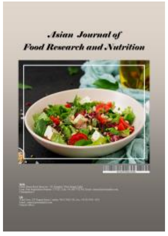

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Nutritional Potential of Two Species of Mushroom Edible by the Tem and Kabyè Peoples Living Along the Alédjo Wildlife Reserve: *P. tuber-regium* (Fr.) Fr and *C. platyphyllus* Heinem

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In tropical Africa, edible wild mushrooms are often collected and used by different peoples for both food and traditional medicine. In order to obtain information on the nutritional values of edible wild mushrooms in Togo, a study was carried out on the species *Cantharellus platyphyllus* and *Pleurotus tuber-regium* consumed by the Tem and Kabyè populations living in the Alédjo Wildlife Reserve. Samples of both species were subjected to biochemical analysis using the usual AOAC methods. The results showed that *C. platyphyllus* and *P. tuber-regium* are rich in macronutrients and essential

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minerals. The total carbohydrate, protein, fat and fibre contents were 67.86 ± 0.08 g, 11.86 ± 0.08 g, 3.19 ± 0.11 g and 3.5 ± 0.29 g per 100 g of dry matter respectively for *C. platyphyllus*. Mineral contents of 100 g of dry matter were also interesting, with 7667 ± 0.09 mg, 1216 ± 0.03 mg, 1067 ± 0.04 mg and 444.44 ± 0.32 mg respectively for K, P, Mg and Ca. The same applies to the species *P. tuber-regium* for which the contents were 65.96 ± 0.91 g, 10.59 ± 0.33 g, 2.79 ± 0.15 g and 5.92 ± 0.30 g per 100 g of dry matter respectively for total carbohydrates, proteins, fats and fibres on the one hand, and on the other hand, 1011 ± 0.01 mg, 893.3 ± 0.42 mg, 66.67 ± 0.39 mg and 440.44 ± 0.9 mg per 100 g of dry matter for K, P, Mg and Ca respectively. In conjunction with their organic matter content, the mushrooms analysed showed significant energy values, with 333.6 ± 0.05 Kcal for *C. platyphyllus* and 308.3 ± 4.44 Kcal for *P. tuber-regium*. These mushrooms can therefore be considered as an endogenous source of food and nutritional security.

Keywords: Pleurotus tuber-regium; Cantharellus platyphyllus; Nutritional potential; aledjo wildlife reserve; Togo.

1. INTRODUCTION

In sub-Saharan Africa, mushrooms are used as food by many people. As a result, they contribute to the fight against famine, malnutrition and poverty [1,2,3]. "In tropical Africa, these mushrooms are used as food and are highly valued, and in times of famine they can be used as a substitute for meat or fish" [4,5]. In other regions, edible mushrooms are sold at local markets, sometimes door-to-door, or in exchange for cassava flour or cooking salt [1,6]. Nutritional analyses have also shown that edible mushrooms are very rich in protein, digestible carbohydrates, dietary fibre and minerals essential for human nutrition, and also have a low fat content [7,8,9]. They are the only natural non-animal food source of vitamin D [10,11]. Mushrooms therefore have a nutritional value close to that of milk and can be used as an excellent food to combat malnutrition, especially in children [12]. Other studies have also reported that mushrooms contain certain bioactive compounds such as non-starch polysaccharides and flavonoids, known for their anti-cancer and anti-oxidant activities [13]. "However, the nutritional value of edible mushrooms in relation to their nutrient content depends on the mushroom in question. All mushrooms are essentially composed of 82 to 92% water, with the remainder consisting of minerals, carbohydrates, lecithin, proteins and vitamins, making them a complete food" [14]. However, while studies on the dietary and medicinal value of edible mushrooms are fairly well developed in some countries, efforts are still needed in others [4,5], such as Togo. In Togo, while Kamou et al. [14,15] looked at the diversity and socio-economic aspects of edible mushrooms consumed by the Kotokoli, Bassar and Kabyè populations living in the Fazao Malfakassa National Park, only Nadjombe et al., (2022) looked at the nutritional potential of Russules used by the Tem and Kabyè populations living in the Alédjo Wildlife Reserve. However, there are species that are still prized by these two sociolinguistic groups. These include *Pleurotus tuber-regium* and *Cantharellus platyphyllus*, which deserve to be investigated in order to contribute to their development. It is in this context that the present study is being carried out, with the aim of contributing to the development of Togo's edible mushrooms. It is therefore a contribution to food and nutritional security through endogenous avenues for a healthy and sustainable diet.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in the Alédjo wildlife reserve (Fig. 1). It is located in Togo's ecological zone II [16], straddling the Assoli and Tchaoudjo Prefectures, more specifically in the cantons of Alédjo-Kadara and Aléhéridè. This reserve is located on the Monts Togo fault, covers an area of 765 ha and lies between latitudes 9°11 and 9°17 north and longitudes 1° and 1°24 east [17]. The reserve is bordered to the north by the villages of Agaradè, Dikorodè, Alédjo-Ba and Kpéwa, to the east by the Alédjo fault bypass road, to the west by the Sokodé-Kara asphalt road and to the south by the village of Aléhéridè [18]. It has a humid Sudano-Guinean climate, with a unimodal regime. There are four (04) types of plant formations: open forests, dense dry forests, gallery forests and savannahs. Open forests are made up of species such as: *Isoberlinia* spp*, Uapaca togoensis* Pax, *Monotes kerstingii* Gilg, *Burkea africana* Hook and

