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# Some Wild Edible Termitomyces Found in the Region of Daloa (Centre-West, Côte d'Ivoire)

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**A B S T R A C T**

This research focuses on the study of the diversity of termitomyces in the region of daloa. The aim is to inventory the species of wild termitomyces in order to identify and valorize them. Trips carried out in the daloa area have made it possible to list seven (7) wild termitomyces. The specimens collected are all edible and are used in the diet of the ivorian population. They are considered as substitute food for animal proteins. Among these species, six (6) have been described for the first time in côte d'ivoire based on their morphological and microscopic characters: *T. striatus*, *T. umkowaani*, *T. robustus*, *T medius*, *T. aurantiacus*, *T. clypeatus*. The species *Termitomyces le-testui* has already been cited and described.

## Introduction

The African continent alone accounts for one third of the 2000 known termite species, of which about 100 are mushroom termites (Flechet, Lefevre, 2007). Termites are insects establishing a symbiosis with a higher fungus called Termitomyces. Termitomyces are fungal species belonging to the basidiomycetes (Tibuhwa, 2012). They make a small aerated structure, the grindstone using coarsely chewed and very poorly digested plants, on which the Termitomyces mycelium will grow (Flechet and Lefevre, 2007). The species of the genus Termitomyces contain many sources of proteins, minerals and some vitamins essential for humans. They appear during the rainy season for a few weeks per year (Bram Van and Janna, 2007).

In recent years, ethnomycological studies in Africa have been carried out on edible mushrooms (Rammeloo and Walleyn, 1993). Some work is emerging from certain countries in tropical Africa (Malaisse, 2008). In Côte d'Ivoire, very little work has been done on edible species (Boa, 2006). In

spite of this work on edible mushrooms and the important role they play in the food and social life of rural populations, data on edible mushrooms are insufficient in Côte d'Ivoire.

The mycological studies oriented for the most part on the estimation of the diversity and abundance of fungal species in the natural environment have been very little interested in edible Termitomyces. The objective of this work is to inventory the edible Termitomyces of the city of Daloa and to appreciate their diversity.

## Materials and Methods

### Presentation of Study Area

The study area is Daloa, Haut-Sassandra region in west central Côte d'Ivoire. This city is located between 6°53'58" N latitude and 6°26'32"W longitude (Figure 1) at an area of 15205 km² (RGPH, 2014). Daloa is an area covered by four seasons: a large rainy season (April to July), a small dry season (July to September), a small rainy season (September to November) and the large dry season (December to March). This is a humid tropical zone with dense forest vegetation that is regressively evolving due to the practice of extensive and shifting agriculture coupled with uncontrolled exploitation of forest species (Sangaré *et al.*, 2009).

The edaphic heritage is of the ferralitic type. The region is experiencing a decrease in rainfall of about 40% (Ligban *et al.*, 2009). The average annual rainfall is between 1100 and 1230 mm, with an average annual temperature 26.7°C (Kouassi *et al.*, 2019). The city of Daloa is watered by the river Sassandra and by its tributary the "Lobo" whose branches the Dé and the Gore flood all localities (Sangaré *et al.*, 2009).

### Biological materials

The biological material consists of various species of wild Termitomyces collected from the collection site (Figure 2).

### Technical equipment

A knife was used to dig the termite mound to the grinding stone before detaching the mushrooms from their supports. A camera (SAMSUNG STC150F/16.2 MP) was used to take pictures of the mushrooms. The collected specimens were stored in a basket. A light microscope was used to observe the spores and reproductive organs. Cap and foot measurements were taken with a tape measure.

### Mushroom collection

Trips were made during the rainy season (March-July) in the forests, plantations and grasslands surrounding the city of Daloa. The collection took place very early in the morning. The fungal species were photographed before they were harvested.

Mushrooms were pulled gently to avoid damaging them. All samples were collected in the field and taken to the laboratory for identification. Fungal specimens were oven dried around 40°C for 1-2 days and preserved for later microscopic observations.

### Observations and Identification

Microscopic observations in the laboratory involved spores, basidia, cystids of the cap weave and cuticle. A fragment of fungal tissue was mounted between slide and coverslip for microscopic observation. Microscopic observations were made on 20 spores for each harvest sample. The mounting fluid was water and the organs were observed at x 400 magnification. Determination and identification were carried out through the books and keys proposed by Heim (1977); De Kesel *et al.*, (2002); Pegler (1980); Pegler and Vanhaecke (1994); Malaisse (2008).

