VITAMIN CONTENT OF A WILD EDIBLE MUSHROOM: *TERMITOMYCES LETESTUI*

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Abstract
In order to determine their physicochemical characteristics with a view to their valorization, the wild edible mushrooms Termitomyces letestui from the department of Bouaflé were collected and analyzed.
To do this, the vitamin contents have been determined. The salient results obtained within the framework of this study reveal that the wild edible mushrooms Termitomyces letestui contain a wide variety of vitamins (B1, B2, B3, B9, B12, C and E) with respective contents of 0.80 ± 0.01 mg / 100g; 0.61 ± 0.30 mg / 100g; 5.73 ± 0.90 mg / 100g; 12.55 ± 0.41 µg / 100g; 0.75 ± 0.10 µg / 100g; 20.10 ± 1.35 mg / 100g and 0.26 ± 0.03 mg / 100g dry matter.
In view of the levels of vitamins contained in these wild edible mushrooms, it seems imperative to popularize them by this study.

KEYWORDS : Côte d'Ivoire, Mushrooms, *Termitomyces letestui*, Vitamins

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1. INTRODUCTION

Fungi are defined as eukaryotic organisms devoid of chlorophyll, which confines them to a completely heterotrophic lifestyle. The filamentous hypha, made up of a wall of polysaccharides, is the basic structure of the fungal organism (Bouchet *et al.*,1999).
Edible wild mushrooms are more valuable non-timber forest products with high potential for commercial expansion (Boa, 2006). They are widely exploited by rural africans mainly as food resources (Eyi-Ndong *et al.*,2001; Härkonen *et al.*, 2003, 2005; Yorou *et al.*, 2014) and / or as a source of income (Boa, 2006 ; Koné *et al.*, 2013) thus contributing to the substantial reduction of rural poverty.
Formerly considered low-nutritional value foods, edible mushrooms are of particular interest today. To this end, local populations consider edible mushrooms as a "healthy" food and do not hesitate to include them in a diet aimed at good cardiovascular health (Pedneault, 2007).
In Côte d'Ivoire, several species of fungi have been listed, among which nine (9) are edible. These species mainly belong to the genera Termitomyces, Lentinus, Psathyrella and Volvariella. Although very popular with people, these mushrooms have so far been little studied. Most of the work on these fungi is limited to the descriptive aspect concerning form and identification (Avit *et al.*, 1999).
In Côte d'Ivoire, many varieties of mushrooms are consumed by people. Among these varieties of fungi is *Termitomyces letestui*, which is mainly found in the departments of Tiassalé and Bouaflé.
The seasonality in the appearance of these mushrooms is a factor limiting their availability. The results of the physicochemical characterization of wild edible fungi Termitomyces letestui could allow a better understanding of their nutritional value and, in turn, allow their development.
It is with this in mind that the present study was initiated. Its objective is to assess the vitamin contents of wild edible mushrooms *Termitomyces letestui* with a view to their promotion in the Ivorian diet.

2. MATERIALS AND METHODS

Study material

The biological material used in this study consists of wild edible fungi *Termitomyces letestui***(Figure 1).** These mushrooms were collected from their natural habitat in the mesophilic forests of the Marahoué region of central Côte d'Ivoire (Bouaflé).The systematic identification and authentication of mushrooms were carried out at the National Floristic Center of Felix Houphouët Boigny University (Abidjan, Côte d'Ivoire).

Figure 1: Photograph of the wild fungus *Termitomyces letestui*

Methods

Preparation of mushroom flour

The harvested mushrooms were first sorted. Then they were rinsed with distilled water twice. Finally a mass of 500g was weighed.

After spreading on aluminum foil at room temperature for 20 min, then dried in the MEMMERT brand ventilated oven at 45 ° C for 2 days. After drying, the mushrooms were ground using a Mill IKA mill (Germany / Deutschland). The ground materials obtained were sieved using a 250 µm mesh sieve. After sieving, the flours were packed in labeled glass bottles, previously dried in an oven at 45 ° C and hermetically sealed. These flasks of flour were stored in a desiccator at 25 ° C for further analysis.

