}$ | 56.23± 0,79$^{b}$ |
| Proteins (%) | 30.58± 0.53$^{a}$ | 30.90± 0.18$^{a}$ | 30.78± 0.08$^{a}$ |
| Fats (%) | 1.78± 0.07$^{c}$ | 1.40± 0.01$^{a}$ | 1.62± 0.01$^{b}$ |
| Fibers (%) | 14.04±0,05$^{b}$ | 13.86±0.15$^{b}$ | 12.97±0.10$^{a}$ |

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

## Mineral composition

Mineral elements are essential for human health, since they have important physiological roles on different organs and cellular mechanisms. Therefore, it appears fundamental to explore the mineral content of our mushroom samples which highly are consumed by local population.

Table 3 shows micromineral (Zn, Cu, Fe and Mn) contents in *V. volvacea* and *P. tuberculata* from the three administrative regions of central Côte d'Ivoire. Overall, the contents of each micromineral in the three regions were statistically different ($p < 0.05$). In *V. volvacea*, Fe, the content of which ranged from 10.15±0.06 mg/100 g of dry weight (N'Zi region) to 63.56±0.38 mg/100 g of dry matter (Gbêkê region) was the most represented of microminerals in this mushroom species from central Côte d'Ivoire. It is the same for *P. tuberculata* where Fe content ranged from 16.31±0.13mg/100 g of dry weight (N'Zi region) to 99.30±059 mg/100 g of dry matter (Gbêkê region). However, these Fe contents were lower than that reported in *V. volvacea* from Tanzania (426±2.4 mg/100 g of dry matter) (Mshandete & Cuff, 2007). Overall, these Fe contents were largely lower than those reported for wild mushrooms from Turkey (Türkekul *et al*., 2004); higher than those from China (Liu *et al*., 2012) and in the range of those reported by Gençcelep *et al*. (2009) in Turkey. These differences could be explained by the fact that the uptake of metal ions in mushrooms depend on mushroom species and their ecosystems (Türkekul *et al*., 2004; Colak *et al*., 2009). In regard to Mn, the levels were very low in the different samples (0.11 to 1.10 mg/100 g of dry matter), except in sample from *P. tuberculata* from Gbêkê (5.35 mg/100 g of dry matter). These values were generally lower than Mn content reported in the literature (Isildak *et al*., 2004; Adejumo & Awosanya., 2005; Gençcelep *et al*., 2009). Concerning Cu, its levels indicated in table 3 are overall lower than values for mushroom in the literature ranging from 100 to 300 mg/kg of dry weigh (Genccelep *et al*., 2009). With respect to Zn, mushrooms are well known as Zn accumulators (Isıloglu *et al*., 2001), but, the Zn levels were included in the range reported in literature indicated by Soylak *et al*. (2005) (33.5– 89.5 µg/g of dry weigh).

From table 4, it was observed that there were significant differences between levels of each macromineral in both mushrooms species for the three regions ($p < 0.05$). Additionally, the highest macromineral levels within samples of both species in the three administrative regions were K levels (ranging from 1227.45 to 1994.95 mg/100 g of dry matter for *V. volvacea* and from 720.78 to 878.11 mg/100 g of dry matter for *P. tuberculata*), followed by P levels (ranging from 43.16±0.02 to 354.83±0.21 mg/100 g of dry matter for *V. volvacea* and 66.50±0.04 to 258.16±0.15 mg/100 g of dry matter for *P. tuberculata*). Ayaz *et al*. (2011) have also reported high concentrations of K (21800- 9800 µg/g dry weigh) and P (2590-14000 µg/g dry weight in wild mushroom samples from Turkey. Ca, Na and Mg had relatively high contents within samples of *V. volvacea* and *P. tuberculata* from the three regions. Within samples of *V. volvacea*, for Ca and Mg, the highest contents were found in Gbêkê region (139.20 and 97.625mg/100 g of dry matter, respectively) whereas for Na, the highest content was noted in Bélier region (181.68 mg/100 g of dry matter). The same observation were noted for samples of *P. tuberculata* ; the highest contents of Ca and Mg were noted in Gbêkê region (144.18 and 71.50 mg/100 g of dry matter, respectively) whereas the highest content of Na was registered in Bélier region (222.43 mg/100 g of dry matter). The relatively higher values of these macrominerals within wild edible mushrooms were reported by several authors in many countries (ÇaglarIrmak *et al*., 2002; Mshandete & Cuff, 2007; Akyüz & Kirbağ, 2010; Mallikarjuna *et al*., 2013).