## Results and Discussion

Observations allowed us to draw up a first list of seven consumed species. The genus Termitomyces shows a diversity of edible species.

### *Termitomyces clypeatus R. Heim*

The cap (5-8.5 cm) is brown, grayish-brown to gray at the perforatorium, smooth, glabrous, radially striate, with irregular lobes, straight margin (Figure 3). Blades are creamy white, free, tight. The foot (5-8 cm) is white to brown, smooth, glabrous, central, cylindrical, thin. It lacks volva and ring. The foot is hollow, bulbous at the base. The pseudorhiza (5-7 cm) is dark brown with smooth surface, glabrous, solid, cylindrical. It narrows towards the end. Spores (6.66-8.32 x 3.33 µm) are hyaline, obovoid to elliptical, smooth. Basidia are hyaline, tetrasporate. The cheilocystids are hyaline, clavate.

### *Termitomyces medius R. Heim & Grassé*

The cap (4-6 cm), is at first conical then spread out, it is depressed around the perforatorium. It is separable from the foot. The coating is slightly shiny and dry. The color of the cap is dirty white to brownish-gray, lighter towards the margin. The margin is first curved, then spread and cracked. The perforatorium is darker, gray-brown to brown-beige. The lamellae are free and tight. The foot (2-4,5 cm) is straight, cylindrical, longitudinally striated. It is frequently twisted, whitish, without ring. The underground part is short (1-2 cm long), slightly swollen (0.7-0.8 cm diameter), whitish. The pseudorhiza is very thin and fragile, brittle, white, 1-2 mm diam., about 10 cm long. Spores are smooth, hyaline (5.8-7.5×3.7-4.2 µm). Basidia (18-22×7-9 µm) are clavate, tetrasporate. The cheilocystids are ovoid to lageniformes. The species grows in small groups in shady, relatively moist sites on deep soils. The species grows in small groups (Figure 4).

### *Termitomyces aurantiacus*

The surface of the cap is orange to ochre (8-12 cm in diameter). The cap is strongly domed-nippled, convex-mucronate and the margin is mostly inflected. It is finely furrowed. It presents elongated fissures. The pilose coating is separable up to the base of the nipple which appears conical, acute and then pointed. The blades are tight, free and of whitish color. The pulp is white and brittle (Figure 5). The stipe is cylindrical, whitish to pale ochre towards the lower part. It tapers into a long, narrow and fragile pseudorhiza whose length is between 20 and 25 cm. The cystidia are numerous, facial, pyriform and ovoid and frequently constricted. They carry at the top a rounded appendix. The spores (5.5-7.5x3.8-4.8 µm) are hyaline.

### *Termitomyces robustus (Beeli) Heimr*

The cap (8-11cm diameter) is firm, fleshy, conical then plano-convex. The perforatorium is blackish brown, darker than the cap. It is weakly demarcated, acute, 1-1.5 cm wide. Margin first curved then revolute, finely striated, finally with radial tears. The coating is entirely separable, slightly viscous in wet weather, otherwise dry and dull. It has multiple concentric ridges and grooves towards the margin, dark to light brown (Figure 6). The foot (10-23 x 1.5-3 cm) is central, massive, cylindrical, smooth, cream to pale ochre-brown, then extending into a long cylindrical pseudorhiza (-40 cm), dark brown at the top, gradually white towards the tip. The lamellae are whitish to cream colored, they are free and tight. The flesh is thin, soft, fibrous and white. Spores (6.4-8.7 x 3.8-5.4 µm) are subglobose to ellipsoid, hyaline, smooth. Basidia (13.5-24 x 4.7-8.7 µm) are clavate and tetrasporate. Cheilocystids and pleurocystids are very abundant, clavate.

### *Termitomyces striatus (Beeli) Heim*

The cap (6.4-7.5 cm diameter) is whitish-brown, firm, convex and then flattens out in the adult state. The surface is smooth, dry. The margin is curved with remains of veils, multiple with radial tears. The perforatorium is darker than the rest of the cap. The flesh (1-1,5 cm) is whitish, soft and thick in the central part of the cap. It is fibrous and firm in the foot. The blades are whitish, free and very tight. The foot (18.5-20 x 0.2-1.5 cm), central, massive, cylindrical, smooth, fibrous, white to creamy white (Figure 7). It is swollen at the collar and then extends into a long cylindrical pseudorhiza (41 cm). The spores (4.99-6.66 x 1.66 µm) are hyaline, ovoid.