Determination of vitamin contents

Vitamin E

The determination of the vitamin E or tocopherol content of the mushrooms was carried out by high performance liquid chromatography (HPLC) according to the international standard ISO (2000). This determination is carried out in two stages: the extraction of the unsaponifiable fraction then the quantification.

• Extraction of the unsaponifiable fraction

Ten (10) g of the sample is dissolved in 150 mL of 96 ° GL ethanol. Then 0.1 g of hydroquinone is added and the flask is brought to a water bath for five (5) min. The saponification is then carried out by adding 25 ml of 50% potassium hydroxide (w / v) for 25 min at boiling point under reflux using an air cooler.

The flask is cooled and the contents are introduced into a 500 ml separating funnel. To the contents of the separating funnel are added 25 mL of ethanol and then 100 mL of petroleum ether.

The bulb is then closed and shaken for 2 min and then left to stand until the phases are clearly separated. The aqueous phase is collected in a second ampoule and washed with 50 mL of petroleum ether. All of the ethereal phases are collected in an ampoule and washed with distilled water until neutralization of the alkali in the presence of phenophthalein.

The ethereal phase is collected and evaporated using a rotary evaporator of the HEIDOLPH brand. The evaporation residue is collected in 25 mL of methanol and then filtered under vacuum on a millipore filter (0.45 µm). The filtrate obtained is then used for the chromatographic analysis.

• Chromatographic analysis

The quantification of vitamin E was carried out by high performance liquid chromatography (HPLC) at a temperature of 45° C and from 10 µL of the filtrate. The detection is carried out in the ultraviolet (UV) at the respective wavelengths of 292 nm for vitamin E, using a detector of the ACQUITY TUV type.

The mobile phase used in this study is a methanol / water mixture in proportion 98: 2 (v / v). The elution rate set at 2 ml / min is generated by an isocratic pump. The chromatograms obtained are displayed usingthe EMPOWER software (ACQUITY, WATERS).

Vitamin E is identified by comparison with the retention time of the α-tocopherol acetate used as standards. The quantification is carried out by reference to a standard curve, established from the areas obtained for different concentrations of the standards.

Vitamin C

The vitamin C or ascorbic acid content of *Termitomyces letestui* mushrooms was determined according to the method described by Pongraz *et al.* (1971). Vitamin C has been stabilized in a solution of metaphosphoric acid (HOPO3) / acetic acid (CH3COOH).

Ten (10) grams of fresh *Termitomyces letestui* mushroom pasta has been stabilized in 20 mL of 2% metaphosphoric acid / acetic acid. The mixture obtained was centrifuged (Jouan centrifuge B4i-BR4i, Germany) at 4000 rpm for 20 min.

The volume of the supernatant was removed. The assay was carried out with 2-6 dichlorophenol indophenol (DCPIP) at 0.5 g / L. The end of the dosage was marked by the appearance of a persistent champagne pink coloration.

A dosage was carried out in 1 ml of a standard solution of vitamin C at a concentration of 1 mg / 1 mL and in 1 mL of metaphosphoric acid / acetic acid-water solution (blank solution).

Vitamins B

The vitamin B content of *Termitomyces letestui* mushrooms was determined according to the method of Fatima *et al.* (2013). One (1) gram of Termitomyces letestui flour was dissolved in 0.1 mL HCl at room temperature. The homogenized mixture is centrifuged at 3000 rpm for 25 minutes at 0 ° C.

The supernatant is collected and filtered on Whatman No. 4 paper and then through a 0.45 µm millipore filter (Sartorius, AG, Goëttingen, Germany). The samples thus treated are stored at -20 ° C. for analysis. 10 µL of the sample / standard is injected into a 254 nm UV monitor.

The standards are filtered and injected separately. All samples were prepared from the pure powders of the primary reference substances. The qualitative analysis at the level of the different samples was obtained by comparison of the retention time of the eluted compounds with the retention time of the solutions

3. RESULTS AND DISCUSSION

Some vitamins have been determined as part of this work. The vitamin contents of the *Termitomyces letestui* mushrooms are shown in the table below. The highest content is observed with vitamin C (20.10 ± 1.35 mg / 100g). In addition, the lowest content is observed with vitamin B_{12} (0.75 ± 0.10 µg / 100g).