**Table 3: Micromineral concentrations (mg/100 g on dry weight basis) in *V. volvacea* and *P. tuberculata* from central Côte d'Ivoire**

| Species | Regions | Minerals | | | |
|---|---|---|---|---|---|
| | | Zn | Cu | Fe | Mn |
| *Volvariella volvacea* | Gbêkê | 7.14±1.13$^{b}$ | 5.85±0.26$^{b}$ | 63.56±0.38$^{c}$ | 1.10±0.98$^{b}$ |
| | Bélier | 7.12±2.07$^{b}$ | 6.48±0.21$^{c}$ | 32.45±0.19$^{b}$ | 0.98±0.18$^{b}$ |
| | N'zi | 5.22±1.20a | 3.23±0.33$^{a}$ | 10.15±0.06$^{a}$ | 0.31±0.65$^{a}$ |
| *Psathyrella tuberculata* | Gbêkê | 11.32±1.55$^{c}$ | 2.26±0.18$^{b}$ | 99.30±059$^{c}$ | 5.35±0.20$^{b}$ |
| | Bélier | 3.87±0.84$^{a}$ | 1.11±0.07$^{a}$ | 31.78±0.19$^{b}$ | 0.11±0.39$^{a}$ |
| | N' zi | 5.65±0.65$^{b}$ | 2.30±0.02$^{b}$ | 16.31±0.13$^{a}$ | 0.85±0.42$^{a}$ |

In each column different letters mean significant differences ($p < 0.05$).

**Table 4: Macromineral concentrations (mg/100 g on dry weight basis) in V. volvacea and P. tuberculata from central Côte d'Ivoire**

| Species | Regions | Minerals | | | | |
|---|---|---|---|---|---|---|
| | | Mg | Na | K | P | Ca |
| *Volvariella volvacea* | Gbêkê | 97.625±0.58$^{c}$ | 58.21±0.37$^{c}$ | 1994,95±0.41$^{c}$ | 354,83±0.21$^{c}$ | 139,20±0.63$^{b}$ |
| | Bélier | 20.29±0.12$^{a}$ | 181.68±1.11$^{b}$ | 1566,28±0.10$^{b}$ | 344,83±0.20$^{b}$ | 49,35±1.03$^{a}$ |
| | N'zi | 24.89±0.15$^{b}$ | 6.85±0.04$^{a}$ | 1227,45±0.32$^{a}$ | 43,16±0.02$^{a}$ | 30,22±0.09$^{a}$ |
| *Psathyrella tuberculata* | Gbêkê | 71.50±0.43$^{c}$ | 83.85±0.52b | 878.11±1.20b | 258.16±0.15c | 144.18±1.86c |
| | Bélier | 66.50±0.40$^{b}$ | 222.43±1.35c | 821.61±0.15b | 139.83±0.08b | 82.84±0.93b |
| | N'zi | 9.45±0.05$^{a}$ | 26.83±0.18a | 720.78±0.15a | 66.50±0.04a | 23.39±0.53a |

In each column different letters mean significant differences ($p < 0.05$).

**Table 5: Lead and Cadmium concentrations (mg/100 g on dry weight basis in *V. volvacea* and *P. tuberculata* from central Côte d'Ivoire**

| Species | Regions | Minerals | |
|---|---|---|---|
| | | Pb | Cd |
| *Volvariella volvacea* | Gbêkê | 0.65±0.20$^{b}$ | 0.04±0.01$^{c}$ |
| | Bélier | 0.81±0.32$^{c}$ | 0.01±0.00$^{a}$ |
| | N'zi | 0.48±0.56 $^{a}$ | 0.03±0.00$^{b}$ |
| *Psathyrella tuberculata* | Gbêkê | 0.91±0.16$^{c}$ | 0.06±0.01$^{b}$ |
| | Bélier | 0.41±0.23$^{a}$ | 0.02±0.00$^{a}$ |
| | N'zi | 0.59±0.23$^{b}$ | 0.20±0.02$^{c}$ |

In each column different letters mean significant differences ($p < 0.05$).

