



Mycophagous Activity of Agaricomycetes Class in IPB University Campus Forest, Indonesia

Aktivitas Mikofagi dari Kelas Agaricomycetes di Hutan Kampus Institut Pertanian Bogor, Indonesia

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ABSTRACT

Macrofungi are a nutraceutical food containing high protein, low fat, and are rich in minerals that play an important role in animal physiology, particularly as food supplements because of their distinctive aroma. This research aimed to provide information on the macroscopic and microscopic characters of several macrofungi from the Agaricomycetes consumed by animals, and to describe their antibacterial potentials. This research employed opportunistic sampling, mushroom identification and description, proximate analysis, and antibacterial assays. A total of seven mushrooms of the Agaricomycetes were described, namely *Lentinus sajor-caju*, *Gymnopilus* sp., *Marasmius* sp., *Phallus indusiatus*, *Panus lecomtei*, *Termitomyces* sp., and *Schizophyllum commune*. *Lentinus sajor-caju* had carbohydrate, fiber, protein, fat, ash, and moisture contents of 72.02%, 30.03%, 11.63%, 1.37%, 4.26 %, and 10.74%, respectively. The antibacterial assay of *L. sajor-caju* indicated that both 0.8 mg/ml and 1 mg/ml concentrations showed no significant difference in activity. However, both exhibited potent inhibitory effects against *Candida albicans*. *Lentinus sajor-caju* extract inhibited Enteropathogenic *Escherichia coli* (EPEC) at a concentration of 5 mg/ml. In comparison, a dose of 0.8 mg/ml effectively suppressed the growth of Methicillin-resistant *Staphylococcus aureus* (MRSA). This current research provided a basic framework for future mycophagy analysis and bioprospection in Indonesia.

INTISARI

KATA KUNCI

fungivory, Agaricomycetes, pakan serangga, nilai gizi, antibakterial

Makrofungi dikenal sebagai pangan nutrasetikal karena mengandung protein tinggi, rendah lemak, dan kaya akan mineral yang berperan penting dalam fisiologi hewan. Selain itu, beberapa hewan memanfaatkan jamur sebagai suplemen makanan karena memiliki aroma khas yang mudah dideteksi. Tujuan penelitian ini adalah untuk memberikan informasi tentang beberapa jamur dari kelas Agaricomycetes yang dimakan oleh hewan dan mengidentifikasi potensi antibakterial jamur tersebut. Metode yang digunakan dalam penelitian ini adalah opportunistic sampling, identifikasi dan deskripsi jamur, uji proksimat, dan uji anti bakteri. Telah ditemukan tujuh jamur dari golongan Agaricomycetes, yaitu *Lentinus sajor-caju*, *Gymnopilus* sp. dan *Marasmius* sp. yang dimakan ulat, serta *Phallus indusiatus*, *Panus lecomtei*, *Termitomyces* sp. dan *Schizophyllum commune* yang dimakan serangga. *Lentinus sajor-caju* memiliki kandungan karbohidrat (72,02%), kandungan serat kasar (30,03%), kandungan protein kasar (11,63%), kandungan lemak kasar (1,37%), kandungan abu (4,26%), dan kadar air (10,74%). Uji ANOVA menunjukkan bahwa dosis 0,8 mg/ml dan 1 mg/ml tidak berbeda nyata, tetapi menghasilkan daya hambat yang kuat terhadap *C. Albicans*. Ekstrak *L. sajor-caju* dapat menghambat EPEC pada dosis 5 mg/ml dan dosis 0,8 mg/ml menghambat pertumbuhan MRSA. Penelitian ini memberikan fondasi dasar untuk penelitian mikofagi selanjutnya di Indonesia dan potensi bioprospeksinya.

Introduction

Mushrooms provide valuable nutrition for animals. Their indigestible fiber components, particularly non-starch polysaccharides, are crucial in maintaining gastrointestinal function and digestive health (Giraldo et al. 2023). Many species demonstrate antifungal and antibacterial activities, showcasing their potential antimicrobial properties beyond dietary applications. These bioactive metabolites may inhibit the proliferation of pathogenic microorganisms affecting animals and humans, reinforcing the potential as functional foods with therapeutic benefits (Giraldo et al. 2023).