They have a germinative pore. Basidia (18.31- 26.64 x 6.66 µm) are hyaline, clavate, tetrasporate, 17-24.5 × 6.5-7.5. Cheilocystids and pleurocystids are similar, clavate, ovate and piriform, usually pedicellate.

***Termitomyces umkowaani Cke & Mass.***

The cap (2-5.6cm) is campanulate to convex, turned upward with age, brown at the periphery to dark brown to reddish brown in the center. The surface is smooth with perforatorium, margin ridged, tuberculate eroded, creamy white and thinly chiseled (Figure 8). Blades are white, cream, not tight, free and curved. The foot (6.5- 8 x 1.8-3 cm) is creamy white, cylindrical, solid, fibrous. It is swollen in the middle. Spores (4.99-8.32 x 3.3 µm) are hyaline, elliptical with thin walls. Basidia are hyaline, bisporate. The cheilocystids (16.65- 24.97 x 6.66-8.32 µm) are hyaline pyriform.

***Termitomyces le-testui (Pat.) R. Heim***

The cap (16-20 cm) is campanulate then convex, cream to light brown, fleshy. The surface is smooth, dry and brittle. The perforatorium is dark brown, cylindrical and made up of small brown scales on the disc. The blade is whitish, tight and loose, uneven. The flesh is whitish with thin walls. It has a small central nipple and a coating ring. The foot (12-16 x 1.8-2.4 cm) is creamy white, solid, fusiform, pubescent under membrane ring is sheath-like. The pseudorhiza (20 x 0.3-1 cm) is dark brown, hollow, cylindrical. Spores (6.66- 9.99 x 3.33 µm) are elliptical, hyaline, smooth and have a germinative pore. Basidia are hyaline, clavate tetrasporate. The cheilocystids are hyaline, clavate, ovoid, and pyriform (Figure 9).

Located in a forest area, the region of Daloa (South West, Ivory Coast) has several termite mounds on which different species of mushrooms grow. Most of these mushrooms are edible. Thus they constitute an important source of income and nutrition for the population.

Termitomyces are superior fungi that have the particularity to establish a symbiosis with termites. They grow on the vegetation covering the termite mounds, acting as a fertilizer. These fungi predigest the plants in order to make them more easily assimilated by the termites. The genus Termitomyces is a group of edible fungi classified in the family Lyophyllaceae (Basidiomycota).

It forms a symbiotic or mutualistic association with fungus-eating termites (Aanen, 2002; 2005). According to Hyodo (2003), Termitomyces species are capable of decomposing and degrading lignin to make cellulose more accessible for termite nutrition. For Batra (1979) Termitomyces fungi provide digestive enzymes and vitamins for their hosts. Karun & Sridhar (2013) showed that Termitomyces are economically valuable species serving as an alternative to plant and animal foods. In addition to nutritional value, many Termitomyces species possess medicinal properties and have industrial applications. Mushrooms Termitomyces are massively harvested by the rural populations of Daloa. Economically, they contribute to the income of this population.

The valorization of all woody and non-woody species from the forests can serve to strengthen local development strategies and actions. In Côte d'Ivoire, mushrooms are consumed by a large part of the local population. Among these mushroom species, the genera Termitomyces, Volvaire and Psathyrelle are harvested on a large scale and occupy an important place in the staple diet of the populations during the outbreak seasons (N'Douba *et al.*, 2021). According to Zanh *et al.*, (2016), non-timber forest products play an important role in the survival of populations at both rural and urban levels. They contribute to poverty reduction and food security of populations in forest regions.