Detarium microcarpum Willd. The dense dry forests are made up of species such as *Dialium guineense* Willd, *Anogeissus leiocarpus* Guill. & Perr, *Margaritaria dioscoidea* (Baill.) Webster, *Bequartiodendron oblanceolatum* (S. Moore) Heine & J. H. Hemsley. Forest galleries are characterised by *Berlinia grandiflora* (Vahl) Hutch. & Dalz, *Aubrevillea kerstingii* (Harms) Pellegr, *Pentadesma butyracea* Sabine, *Uapacca guineensis* Müll, *Dacryodes klaineana* (Pierre) H. J. Lam, *Khaya senegalensis* (Desr.) A.Juss *Afzelia africana* Sm and *Albizia zygia* Macbr. In addition to grasses such as *Loutetia* sp and *Loudesiopsis* sp, savannahs are made up of woody plant species especially : *Pterocarpus erinaceus* Poir, *Burkea africana* Hook, *Lannea acida* L., *Ficus populifolia* Vahl, *Pericopsis laxiflora* (Benth.) Meeuwen, *Crossopteryx febrifuga* (Afzel. ex G. Don) Benth, *Euphorbia poissonnii* Pax, *Terminalia macroptera* Guill. & Perr., *Terminalia laxiflora* Engl. and *Daniella oliveri* Hutch. & Dalziel.

2.2 Methods

2.2.1 Laboratory work

The specimens of edible mushrooms (*Pleurotus tuber-regium* and *Cantharellus platyphyllus*) were carefully selected, washed and rinsed in distilled water, then asepticised. They were then dried in an oven at 45°C for 5 days, then crushed using a laboratory mortar. The crushed products were oven-dried a second time for a further 5 days to ensure complete dehydration, then ground to a powder using a Moulinex laboratory brand "Sunbean". The resulting powders were stored at -4°C pending analysis.

2.2.2 Determining water content

The water content (Wc) have been determined after oven-drying the fresh sample (fw) until the sample mass (dw) have been stabilised :

$$\mathrm{Wc}\ (\%) = \frac{\mathrm{fw-dw}}{\mathrm{fw}} \mathrm{x}\ 100$$

where, fw = fresh weight ; dw = dry weight

2.2.3 Determining dietary fiber content

Dietary fiber content was determined using the WEENDE cellulose insoluble method [19], in accordance with French standard NF V 03-040. To 3g of sample weighed in a flask, were added 200 mL of a sulphuric acid solution (0.255 N); the whole was boiled for 30 min. "The acid solution was filtered and the residue obtained was taken up by 200 mL of a sodium hydroxide solution (0.313 N) and boiled for 30 min. The soda solution was filtered again and the residue obtained was dried, weighed ($\boldsymbol{P_1}$), calcined and then reweighed ($\boldsymbol{P_2}$) ". [19] The fiber content was then calculated according to the following formula :

$$\text{Crude fiber content}\ (\%) = \frac{(\mathrm{P_1} - \mathrm{P_2})}{\mathrm{P_0}}\ \mathrm{x}\ 100$$

where, $\mathrm{P_0}$ is the weight of the sample taken.