Mycophagy refers to consuming fungal fruiting bodies and provides essential nutritional supplements for many animal species. Mammals, in particular, often target epigeous (aboveground) and hypogeous (belowground) sporocarps as food sources (Elliott et al. 2019). This feeding strategy establishes a mutualistic relationship in which animals aid fungal dispersal by adhering spores to fur or feathers, ingesting fruiting bodies, and excreting viable spores at new locations. Therefore, mycophagy can markedly increase the distance and likelihood of fungal colonization across diverse habitats (Nuñez et al. 2013). Mycophagy, the interaction between vertebrates and mushrooms has been well analyzed (Santamaria et al. 2023), whereas invertebrates have received relatively less attention. Research on mycophagy in invertebrates, including insects such as gypsy moth caterpillars (*Lymantria dispar*, *Lepidoptera*), has reported that they eat spores of the rust fungus *Melampsora laricis-populina* (Pucciniales, Pucciniomycetes) and the lamellae of *Agaricus bisporus* (Santamaria et al. 2023). However, the knowledge of Indonesian mycophagy remains scarce. The only report was the observation of gastropods that consume *Coprinellus* basidiocarps (Putra & Thamrin 2021). This research aimed to explore mycophagy activities at the IPB University Campus Forest (IPBUCF) and their antimicrobial properties, following the encounter of several invertebrates consuming the basidiomata of Agaricomycetes during a mushroom foray.

Methods

Time and Location

Agaricomycetes samples were collected from the IPBUCF in January-February 2024. This research employed opportunistic sampling by traversing the research area without predefined plots or transects, visually inspecting substrates such as soil, decaying wood, leaf litter, as well as living trees for conspicuous sporocarps and insects with mycophagous activity. The basidiomata were photographed in their natural habitat, and the surrounding vegetation, growth patterns, and habitat characteristics were documented. Afterward, the samples were preserved in 70% ethanol, while some were dried in a food dehydrator at 50°C for three days. The dried samples were stored at room temperature. Insects were collected directly from the basidiomata and preserved in 70% alcohol. The observations were conducted in the Mycology laboratory of the Department of Biology at the Faculty of Mathematics and Natural Sciences, IPB University, Indonesia.

Macroscopic and Microscopic Description

Mushroom identification was based on macroscopic and microscopic observations. Macroscopic identification included the characteristics of fruit bodies, such as shape, color, colony formation, lamellae, and size (Alim et al. 2023). Meanwhile, microscopic observation focused on examining hyphae, spores, basidia, and cystidia and was performed using a digital bright field microscope, Olympus BX-63, at 1000x magnification. The identification and classification of invertebrates were based on morphological characters following the references from global biodiversity sources (gbif.org/search).

Proximate Analysis

The proximate analysis of mushrooms was conducted using the Association of Official Analytical Collaboration International (AOAC 2005) method to determine the total percentage of ash, water, crude fat, crude protein, and crude fiber content. In subsequent mushroom testing, only *Lentinus sajor-caju* was subjected to proximate analysis and extracted for antibacterial testing. The remaining six mushrooms could not undergo further testing due to insufficient

weight. Mushroom samples were dried at 50°C for 24 hours until a constant weight and used to determine dry weight (Srikram & Supapvanich 2016). Crude fat content was also determined by extraction with petroleum ether using the Soxhlet system. After crude fat analysis, the sample was used to determine the crude fiber content by sequential extraction of the sample with 1.25% sulfuric acid (H₂SO₄) and 1.25% sodium hydroxide (NaOH). Furthermore, the samples were dried, and the weight was recorded before determining the ash content. The carbohydrate content was calculated from the sum of the percentages of crude protein, ash, fat, and crude fiber minus 100% (Adeniyi et al. 2018).

Antibacterial Assays

The fruit bodies were dried at 45°C for 24 hours and ground into powder. In addition, a powder sample of 20 g was extracted with 200 ml of methanol (ratio 1:10) at a temperature of 30°C while stirring at 100 rpm for 24 hours. Maceration was carried out three times and filtered using Whatman filter paper number 42 (2.5 µm) to obtain a filtrate (Noverita & Ratmini 2022) with modifications. The filtrate was evaporated using a rotary evaporator (50°C) to obtain mushroom extract and stored for further analysis.