Table : Vitamin content of fungi *Termitomyces letestui*

Vitamins	Content (/100g)
B_1, mg	0,80±0,01
B_2, mg	0,61±0,30
B_3, mg	5,73±0,90
B_9, µg	12,55±0,41
B_{12}, µg	0,75±0,10
C, mg	20,10±1,35
E, mg	0,26±0,03

The values in the table are the means of three tests, assigned standard deviations

The vitamin contents of wild edible mushrooms*Termitomyces letestui* reveal that they contain a wide variety of vitamins (B_1, B_2, B_3, B_9, B_{12}, C and E) with respective contents of 0.80 ± 0.01mg / 100g; 0.61 ± 0.30 mg / 100g; 5.73 ± 0.90 mg / 100g; 12.55 ± 0.41 µg / 100g; 0.75 ± 0.10 µg / 100g; 20.10 ± 1.35 mg / 100g and 0.26 ± 0.03 mg / 100g dry matter.

Vitamins are defined as organic substances without energy value, essential to the organism and which man cannot synthesize (with the exception to a certain extent of vitamin D and niacin) (Martin et Potier de Courcy , 2012), and whose absence from the ration results, in the medium or long term, in the development of deficiency diseases (Guilland, 2012).

Wild edible mushrooms*Termitomyces letestui* contain a vitamin C or ascorbic acid content of 20.10 ± 1.35 mg / 100g which agrees with that of *Pleurotus ostreatus* (20 mg / 100g) (Mattila *et al.*, 2001). This vitamin C content is higher than that obtained by Adejumo *et al.* (2015) for

the fungi *Pleurotus ostreatus* (10.16 mg / 100g), *Termitomyces robusta* (10.25 mg / 100g), *Volvariella volvacea* (6.57 mg / 100g), *Termitomyces microcarpus* (12.15 mg / 100g), *Pleurotus pulmonarius* (14.10 mg / 100g).

Ascorbic acid is a water-soluble vitamin that the human body does not produce endogenously (Langlois *et al.*, 2016). Vitamin C is necessary for the gastroduodenal absorption of iron (Larbier et Leclercq, 1992; Vidacs, 1992). It intervenes in detoxification processes by blocking the formation of nitrosamines; it reduces the harmful effects of mycotoxins, heavy metals and pollutants on health and performance (Guillot *et al.*, 1998). Vitamin C boosts non-specific immunity against bacterial toxins (Latshaw, 1991).

Insufficient vitamin C intake for several weeks can cause scurvy, the clinical symptoms of which are fatigue, fragile capillaries and slow healing. Although serious vitamin C deficiencies are rare in developed countries, they can occur in people whose daily intake is less than 10 mg (Langlois *et al.*, 2016).

It intervenes in particular as an enzyme cofactor in different syntheses (of collagen, carnitine, and hormonal), a stimulator of the immune system (Padayatty *et al.*, 2003). Finally, it is a powerful antioxidant, and a free radical scavenger in the plasma, hence protecting the cell against oxidative damage (Buettner, 1993).

The vitamin E content of *Termitomyces letestui* mushrooms is 0.26 ± 0.03 mg / 100g. It is higher than that of *Pleurotus ostreatus* mushrooms (0.1818 mg / 100g) obtained by Abou Raya *et al.* (2014). It is also superior to that of *Cortinarius glaucopus* (0.92 ± 0.09 µg / g), *Hypholoma capnoides* (0.71 ± 0.03 µg / g), *Russula delica* (0.74 ± 0.06 µg / g), *Tricholoma sulphureum* (0.52 ± 0.03 µg / g) and *Lactarius salmonicolor* (0.15 ± 0.03 µg / g) obtained by Heleno *et al.* (2010) and *Lactarius citriolens* (101.05 ± 7.30 µg / 100 g) and *Lactarius turpis* (132.94 ± 11.50 µg / 100 g) (Vieira *et al.*, 2014).

The generic term vitamin E brings together two large groups of molecules: tocopherols and tocotrienols (Brigelius-Flohe, 2009; Aggarwal *et al.*, 2010). Vitamin E deficiencies can lead in particular to neuromuscular damage or retinal damage (Banks *et al.*, 2010). Vitamin E has anti-inflammatory properties: it boosts the immune system and helps cells fight infection. But it is mainly for its antioxidant activity that vitamin E is useful for our organism (Bourgeois, 2003).