Table 5 shows the levels of two toxic minerals (Pb and Cd) analyzed in this work. From the results, it was noted that there were significant differences between levels of Pb and Cd within both mushrooms species for the three regions ($p < 0.05$). However, concentrations of these toxic minerals were overall low within mushrooms samples. For *V. volvacea*, the highest concentration of Pb was found within sample of Bélier region (0.81±0.03 mg/100 g of dry matter) whereas N'Zi region displayed the lowest level (0.48±0.05 mg/100 g of dry matter). In contrast, Cd level was the lowest in Bélier region (0.01±0.00 mg/100 g of dry matter) and the highest in Gbêkê region (0.04±0.01 mg/100 g of dry matter). In regard to *P. tuberculata*, the highest level of Pb was attributed to sample of Gbêkê region (0.91±0.01 mg/100 g of dry matter) whereas the lowest level was found in that of Bélier region (0.41±0.02 mg/100 g of dry matter). Cd displayed concentration of 0.20±0.02 mg/100 g of dry matter in *P. tuberculata* sample of NZi region; its lower level was found in sample of Bélier region (0.02±0.00 mg/100 g of dry matter). Mirończuk-Chodakowska *et al*. (2013) reported Pb and Cd levels ranging from 0.14 to 2.61 µg/g dry mass and from 0.10 to 10.20 µg/g dry mass, respectively within samples wild mushrooms from Poland. Others authors such as Şen *et al*. (2012) indicated levels of Cd in mushroom samples from Turkey ranging from 0.11 to 2.58 mg $kg^{-1}$. According to Sarikurkcu et al. (2011), Pb concentration in mushrooms from unpolluted areas may vary between < 0.5 µg/g and 5 µg/g dry weigh. 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).

## Amino acid Profile

In order to evaluate the quality of proteins within our samples of mushroom, it appears also fundamental to determine their amino acid profile.

Table 6 shows the amino acids found in each sample with their levels. Of the twenty amino acids biologically active for humans, fifteen were tested in our samples (lysine, histidine, arginine, aspartic acid, threonine, proline, glycine, alanine, valine, methionine, isoleucine, leucine, tyrosine and phenylalanine, tryptophan). In general, there appears to be significant differences between mushroom samples for amino acid profiles of each species and for each region. This could be attributed to some factors such as growth stages and harvesting times (Woldegiorgis *et al*., 2015). The most abundant ones were aspartic acid (concentrations ranging from 5.85±0.07 to 9.95±0.35 g/100g of proteins in *V. volvacea* and from 6.30±0.14 to 8.30±0.03 g/100 g of proteins in *P. tuberculata*) and leucine (concentrations ranging from 4.35±0.35 to 6.75±0.07 g/100g of proteins in *V. volvacea* and from 4.15±0.07 to 7.65±0.21g/100 g of proteins in *P. tuberculata*) in all samples in the three regions. Díez & Alvarez (2001) and Mattila *et al.* (2002) reported that aspartic acid was detected with fairly high level in wild mushrooms and cultivated mushrooms from Spain and Finland, respectively. As to Agrahar-Murugkar & Subbulakshmi (2005), they found leucine with high content in wild mushrooms from India. However lysine was available with high levels within samples of *V. volvacea* from the three regions and within samples of *P. tuberculata* from two regions (Bélier and N'Zi). In contrast, its concentration for sample of this mushroom from Gbêkê region was low. Tryptophan (with concentrations ranging from 0.75±0.07 to 1.25±0.07 g/100g of proteins in *V. volvacea* and from 1.55±0.07 to 3.05±0.21 g/100g of proteins in *P. tuberculata*), arginine (with statistically identical concentrations in *V. volvacea* around 1.4 g/100g of proteins and concentration ranging from 1.55±0.07 to 3.00±0.14 g/100g of proteins in *P. tuberculata*) and methionine (with concentrations ranging from 1.75±0.07 to 4.1±0.14g/100g of proteins in *V. volvacea* and from 0.8±0.14 to 3.25±0.35

**Table 6:** Contents of amino acid (g/100 g protein dry weight basis) in in *V. volvaceae* and *P. tuberculata* from central Côte d'Ivoire