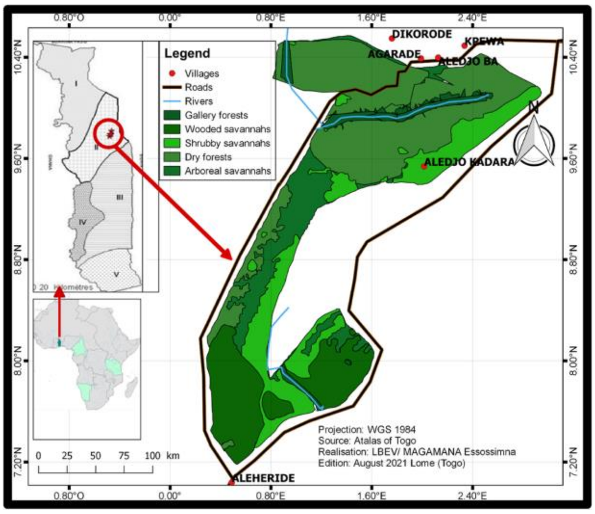

Fig. 1. Location of the Alédjo Wildlife Reserve

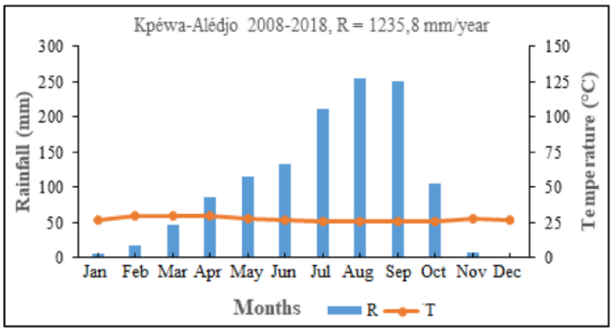

Fig. 2. Umbrothermal curve

2.2.4 Determination of crude protein content

"Proteins were determined by the Kjeldahl method adapted to the feed. Nitrogen mineralisation by decomposition of the organic matter in the sample using concentrated sulphuric acid results in the formation of ammonium sulphate. This is then decomposed by soda ash, releasing ammonia, which is distilled, collected in a known quantity of titrated acid and measured using a standard solution of base. The nitrogen content obtained is converted into a percentage of crude protein by multiplying the result by a factor of 6.25". [19].

2.2.5 Determination of fat content

"The total fat content was determined in accordance with AFNOR standard NFV03-713" [20]. "The operation involved extracting the fat from 1 g of test sample with hexane in a soxhlet extractor. The hexane was then evaporated on a rotary evaporator and the capsule was dried in an oven at 103◦C and constant weight" [20]. The difference in weight gave the total lipid content "L" in g per 100 g of product and expressed by the following formula :

$$\mathrm{L} = \frac{\mathrm{W}}{\mathrm{Ts}} \mathrm{~x~} 100\,;$$

where W is weight in grams (g) of lipid residue, Ts is Test sample in grams (g).

2.2.6 Ash content

The total mineral content was determined from a 5 g test sample. The test sample was placed in a porcelain crucible, which was first heated to 550°C, then cooled in a desiccator and tared. The crucible is then gradually heated to 550°C in a furnace to ensure slow carbonisation without ignition. The temperature is maintained at 550°C for 6 hours, producing white ash. The ash content (Ac) was calculated as follows :

$$\mathrm{Ac}\ (\%) = \frac{(\mathrm{mi} - \mathrm{mf})}{\mathrm{me}} \mathrm{~x~} 100$$

where, $mi\ is$ mass of the crucible calcined in a vacuum, $mf is$ mass of calcined crucible + ash, $me\ is$ mass of the test socket.

2.2.7 Determination of total carbohydrate content

The carbohydrate content has been deduced by differential calculation :

$$\text{Carbohydrate conte} = \mathrm{D_m} - (\mathrm{Pw} + \mathrm{Fw} + \mathrm{Aw})$$

where, Pw is Protein weight ; Fw is Fat weight ; D_m is Dry stuff, $Aw\ is$ Ash weight.

2.2.8 Determination of energy value

"The overall energy value was determined by adding the metabolizable energies of the carbohydrate, fat and protein components. These energies were calculated by multiplying the protein, fat and carbohydrate contents by the Atwater coefficients" [21]. The overall energy value (E), expressed in kilocalories (Kcal) per 100 g of dry weight of the samples, was therefore calculated from the following relationship.

$$\mathrm{E(Kcal)} = (\mathrm{G~x~4}) + (\mathrm{L~x~9}) + (\mathrm{P~x~4})$$

$\boldsymbol{G, L\ et\ P}$: Carbohydrate, lipid and protein content per 100g of dry matter.