The levels of vitamin B_1 or Thiamin and vitamin B_2 or Riboflavin in *Termitomyces letestui* mushrooms are 0.80 ± 0.01 mg / 100g and 0.61 ± 0.30 mg / 100g, respectively. These levels are much higher than those of vitamin B_1 for the fungi *Agaricus bisporus* (0.03 mg / 100g), *Lentinus edodes* (0.009 mg / 100g), *Pleurotus* spp. (0.042 mg / 100g) and those of vitamin B_2 for *Agaricus bisporus* (0.25 mg / 100g), *Lentinus edodes* (0.057 mg / 100g) and *Pleurotus* spp. (0.083 mg / 100g) (Furlani et Godoy, 2008).

The vitamin B_1 content of *Termitomyces letestui* mushrooms is also higher than that of *Pleurotus citrinopileatus* mushrooms (0.16 mg / 100g) (Musieba *et al.*, 2013).

Thiamine is a water-soluble vitamin found in brewer's yeast, the pulp of raw fruit, cereal germs and animal products. (Quilliot *et al.*, 2017). Vitamin B_2 contributes to the use of iron (Powers, 1995; Ma *et al.*, 2008; Powers *et al.*, 2011). It is also involved in muscle repair metabolism (Biesalski *et al.*, 2010).

The vitamin B_3 or Niacin content of the *Termitomyces letestui* mushrooms is 5.73 ± 0.90 mg / 100g. This content is higher than that of the fungi *Termitomyces heimii* (2.24 ± 0.45 mg / 100g) and *Termitomyces microcarpus* (2.39 ± 0.6 mg / 100g) (Johnsy et Kaviyarasan, 2015). The vitamin B_3 content is very close to those obtained by Nwoko *et al.* (2017) for the fungi *Dacryodes edulis* (5.28 mg / 100g), *Mangifera indica* (5.07 mg / 100g) and *Treculia africana* (5.16 mg / 100g).

Vitamin B3 has an important role in energy production during the catabolism of carbohydrates, fats, proteins and alcohol (Martin, 2000). It allows an increase in HDL a decrease in LDL and a reduction in triglyceride levels (Cattan *et al.*, 2004; Goldberg, 2004).

It is also believed to decrease muscle inflammation (Descamps, 2009). Clinical manifestations of niacin deficiency are episodic vomiting, abdominal pain, constipation, headache, insomnia, fatigue, painful swallowing and photosensitive pruritus on body surfaces exposed to the sun. (Sechi *et al.*, 2016).

The vitamin B_9 content of *Termitomyces letestui* mushrooms is 12.55 ± 0.41 µg / 100 g. This value obtained in the context of this work is very close to that of the fungus *Lentinus edodes* (12.4 ± 1.42 µg / 100 g) obtained by Philips *et al.* (2011). Vitamin B_9 or folic acid is involved in human reproduction (Tamura and Picciano, 2006).

The vitamin B12 content of *Termitomyces letestui* mushrooms is 0.75 ± 0.10 µg / 100 g. It is higher than that of *Pleurotus citrinopileatus* (<0.30 µg / 100 g) obtained by Musieba *et al.* (2013). Vitamin B_{12} appears to stimulate the immune system (Tamura *et al.*, 1999).

4. CONCLUSION

The vitamin contents of wild edible mushrooms *Termitomyces letestui* were determined in this study. The results obtained revealed that these mushrooms contain a wide variety of vitamins (B_1, B_2, B_3, B_9, B_{12}, C and E). The highest content is observed with vitamin C (20.10 ± 1.35 mg / 100g). In addition, the lowest content is observed with vitamin B_{12} (0.75 ± 0.10 µg / 100g). These mushrooms could be used as sources of essential nutrients for the body. This will effectively combat the vitamin deficiency that prevails in developing countries including Côte d'Ivoire. This will allow even the most disadvantaged populations to access the nutrients essential for the proper functioning of their organism.

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Conflicts of interest

Authors declare that there is no conflict of interest regarding the writing and publication on this work.

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