Antibacterial assays were conducted only for *L. sajor-caju* due to sample sufficiency for the test. The test was subjected to Enteropathogenic *Escherichia coli* (EPEC), Methicillin-resistant *Staphylococcus aureus* (MRSA), and *Candida albicans*. Mushroom methanol extract was dissolved in 5% dimethyl sulfoxide (DMSO) to a final concentration of 1 mg/ml. Pathogenic bacteria and yeast were also grown in *Luria Bertani* (LB) and Potato Dextrose (PDB) Broth media at a temperature of 37°C and 100 rpm for 24 hours. A culture suspension was obtained by adjusting the final density to 0.5 McFarland standard, approximately 10⁸ Colony-Forming Unit (CFU)/ml. Mueller-Hinton agar media for bacterial pathogens and PDA media for yeast pathogens were inoculated with 100 µL of microbial inoculum, poured into a petri dish, and left for 15 minutes at room temperature. Mushroom extract concentrations started from 0.8 mg/ml to 20 mg/ml using disk diffusion, the antibiotic chloramphenicol (positive control), and 5% DMSO (negative control). Dilution of the extract was performed before

applying the extract to the sterile discs by mixing 96% methanol with the specimen at a ratio of 1:19. The diluted extract was dropped onto sterile discs. Plates containing bacteria and fungi were incubated for 18 hours until 24 hours and 24 hours until 48 hours at 37°C. The antimicrobial activity of the tested fungi was evaluated based on the diameter of the inhibition zone (mm) using ImageJ. The tests were performed in triplicate in accordance with Salihović et al. (2020), and mean values were calculated using Microsoft Excel.

Result and Discussion

The exploration of mycophagy during the rainy season obtained a considerable diversity of mushroom specimens. A greater species diversity was common during the rainy season (Adeniyi et al. 2018). Climate, temperature, and habitat were crucial in assessing fungal diversity (Mridu et al. 2024). All the mushrooms reported in this research belonged to the Agaricomycetes, Basidiomycota. Generally, the fruiting bodies and fungal sporocarps were used by invertebrates as a food source and home or habitat for breeding, respectively (Santamaria et al. 2023). Some of the mycophagous mushrooms were edible and had medicinal properties. Various invertebrates consumed *Panus lecomtei*, *L. sajor-caju*, *Gymnopilus* sp., *T. eurrhizus*, *S. commune*, *M. siccus*, and *P. indusiatus*, including caterpillars and other insects. Most invertebrates ate the lamella parts, marked by bites and visible holes in the mushroom cap. Table 1 summarizes the mycophagy activities observed at the IPBUCF.

Description of Mushrooms

Panus lecomtei

The taxonomy of *Panus lecomtei* is described along with its morphological traits (Figure 1–2) as follows.

Taxonomy: *Panus lecomtei* (Fr.) Corner, Beih. Nova Hedwigia 69: 90 (1981).

Basionym: *Lentinus lecomtei* Fr. 1825.

The fruiting bodies were 2.3–8.4 cm in size, with the gregarious and infundibuliform, resembling a funnel (Figure 1a). The cap size was between 1–5 cm with a purple or burgundy shade during the immature

Table 1. Mycophagy discovered at the IPBUCF

No.	Common names of mushrooms	Family	Ordo	Class	Latin name	Invertebrate
1	Hairy oyster mushroom	Panaceae	Polyporales	Agaricomycetes	<i>Panus lecomtei</i>	Insect
2	White rot mushroom	Polyporaceae	Polyporales	Agaricomycetes	<i>Lentinus sajor-caju</i>	Caterpillars
3	Gilled mushroom	Hymenogastraceae	Agaricales	Agaricomycetes	<i>Gymnopilus</i> sp.	Caterpillars
4	Termite mushroom	Lyophyllaceae	Agaricales	Agaricomycetes	<i>Termitomyces</i> sp.	Insect
5	Orange pinwheel	Marasmiaceae	Agaricales	Agaricomycetes	<i>Marasmius</i> sp.	Caterpillars
6	The grigit mushroom	Schizophyllaceae	Agaricales	Agaricomycetes	<i>Schizophyllum commune</i>	Insect
7	Bridal veil fungus	Phallaceae	Phallales	Agaricomycetes	<i>Phallus indusiatus</i>	Insect