2.2.9 Mineral determination

"The determination of minerals has been carried out according to the AOAC methods" [22]. "After mineralisation by wet destruction of the organic matter with the combined action of nitric and sulphuric acids, the mineral contents have been determined by flame atomic absorption spectrophotometry. Phosphorus has been determined by colorimetry with a UV–visible spectrophotometer. Total phosphorus has been first transformed into a yellow phospho-vanado-molybdate complex measured at 430 nm" as described by Pauwels et al. [21]. The various concentrations were read using an atomic absorption spectrophotometer under the experimental conditions summarised in Table 1.

Table 1. Summary of experimental conditions for mineral analysis

Analysed components	Wave length (nm)	Slot width (nm)	Type of flame
Potassium	766.5	0.5	Air-Acetylene
Calcium	422.7	0.5	Air-Acetylene
Sodium	589.0	0.2	Air-Acetylene
Magnésium	285.2	0.5	Air-Acetylene

2.2.10 Statistical analysis

All results have been analysed using Graph Pad Prism version 8.00 software. Results were expressed as means with standard error of the mean (SEM). The significance level was set at $p < 0.05$. All contents were expressed in terms of weight per 100 g of dry matter (Dm).

3. RESULTS AND DISCUSSION

3.1 Macronutrient Content and Energy Value

The macronutrient contents, expressed in g/100 g of dry matter for the macronutrients and in Kcal for the energy value, are summarised in Table 2. Both species of edible mushroom contain interesting levels of organic matter. However, the water content was also determined as a percentage (%) of fresh matter.

3.1.1 Water content

For every 100 g of fresh sample of *Cantharellus platyphyllus* and *Pleurotus tuber-regium* analysed, the water content was relatively high at 93.62 ± 0.22% for *Cantharellus platyphyllus* and 91.39 ± 0.38% for *Pleurotus tuber-regium* (Table 2). These results were similar to those for fruit and vegetables (80 - 90%) but much higher than those for cereals (10 - 20%) and fish, meat and animal flesh (60 - 75%) [23]. These levels are also similar to those reported by Nadjombe et al. [24] with fifteen (15) edible Russules from the same environment (91.51 ± 0.38%) and with the results of Silue [25] with the fungus *Termitomyces tetanicus* from the Adzope region in Côte d'Ivoire, whose water content was evaluated at 90.01 ± 01.11%, and with those of Zoho et al*.* [26] with six species of edible mushrooms from Côte d'Ivoire whose water content varied from 89.62 ± 1.42% to 92.05 ± 0.55%.

3.1.2 Dietary fiber content

Pour 100 grammes de matière sèche analysée de chacune de ces deux espèces de champignons comestibles, *Pleurotus tuber-regium* a montré une teneur en fibres de 5,92 ± 0,30% plus intéressante que celle de *Cantharellus platyphyllus* avec 3,5 ± 0,29% (Tableau 2). Comparativement à celles obtenue par Silue [25] avec le chapeau (24,01 ± 0,50%) et le pied (26,45 ± 1,13 %) de *Termitomyces tetanicus*, les teneurs en fibres alimentaires de cette étude sont faibles surtout avec *Cantharellus platyphyllus*. The average dietary fibre content also remains low compared to that reported for *Russula delica* (19.78%), *Cantharellus platyphyllus* (l8.72%) and *Pleurotus subsericatus* (l6.50%) in the work of Kouassi et al. [27]. However, the contents of the present study are similar to those obtained by Nadjombe et al. [24] with fifteen (15) edible Russules from the Alédjo Wildlife Reserve (5.77 ± 0.30%). The variation in fibre content depends on the collection area and the type of substrate. However, the presence of these dietary fibres in the two edible mushroom species analysed constitutes an added value in relation to their nutritional potential. Fibre is generally recommended to prevent atherosclerosis. A diet rich in fibre is beneficial in preventing constipation and intestinal diseases such as appendicitis and cancer [28]. Thanks to their dietary fibre content, edible mushrooms also help to control the risk of cardiovascular disease by reducing cholesterol levels [29] and regulating blood sugar levels [30].