**Fig.1** Overview of the study area (INS, 2014)

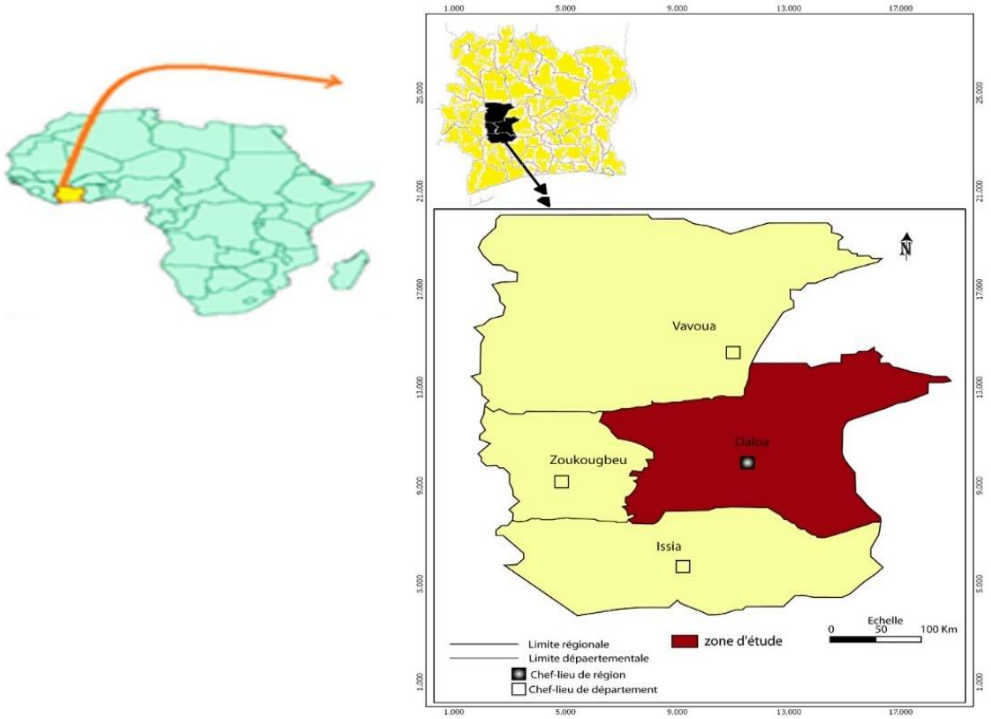



**Fig.2** Some fungal species collected on the study site; A and B: Termitomyces

**Fig.3** *Termitomyces clypeatus;* A: Carpophore; B: Cystids; Magnification: x 400

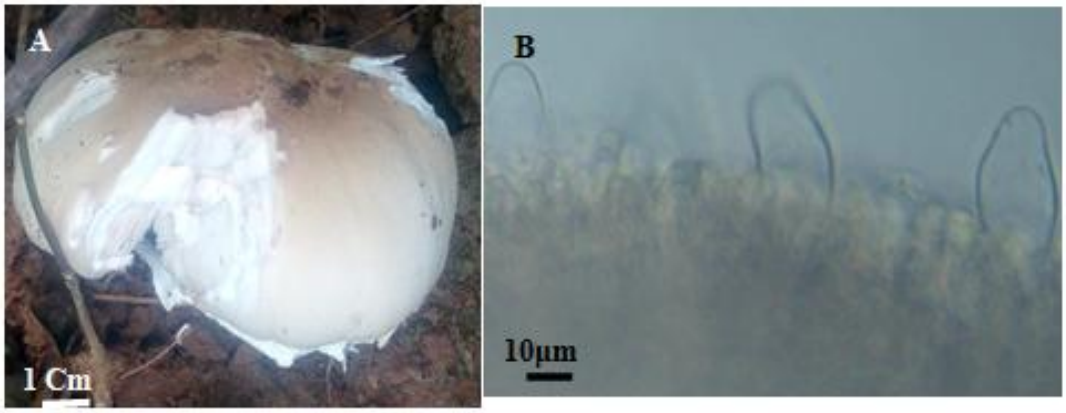



**Fig.4** *Termitomyces medius*; A: carpophore on grinding wheel; B: spores; Magnification: x 400

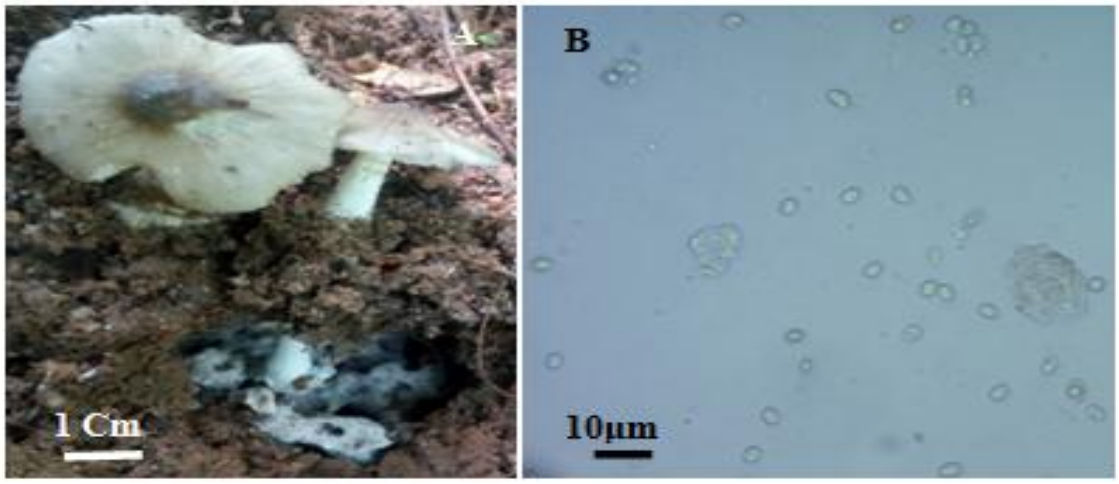