stage, and became orange-brown at maturity. Furthermore, the edges rolled up and were covered with dense, small hairs on the surface. Lamellae (Figure 1b) were light or cream colored, decurrent, and regularly from the stem to near the edge, and their shape was straight and crowded. Some of the features included Stipe 1–1.3 cm x 0.7–1.8 cm, cylindrical, cream-colored, densely hairy with a white or cream color, basidiospores (Figure 2c) size 4–4.2 μm x 1.8–2.6 μm , ellipsoid, smooth and hyaline, basidia (Figure 2a) 2.5–3.3 μm in width, sterigma, and cheilocystidia (Figure 2b) 3–4.1 μm in width. This mushroom had a clamp connection and a hyphal structure on the stipe ((Figure 2f) and pileus (Figure 2d-e) arranged in parallel and compact. Insects on the lamella consumed *P. lecomtei*, but had not been documented as a fungus eaten by animals or associated with mycophagy. Therefore, this exploration represents the first report of mycophagy in *P. lecomtei* (Figure 1c-d) from Indonesia. Specimen was examined at 6°33'24.7"S 106°43'19.1"E, on stumps and big tree roots, January 2024, collected by I. Dianita and N. Syahbani.

Lentinus sajor-caju

The taxonomy of *Lentinus sajor-caju* is described along with its morphological traits (Figure 3–4) as follows.

Taxonomy: *Lentinus sajor-caju* (Fr.) Fr., Epicr. Syst. mycol. (Upsaliae): 393 (1838) [1836-1838].

Basionym: *Agaricus sajor-caju* Fr. 1821.

The fruiting bodies were 1.5–5.7 cm and gregarious (Figure 3a). Pileus was widened and pulled up, cream to light brown in color, funnel-shaped or infundibuliform with a light brown hollow part, and the pileus margin was wavy between 2.6 cm and 7 cm. The lamellae (Figure 3b) were straight, crowded, decurrent, and ranged in color from white to cream. The stipe was centrally positioned, with coloration varying from white and cream to light brown and bore

an annulus. Basidiospores (Figure 4c) measured 3.9–4.6 μm x 2.1–2.8 μm and were predominantly ellipsoid, but some appeared nearly subfusiform, cystidia abundant (Figure 4 d-i). Hyphae were hyaline (Figure 4 a-b). *L. sajor-caju* was used as a habitat for caterpillars, where the animals used the mushroom to reproduce and leave the eggs to nest in the fruiting body (Figure 3c-d). Basidiomata were getting withered and thinner due to continuous use by animals. There was no previous report regarding the consumption of *L. sajor-caju* by animals. Specimen examined was found at 6°33'37.8"S 106°43'31.8"E, 6°33'34.4"S 106°43'41.5"E, 6°33'25.6"S 106°43'23.1"E, on stumps and fallen logs, January-February 2024, collected by I. Dianita and N. Syahbani.

Gymnopilus sp.

The taxonomy of *Gymnopilus* sp. is described along with its morphological traits (Figure 5–6) as follows.

Taxonomy: *Gymnopilus* P. Karst., Bidrag Kännedom Finlands Natur Folk 32: 21, 400 (1879).

Synonym: *Fulvidula* Romagn., Rev. Mycol. France: 209 (1936).

The fruiting bodies measured 3–4.3 cm in diameter and showed gradient (Figure 5a). The 4.7–5.4 cm pileus was convex with a distinct umbo, smooth and shiny on the surface, ranging from orange-yellow to brownish, and with flat margins. The lamellae (Figure 5b) were adnexed, orange, moderately spaced, and not directly attached to the stipe. In addition, the stipe measured 2.8–4 cm x 0.7–0.8 cm and was brownish-orange. Basidiospores (Figure 6a) measured 4.8–5.4 μm x 4.1–4.5 μm and were ellipsoid. Basidia bore sterigmata with cystidia (Figure 6b-c), and hyphae (Figure 6d) were derived from stipe tissue. Species of *Gymnopilus* were known to be consumed by caterpillars (Figure 5c-d) and maggots, but some members of the genus were inedible. Sawada et al. (2014) reported that *G. crociphylus* was ignored by



Figure 1. Field photograph of *Panus lecomtei*: (a) Pileus; (b) Lamella; (c and d) Insects feeding (circle) on *P. lecomtei*