3.1.3 Protein content

For 100 grams of dry matter, the average protein content was 11.86 ± 0.08% for *Cantharellus platyphyllus* and 10.59 ± 0.33% for *Pleurotus tuber-regium* (Table 2). These values were close to the average content obtained by Kouame et al*.* [31] with three edible wild mushroom species commonly found in the Haut-Sassandra region of Côte d'Ivoire (15.86 ± 0.22%). However, the same protein content was low compared with that reported by Ayodelea and Okhuoyab [32] and Sahore et al. [33] with *Volvariella volvacea* and *Psathyrella atroumbonata* (17 - 30.40%) and by Silue [25] who found a content of 38.68 ± 0.52% with the cap of *Termitomyces tetanicus* and 29.68 ± 1.10% with the foot of the same species of fungus from the Adzope region of Côte d'Ivoire. The protein content in the present study have been also low compared with those obtained by Tounkara et al. [34] with *Pleurotus florida* (8.02 ± 0.52%) in Senegal. This difference could be due not only to ecological factors (temperature, soil pH, etc.), but also to the type of substrate on which these fungi grow [35]. Nevertheless, the two mushrooms have interesting proportions in terms of protein contribution to the RDA. Per 100 grams of dry matter, Cantharellus platyphyllus contributed 21.18% and Pleurotus tuber-regium 18.91% (Table 4). In both cases, the contribution to the RDA in protein is low. These data are lower than those reported by Silue [25]. For this author, the contribution could be as high as 69.07%, thus confirming that edible wild mushrooms are a significant source of plant protein [36,37,38]. This is why mushrooms are often used as a substitute for meat products. However, their protein content is still lower than that of meat. This does not pose a problem for the use of mushrooms as food supplements or as substitutes for fish and meat products in rural areas. Vegans could also consume edible wild mushrooms to meet their protein requirements [36,38]. The significant presence of protein in mushrooms is an excellent indicator of their nutritional quality [24] and also provides evidence that edible mushrooms are a significant source of protein compared with other non-wood forest products [39,40].

3.1.4 Fat content

Per 100 grams of dry matter, *Pleurotus tuber-regium* and *Cantharellus platyphyllus* contain 2.79 ± 0.15% and 3.19 ± 0.11% fat respectively (Table 2). The fat contribution to the RDA of each of these mushroom species is 2.88% in men and 6.34% in women for the species *Pleurotus tuber-regium* and 3.29% in men and 7.25% in women for the species *Cantharellus platyphyllus* (Table 4). These lipid contents corroborate those obtained by Johnsy et al, [41] with *L. subsericatus* (03.50%) and by Kouassi et al. [27] with *Cantharellus platyphyllus* (02.39%). However, the same contents were low compared to those reported by Kouame et al. [31] on three mushroom species (*Termitomyces letestui*, *Volvariella volvacea* and *Psathyrella tuberculata*) whose average fat content was 4.00 ± 0.76%. These lipid contents, albeit low, are comparable to those reported with lean meats such as African chickens and turkeys. The low lipid content therefore suggests that these wild mushroom species can be eaten by people with heart problems or who are overweight. This confirms that edible wild mushrooms may reduce the risk of cardiovascular disease. Thanks to their low fat content, the two species of mushroom can help to enrich the diets of vulnerable populations in rural areas or those suffering from malnutrition [42].

In summary, the mineral, protein, carbohydrate and lipid contents of the two species of wild edible mushrooms confirm that the mushrooms studied have an excellent nutritional value, comparable to that of milk, soya and beans [12]. Indeed, previous studies support the view that the proteins contained in mushrooms are an interesting source of essential amino acids for good health [43,44]. Edible mushrooms could therefore be an important source of protein for children in developing countries such as Togo.

3.1.5 Ash content

The average mineral content, *i.e*. total ash, was relatively high for both species with 17.09 ± 0.05% for *Cantharellus platyphyllus* and 20.64 ± 0.81% for *Pleurotus* tuber-regium (Table 2). These average contents are similar to those reported by Nadjombe et al. [24] with fifteen (15) edible Russules from the same harvesting area and to those of Kouame et al, [31] with three (03) species of edible wild mushrooms commonly found in the Haut-Sassandra region of Côte d'Ivoire (20.59 ± 6.77%). However, these same ash contents are much higher than those reported by Barros et al. [45] with *Amanita silvaticus* (16.48%) and *Amanaita silicol* (14.93%). They are also higher than those reported by Kouassi et al. [27] with *Lactarius subsericatus* (8.61%) and *Cantharellus platyphyllus* (10.04%), and higher than those reported by Kumar et al. [46] with *Cantharellus cibarius* (7.78%) and those reported by Agrahar-Murugkar and Subbulakshmi [36] with *Lactarius quieticolor* (6.6%). This indicates that the mineral constitution of mushrooms varies according to the harvesting environment and often also according to the age of the species analysed.