**Fig.5** *Termitomyces aurantiacus*; A: carpophore, B: Spores; Magnification: x 400

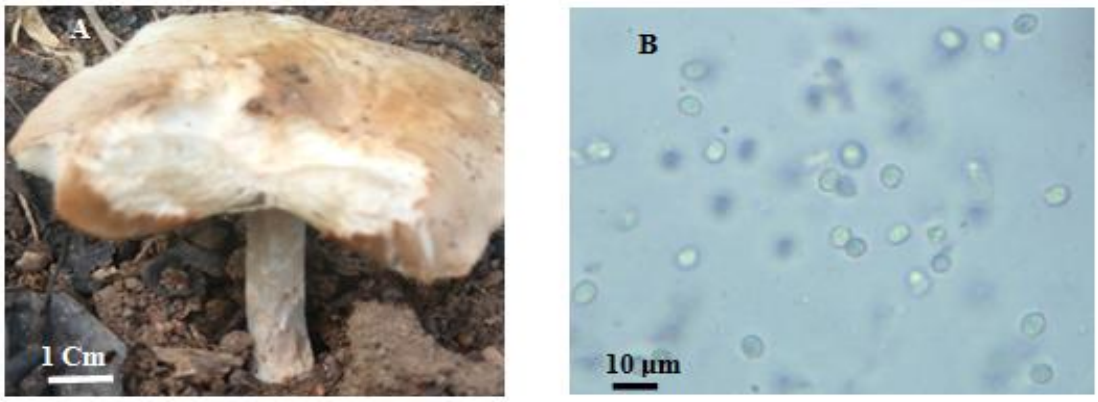


**Fig.6** *Termitomyces robustus*. A and B: Carpophores; C: Spore; Magnification: x 400

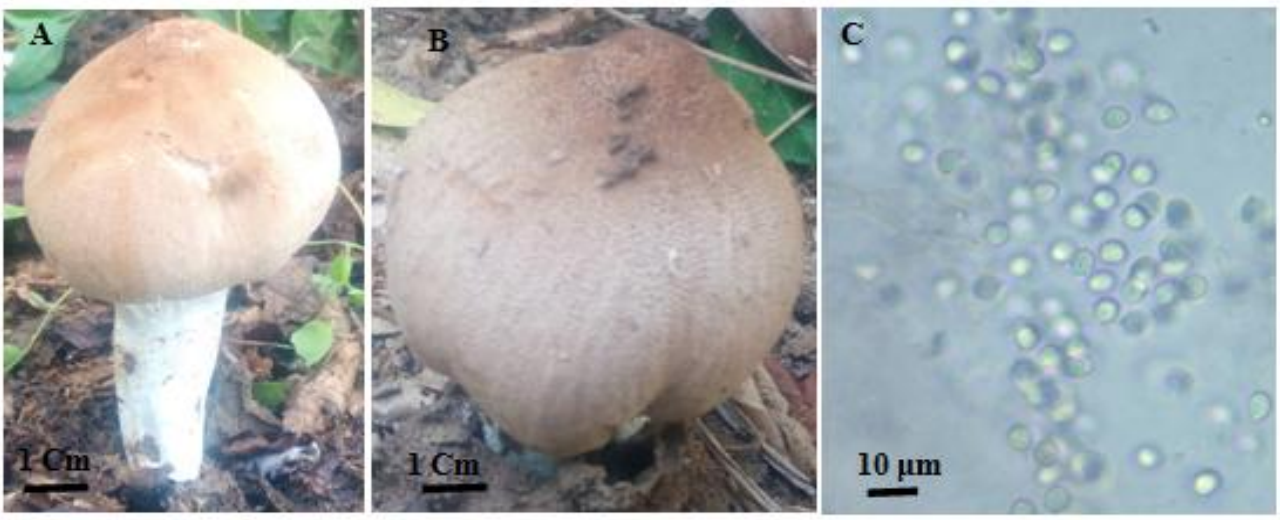



**Fig.7** *Termitomyces striatus*; A: Carpophore; B: Transverse section of a lamina showing the facial and marginal cystids; C: Radial longitudinal section through the nipple of the cap showing the chains of ovoid cells; Magnification: x 400