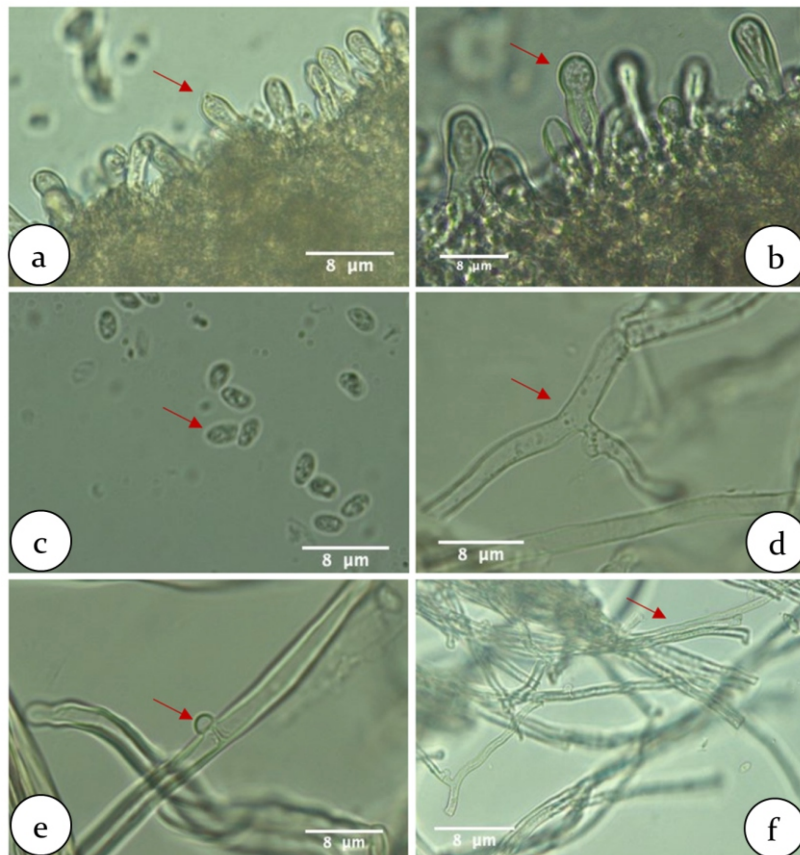


Figure 2. Microscopic features (arrow) of *Panus lecomtei*: (a) Basidia (400x); (b) Cystidia (400x); (c) Basidiospore (1000x); (d-e) Hyphae of the pileus (1000x); (f) Hyphae from stipe (400x) *lecomtei*



Figure 3. Field photograph of *Lentinus sajor-caju*: (a) Pileus; (b) Lamella (circle); (c and d) Insects feeding (circle) on *L. sajor-caju*