3.1.6 Carbohydrate content

The average total carbohydrate content was 65.96 ± 0.91% of dry matter for *Pleurotus tuber-regium* and 67.86 ± 0.08% for *Cantharellus platyphyllus* (Table 2). However, the average digestible carbohydrate content was 64.36 ± 0.37% for *Cantharellus platyphyllus* and 60.18 ± 1.14% for *Pleurotus tuber-regium* with very interesting contributions to the Recommended Daily Allowance in carbohydrates. Indeed, per 100 grams of dry matter, the contribution to the RDA assessed was 49.51% for *Cantharellus platyphyllus* and 46.29% for *Pleurotus tuber-regium* (Table 4). However, the average total carbohydrate contents reported in this study were higher than those obtained by Kouame et al. [31] with three (03) species of edible fungi (*Termitomyces letestui*, *Volvariella volvacea* and *Psathyrella tuberculata*) with a value of 45.45 ± 7.64 %. These mean total carbohydrate contents were also high compared with those reported by Silue [25] for the cap (48.37 ± 1.71%) and foot

(58.55 ± 1.41%) of the *Termitomyces tetanicus* mushroom species. However, the digestible carbohydrate content in this study was similar to that reported by Zoho et al. [26] for the edible mushroom species *Hirneola auricula-judae* (57.60 ± 0.65% dry matter) and also close to that obtained by Nadjombe et al. [24] for fifteen (15) edible species of the genus Russula from the Alédjo Wildlife Reserve, where the content was 60.18 ± 1.14%. As in the case of minerals, these variations can be explained by ecological and edaphic factors, but also by the availability and mineral content of the substrate, the absorption capacity of mushroom mycelia, the age of the mushrooms and the environment [35]. Wild edible mushrooms are therefore an interesting source of carbohydrates and make a significant contribution to the Recommended Daily Allowance for carbohydrates. These carbohydrate levels are also evidence that edible mushrooms are a source of energy [40].

3.1.7 Metabolizable energy

The mushrooms analysed can also be considered as energy foods. In this study, for 100 grams of dry matter, the energy value was 333.6 ± 0.05 Kcal for *Cantharellus platyphyllus* and 308.3 ± 4.44 for *Pleurotus tuber-regium* (Table 2). In particular, mushrooms contribute 13.34/16.68% of the RDA in metabolizable energy for men and women respectively for *Cantharellus platyphyllus* and 12.33/15.42% for men and women respectively for *Pleurotus tuber-regium* (Table 4). Given the low caloric value of mushrooms, they can be used to rebalance or supplement menus that are too rich in lipids or as part of low-calorie diets [47].

3.2 Mineral Content

The mineral content of the mushroom samples analysed is summarised in Table 3. The samples analysed belonged to two species: *Cantharellus platyphyllus* and *Pleurotus tuber-regium*. Overall, the results obtained showed that these two species are relatively rich in minerals. However, the content of *Cantharellus platyphyllus* was much higher than that of *Pleurotus tuber-regium*, particularly in terms of sodium and magnesium. The contributions of these two species to the recommended daily intake of minerals considered (Table 4) such as : sodium, magnesium**,** calcium**,** phosphorus**,** potassium are therefore not negligible.

3.2.1 Potassium content (K)

In terms of potassium content, both species have interesting levels. We note 1011 ± 0.01 mg/100g for *Pleurotus tuber-regium* and 7667 ± 0.09 mg/100g for *Cantharellus platyphyllus* (Table 3). The contribution of these species to the RDA is not negligible. *Pleurotus tuber-regium* contributed 21.51% and *Cantharellus platyphyllus* 163.13% (Table 4). In comparison, *Cantharellus platyphyllus* has a potassium content eight times higher than that of *Pleurotus tuber-regium*. These levels are much higher than those reported by Bastos et al. [48]. Potassium levels are thought to be responsible for the high ash levels observed in both mushroom species [49].

3.2.2 Calcium content (Ca)

The calcium content of the two mushroom species analysed was roughly equal. The calcium content for *Cantharellus platyphyllus* was 444.44 ± 0.32 mg/100g, compared with 440.44 ± 0.9 mg/100g for *Pleurotus tuber-regium* (Table 3). These two mushrooms thus contribute to the RDA with 49.38% for *Pleurotus tuber-regium* and 49.37% for *Cantharellus platyphyllus* (Table 4). These results are similar to those obtained by Nadjombe et al. [24] with fifteen (15) edible Russules from the same harvesting area. The consumption of edible wild mushrooms would therefore be beneficial for meals low in micronutrients thanks to the presence of minerals such as calcium [40]. This high calcium content is thought to be due to its absorption into the substrate by the growing mycelium and subsequent translocation to the sporophores [50].