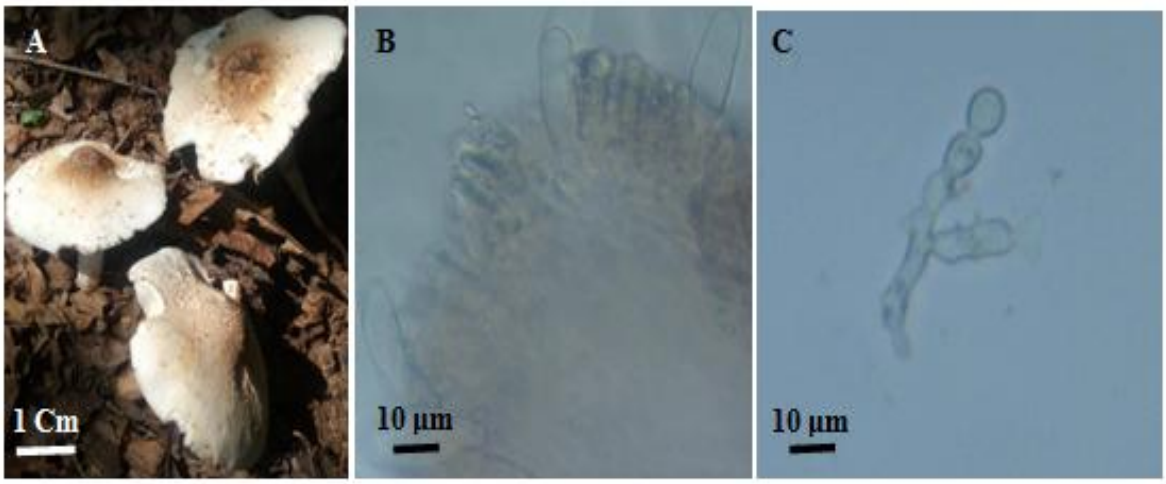


**Fig.8** *Termitomyces umkowaani;* A and B: Carpophore on grinding wheel; C: Spores; Magnification: x 400

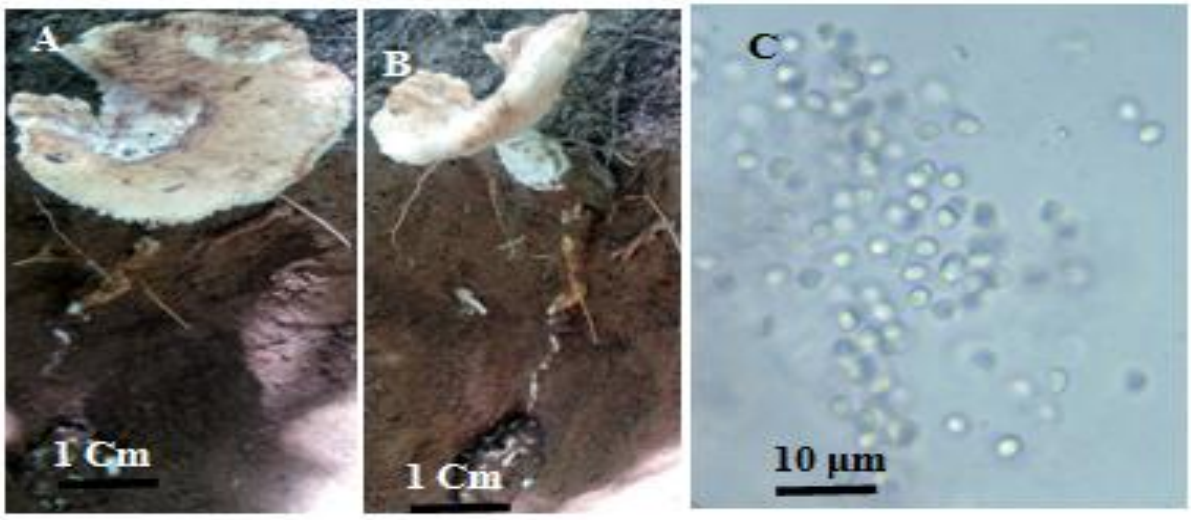
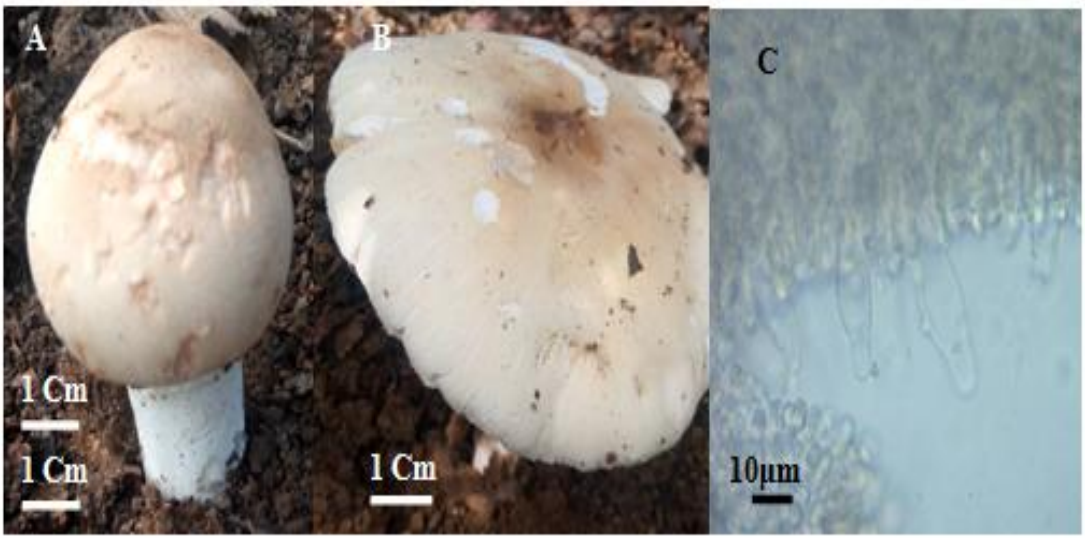



**Fig.9** *Termitomyces le-testui*; A and B: Carpophore, C: Cheilocystids




In this study, seven (7) species of Termitomyces were observed and identified in the Daloa area. N'Douba *et al.*, (2021) in their work on the contribution to the study of edible wild mushrooms in the city of Daloa (central-western Côte d'Ivoire,) cited three (3) species of termitomyces in the Daloa region. These are: *Termitomyces striatus* (Beeli.) Heim, *Termitomyces medius* R. Heim & Grassé and *Termitomyces le-testui* (Pat.) R. Heim. Yian and Tiebré (2013) cited seven (7) species of Termitomyces in their studies of edible fungi from the dense forest of Côte d'Ivoire. These species are as follows: *T fuliginosus, T. eurhizus, T. microcarpus, T. schimperi, T medius, T. le-testui* and *T. striatus*.

This study on the diversity of Termitomyces presents the great fungal wealth of the Daloa area. It allowed the identification and description of seven (7) wild edible species distributed in the forests, plantations and grasslands of the city of Daloa: *Termitomyces striastus, T. umkowaani, T. Robustus, T medius, T aurantiacus, T clypeatu, s T. le-testui*. This work is a first achievement in the study area and a first contribution that deals with species of the genus Termitomyces. These results provide the

basic data for further studies that could be extended to other regions of the Ivorian territory.

## Competing Interests

Authors have declared that no competing interests exist.

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