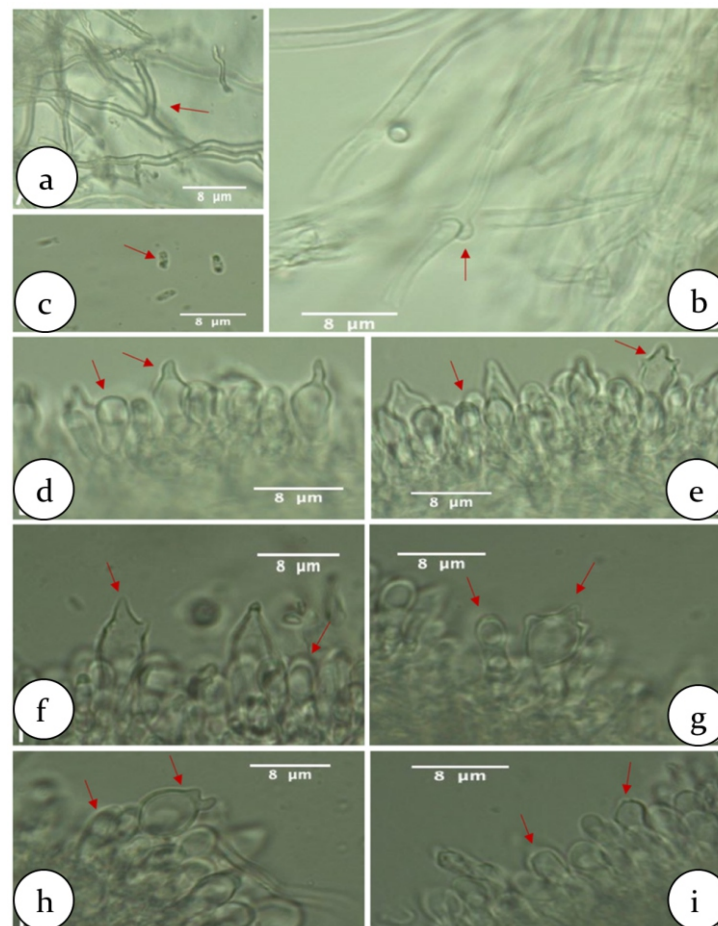


Figure 4. Microscopic features (arrow) of *Lentinus sajor-caju*: (a) Hyphae of the pileus (400x); (b) Hyphae of lamellae (400x); (c) Basidiospore (1000x); (d-i) Basidia and cystidia with sterigma (1000x)



Figure 5. Field photograph of *Gymnopilus* sp.: (a) Pileus; (b) Lamella and stipe; (c and d) Insects feeding (circle) on *Gymnopilus* sp.

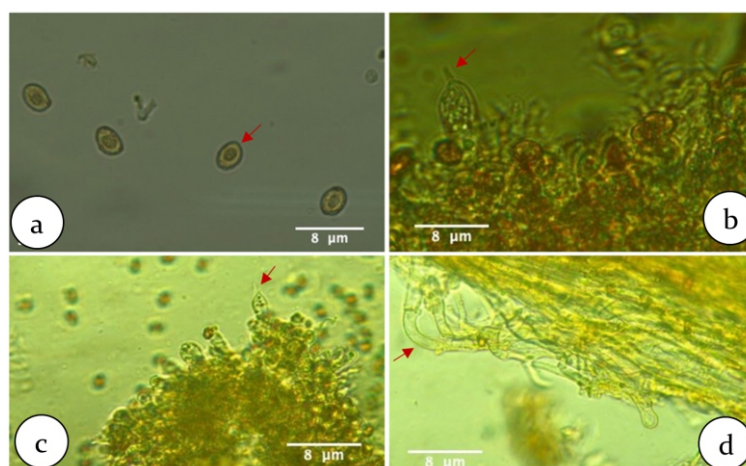


Figure 6. Microscopic features (arrow) of *Gymnopilus* sp.: (a) Basidiospores (1000x); (b) Basidia (1000x); (c) Cheilocystidia (400x); (d) Hyphae from stipe tissue (400x)

test animals, while *G. liquiritiae* was consumed without assessment of the potential toxicity. However, no determination of the edibility or toxicity of these species was made. Specimen examined was found at 6°33'10.9"S 106°43'25.2"E, on stumps, February 2024, collected by I. Dianita and N. Syahbani.

Termitomyces sp.

The taxonomy of *Termitomyces* sp. is described along with its morphological traits (Figure 7–8) as follows.

Taxonomy: *Termitomyces* R. Heim, Arch. Mus. Natl. Hist. Nat. Sér. 6, 18: 147 (1942).
Synonym: *Podabrella* Singer, Lloydia 8: 143 (1945);

Sinotermitomyces M. Zang, Mycotaxon 13 (1): 171 (1981); *Rajapa* Singer, Lloydia 8: 142 (1945); *Termitomyces* R. Heim, Mém. Acad. Sci. Inst. Fr. 64: 72 (1941).

The fruiting bodies (Figure 7a) measured 7.8–8.7 cm in height. The 6.5–8.8 cm pileus bore a distinct umbo and split margins. The surface was smooth to slippery and cream to pale brownish toward the edges. The lamellae (Figure 7b) were close, white to slightly creamy, uneven, and split at the edges, consisting of one to two tiers, as well as adnexed (narrowly attached). The stipe measured 6.5–7.6 cm x 1.6–3.2 cm, centrally positioned, robust, white, smooth, solid, hyphae hyaline (Figure 8f). Basidiospores (Figure 8e)



Figure 7. Field photograph of *Termitomyces* sp.: (a) Pileus; (b) Lamella; (c and d) Insects feeding (circle) on *Termitomyces* sp.