3.2.3 Sodium content (Na)

The sodium content 2500 ± 57.74 mg/100g of *Cantharellus platyphyllus* is much higher than that of *Pleurotus tuber-regium* 288.9 ± 0.064 mg/100g (Table 3). Consumption of these mushroom species would therefore contribute to the recommended daily intake of Na. The daily contribution of *Pleurotus tuber-regium* was 19.26 mg/100g, much lower than that of *Cantharellus platyphyllus*, which contributed 166.67 mg/100g to the RDA (Table 4). Compared with *Pleurotus tuber-regium*, *Cantharellus platyphyllus* has interesting sodium levels. These levels were therefore significant and even comparable to those of certain vegetables and legumes, which are the main sources of sodium [51].

Table 2. Teneur en macronutriments (g/100 g of dw) et valeur énergétique (Kcal) de *C. platphyllus* et *P. tuber-regium*

Genres	Parameters	Total Carbohydrates (g/100 g of dw)	Digestibles Carbohydrates (g/100 g of dw)	Dietary Fibers (g/100 g of dw)	Fats (g/ 100 g of dw)	Proteins (g/ 100 g of dw)	Ashes (g/ 100 g of dw)	Water content (% de fw)	Energy for 100 g de dw (Kcal)
	Minimum	67.72	63.72	3	3	11.72	17	93.24	333.5
C. platyphyllus	Medium	67.86	64.36	3.5	3.19	11.86	17.09	93.62	333.6
	Maximum	68	65	4	3.38	12	17.18	94	333.7
	Mean ± ESM	67.86 ± 0.08	64.36 ± 0.37	3.5 ± 0.29	3.19 ± 0.11	11.86 ± 0.08	17.09 ± 0.05	93.62 ± 0.22	333.6 ± 0.05
	Minimum	61.1	52.6	4.37	1.95	8.51	16.47	89.17	269.6
P. tuber-regium	Medium	66.73	60.98	5.71	2.8	10.49	20.18	91.35	310.2
	Maximum	70.64	65.89	8.5	3.9	12.52	27.59	93.79	333.2
	Mean ± ESM	65.96 ± 0.91	60.18 ± 1.14	5.92 ± 0.30	2.79 ± 0.15	10.59 ± 0.33	20.64 ± 0.81	91.39 ± 0.38	308.3 ± 4.44

Values are expressed as mean ± ESM (n = 3); dw: dry weight; fw: fresh weight

Table 3. Mineral content in mg/100 g dry matter of two edible mushrooms *C. platyphyllus* and *P. tuber-regium*

Species	Paramètres	Na	K	Ca	Mg	P	Na/K	Ca/P
	Minimum	288.8	1011	442.9	66	892.6	_	_
P. tuber-regium	Medium	288.9	1011	444.4	66.67	893.3	_	_
	Maximum	289	1011	446	67.34	894	_	_
	Mean ± ESM	288.9 ± 0.064	1011 ± 0.01	440.44 ± 0.9	66.67 ± 0.39	893.3 ± 0.42	0.29 ± 0.01	0.5 ± 0.01
	Minimum	2400	7667	443.9	1067	1216	_	_
C. platyphyllus	Medium	2500	7667	444.4	1067	1216	_	_
	Maximum	2600	7667	445	1067	1216	_	_
	Mean ± ESM	2500 ± 57.74	7667 ± 0.09	444.44 ± 0.32	1067 ± 0.04	1216 ± 0.03	0.33 ± 0.02	0.37 ± 0.02

Values are expressed as mean ± ESM (n=3)

Table 4. Contribution (%) of organic matter (g) and mineral matter (mg) to the RDA of 100 g of dry matter from *C. platyphyllus* and *P. tuber-regium*

Species	Analysed components	RDA for an adult (Man/ Woman)	Quantity in 100 g de DW of fungi	Contribution of 100 g fungi dry weight to RDA (%)
	Digestibles Carbohydrates (g)	130[a]	60,18	46,29
	Fats (g)	44 – 97[a]	2,79	2,88 – 6,34
	Nitrogenous substances (g)	56[a]	10,59	18,91
P. tuber-regium	Metabolisable energy (Kcal)	2500/2000[a]	308,30	12,33/15,42
	Na (mg)	1500[b]	288,90	19,26
	K (mg)	4700[b]	1011,00	21,51
	Ca (mg)	900[bc]	444,44	49,38
	Mg (mg)	420[a]	66,67	15,87
	P (mg)	750[bc]	893,30	119,11
	Digestibles Carbohydrates (g)	130[a]	64,36	49,51
	Fats (g)	44 – 97[a]	3,19	3,29 – 7,25
	Nitrogenous substances (g)	56[a]	11,86	21,18
C. platyphyllus	Metabolisable energy (Kcal)	2500/2000[a]	333,60	13,34/16,68
	Na (mg)	1500[b]	2500	166,67
	K (mg)	4700[b]	7667,00	163,13
	Ca (mg)	900[bc]	444,40	49,37
	Mg (mg)	420[a]	1067,00	254,05
	P (mg)	750[bc]	1216,00	162,13