| Amino acids contents (g/100g of protein) | *Volvariella volvacea* | | | *Psathyrella tuberculata* | | |
|---|---|---|---|---|---|---|
| | Gbêkê | Bélier | N'zi | Gbêkê | Bélier | N'zi |
| Leucine* | 6.75±0.07[c] | 4.35±0.35[a] | 5.35±0.07[b] | 7.65±0.21[c] | 4.15±0.07[a] | 5.00±0.28[b] |
| Isoleucine* | 3.40±0.28[a] | 5.00±0.14[b] | 4.70±0.56[b] | 4.15±0.07[a] | 5.60±0.14[b] | 5.15±0.21[b] |
| Valine* | 5.50±0.28[b] | 3.5±0.28[a] | 3.19±0.28[a] | 5.50±0.28[a] | 6.35±0.21[b] | 6.80±0.14[b] |
| Tryptophan* | 1.25±0.07[b] | 1.2±0.14[b] | 0.75±0.07[a] | 2.15±0.35[b] | 1.55±0.07[a] | 3.05±0.21[c] |
| Lysine* | 8.15±0.07[b] | 8.5±0.28[b] | 7.40±0.14[a] | 3.65±0.07[a] | 7.90±0.14[c] | 6.30±0.56[b] |
| Threonine* | 4.70±0.28[a] | 5.4±0.28[b] | 5.95±0.21[b] | 5.25±0.21[b] | 5.00±014[ab] | 4.75±0.07[a] |
| Phenylalanine* | 4.90±0.28[b] | 2.65±0.07[a] | 3.55±0.49[a] | 4.7±0.14[a] | 5.90±0.42[b] | 4.10±0.28[a] |
| Methionine* | 1.75±0.07[a] | 2.9±0.14[b] | 4.10±0.14[c] | 0.80±0.14[a] | 2.90±0.14[b] | 3.25±0.35[b] |
| Histidine* | 3.35±0.35[b] | 1.75±0.07[a] | 1.85±0.21[a] | 2.95±0.07[a] | 3.15±0.07[a] | 4.4±0.28[b] |
| Arginine | 1.45±0.35[a] | 1.45±0.07[a] | 1.30±0.14[a] | 3.00±0.14[c] | 2.05±0.07[b] | 1.55±0.07[a] |
| Alanine | 7.25±0.49[b] | 4.65±0.21[a] | 3.90±0.14a | 5.15±0.07[b] | 3.50±0.28[a] | 4.60±0.14[ab] |
| Proline | 5.1±0.14[b] | 4.35±0.35[ab] | 3.75±0.21[a] | 5.65±0.21[c] | 5.15±0.07[b] | 3.00±0.14[a] |
| aspartic acid | 5.85±0.07[a] | 9.95±0.35[c] | 6.75±0.07[b] | 8.3±0.03[c] | 7.95±0.07[b] | 6.30±0.14[a] |
| Glycine | 4.2±0.14[b] | 5.30±0,32[c] | 2.25±0.07[a] | 3.55±0.07[b] | 3.65±0.21[b] | 1.70±0.14[a] |
| Tyrosine | 3.35±0.21[a] | 4.10±0.14[b] | 4.30±0.28[b] | 5.40±0.14[c] | 4.45±0.21[b] | 2.75±0.21[a] |

In each line different letters mean significant differences ($p < 0.05$). *Essential amino acid

g/100g of proteins in *P. tuberculata*) displayed the lowest levels within these mushroom samples. Particularly for methionine, it was reported that it constitute one of limiting amino acids within the mushrooms because mushrooms are recognized to be deficient in sulphur-containing amino acid (Senatore *et al.*, 1988; León-Guzmán *et al.*, 1997; Longvah and Deosthale, 1998; Sumathy *et al.*, 2015). In term of essential amino acids, results presented in table showed that most of them (lysine, leucine, valine, isoleucine, threonine and phenylalanine) displayed significant contents in all samples investigated in this work. However the three others (tryptophan, methionine and histidine) were detected with low contents in the whole of the samples. Our findings were in agreement with the previous reports in the literature (Manzi *et al.*, 1999; Mdachi *et al.*, 2004; Sumathy *et al.*, 2015) who indicated that edible mushroom proteins contain most of the essential amino acids. Therefore proteins of our mushrooms samples could be termed as quality proteins.

## 4. CONCLUSIONS

Results obtained in the present study revealed clearly that both highly consumed mushrooms (*V. volvacea* and *P. tuberculata*) from central Côte d'Ivoire constitute good sources of carbohydrates, proteins, essential amino acids, fibers and mineral (ash). But their fat contents were low. Better, Apart from a few differences between proximate and mineral composition, samples of both mushrooms from the three administrative regions of central Côte d'Ivoire showed great potentials in preventing protein and mineral deficiency often prevailing in developing countries including Côte d'Ivoire. More interesting, levels of toxic minerals as lead and cadmium in these mushroom samples were very low. Ultimately, findings of this report could constitute a major contribution for food safety in Côte d'Ivoire.

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