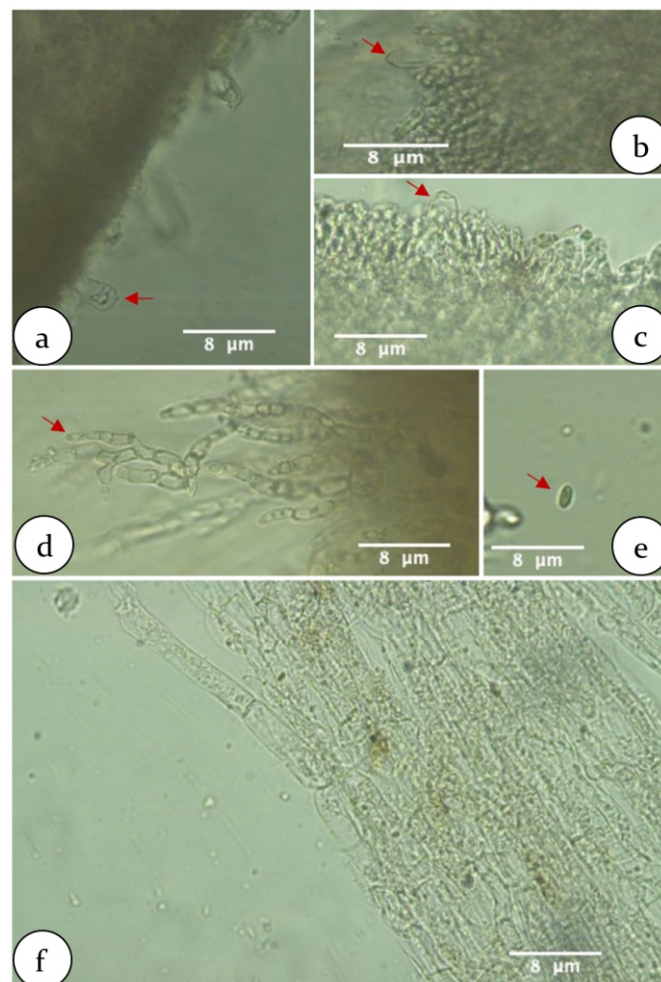


Figure 8. Microscopic features (arrow) of *Termitomyces* sp.: (a) Basidia (400x); (b) Pleurocystidia (400x); (c) Cheilocystidia (400x); (d) Hyphae (400x); (e) Basidiospore (1000x); (f) Hyphae from stipe tissue (400x)



Figure 9. Field photograph of *Marasmius* sp.: (a) Characteristics of fruiting bodies; (b) Lamella and Stipe; (c and d) Insects feeding on *Marasmius* sp.

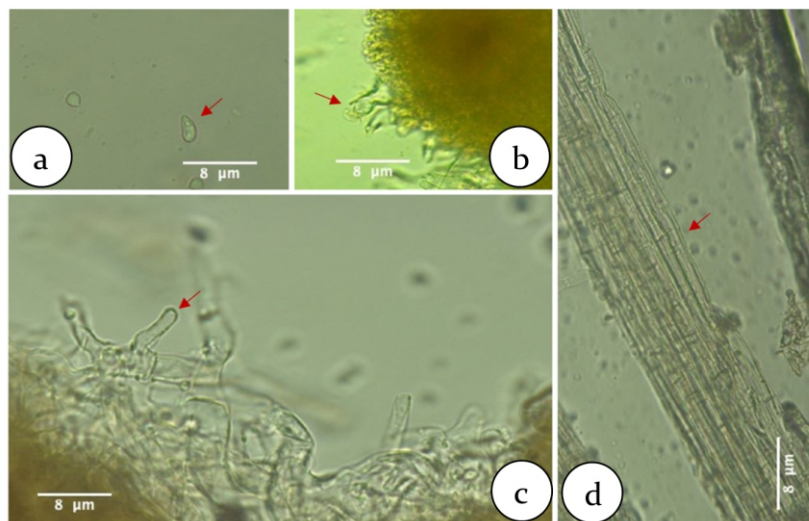


Figure 10. Microscopic features (arrow) of *Marasmius* sp.: (a) Basidiospores (1000x); (b) Cheilocystidia (400x); (c) Hyphae of trama (1000x); (d) Hyphae from stipe tissue (400x)

were 3.1–3.4 µm x 2.1–2.4 µm, ellipsoid, while basidia typically bore a single sterigma. Pleurocystidia were fusiform, but cheilocystidia were Y-shaped and associated with hyaline hyphae (Figure 8a-d). Insect activity was observed (Figure 7c-d) on the lamellae of *Termitomyces* sp., a species recognized for its edibility. According to Van De Peppel (2021), the *Termitomyces* sp. group was previously unknown until the existence of fungus-eating animals played a role in the initial steps towards domestication. Specimen examined was found at 6°33'11.4"S 106°43'20.9"E, in soil, January 2024, collected by I. Dianita and N. Syahbani.