Values are expressed as mean ± ESM (n = 3; n = 45); DW: Dry weight; FW: Fresh weight.
NB : a Nutrient reference intakes for minerals, energy, carbohydrates, fibre, fats, fatty acids, cholesterol, proteins and amino acids (Trumbo et al*. 2002). b Recommended dietary allowance for a body weight of 70 kg (Frenot and Vierling 2002). c AFSSA (2009); RDA: Recommended Daily Allowance*

3.2.4 Magnesium content (Mg)

The *Cantharellus platyphyllus* mushroom species had a content of 1067 ± 0.04 mg/100g compared with 66.67 ± 0.39 mg/100g for the *Pleurotus tuber-regium* species (Table 2). These two species also made an interesting contribution to the RDA in magnesium: 15.87% for *Pleurotus tuber-regium* and 254.05% for *Cantharellus platyphyllus* (Table 4). *Cantharellus platyphyllus* has interesting magnesium levels compared to Pleurotus tuber-regium. The relatively high magnesium content of these wild edible mushrooms is also beneficial to the body. Magnesium is involved in the mechanism of chemical reactions in intestinal absorption and is an essential cofactor in metabolic enzymes [52].

3.2.5 Phosphorus (P) content

The phosphorus content was also determined for both species. The results were 1216 ± 0.03 mg/100g for *Cantharellus platyphyllus* and 893.3 ± 0.42 mg/100g for *Pleurotus tuber-regium* (Table III). *Pleurotus tuber-regium* contributed 119.11% to the RDA compared with 162.13% for *Cantharellus platyphyllus* (Table 4). These results are similar to those reported by Bastos et al. [48] for *Volvariella volvacea*. These high levels of phosphorus are thought to be responsible for the high ash levels observed in both species [49].

3.2.6 Na/K and Ca/P nutrient ratios

The mean Na/K ratio (Table 2) was 0.29 ± 0.01 (less than 1) for *Pleurotus tuber-regium* and 0.33 ± 0.02 (less than 1) for *Cantharellus platyphyllus* (Table 3). Consumption of edible mushrooms is therefore beneficial for promoting cardiovascular health [53]. This low concentration of sodium in relation to potassium implies that mushrooms should be used in an anti-hypertensive diet. However, the Ca/P ratio (Table II) was 0.5 ± 0.01

for *Pleurotus tuber-regium* and 0.37 ± 0.02 for *Cantharellus platyphyllus*, together with the high average phosphorus content of the samples analysed, indicates that these mushrooms are less rich in calcium than in phosphorus. The high phosphorus content of mushrooms means they can be used in diets aimed at building the skeleton [54] and balancing the body's pH by neutralising excess acids. Phosphorus is also essential in the process of storing energy in the body in the form of ATP. However, the calcium content of the samples analysed is not negligible. The phosphorus and calcium contained in edible wild mushrooms can therefore help in the formation of the skeleton, especially in children [53].

The mineral content of samples of wild edible mushrooms was therefore not negligible and was even comparable to that of certain vegetables and legumes, which are the main sources of supply [51]. The presence of these various minerals in the two species studied makes them a highly beneficial food for human health, due to their role in a number of physiological activities [55,56,57,58].

4. CONCLUSION

Biochemical analysis revealed that *Cantharellus platyphyllus* and *Pleurotus tuber-regium* are rich in total carbohydrates, digestible carbohydrates, protein, dietary fibre, ash and have a high water content. The low fat content suggests that these two species of edible mushroom can be eaten by people with heart problems. In addition to these macronutrients, essential minerals are also important. These include sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P), all of which are essential for the activity of hormones and especially enzymes in the body. In addition, this study shows that the contribution to the Recommended Daily Allowance is relatively high for all the minerals and macronutrients analysed. This contribution varied considerably between the two edible species studied. Mushrooms can make an effective contribution to combating deficiencies in these nutrients and therefore to food and nutritional safety.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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