Marasmius sp.

The taxonomy of *Marasmius* sp. is described along with its morphological traits (Figure 9–10) as follows.

Taxonomy: *Marasmius* Fr., *Corpus Florarum provincialium suecicae* I. Floram Scanicam: 339 (1836).

Obligate Synonym: *Chamaeceras* Rebert. ex Kuntze, *Revisio generum plantarum* 3 (3): 454 (1898).

This mushroom was 3.6–4.7 cm with a "beach umbrella"-shaped cap, hard, and lived in colonies (Figures 9a). The pileus was 1.8–3.2 cm, umbrella-like, with uneven edges, and was gradient orange to dark brown. The lamella gills (Figure 9b) were distant,



Figure 11. Field photograph of *Schizophyllum commune*: (a) Characteristics of fruiting bodies; (b) surface of *S. commune*; (c and d) Insect feeding (circle) on *S. commune*

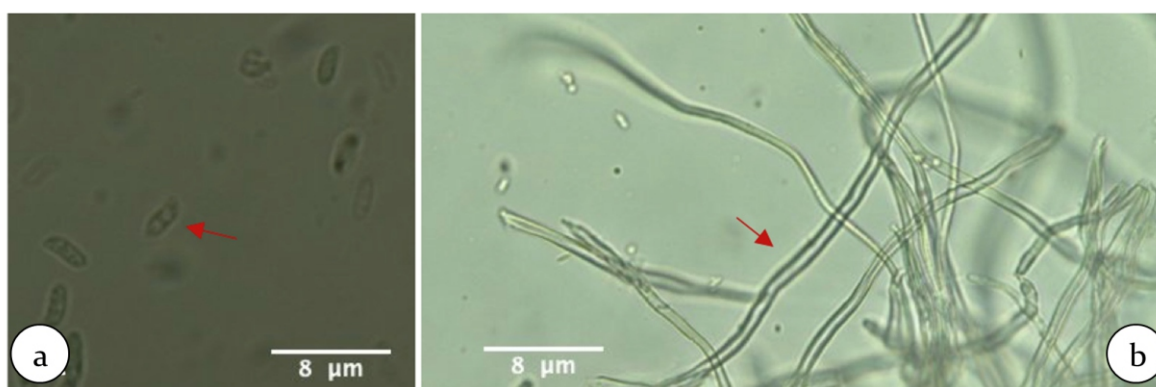


Figure 12. Microscopic features (arrow) of *Schizophyllum commune*: (a) Basidiospores (1000x); (b) Hyphae (400x)

while the lamella attachments were free and cream-colored. The Stipe was 3.2–4.4 cm x 0.2–0.4 cm, cylindrical, and cream to dark brown. Basidiospores (Figure 10a) were 4–4.8 µm x 2.1–2.7 µm in diameter and ellipsoidal. Basidia and hyphae had clamp connections and hyphae from the stipe tissue (Figure 10b-d). *Marasmius* sp. was edible and could be eaten by caterpillars (Figure 9c-d). Some edible species included *Marasmius* spp., which were eaten by European rabbits (*Oryctolagus cuniculus* (L.)), and *Marasmius* sp., which was most frequently visited by flies (Fogel & Trappe 1978; Duarte et al. 2024). The specimen examined was found at -6°33'13.6"N 106°42'58.5"E, in soil, January 2024, collected by I. Dianita and N. Syahbani.

Schizophyllum commune

The taxonomy of *Schizophyllum commune* is described along with its morphological traits (Figure 11–12) as follows.

Taxonomy: *Schizophyllum commune* Fr. [as '*Schizophyllum commune*'], *Observ. mycol.* (Havniae) 1: 103 (1815).
Obligate Synonym: *Schizonia vulgaris* Pers., *Mycologia Europaea* 3: 14 (1828); *Merulius communis* (Fr.) Spirin & Zmitr., *Novosti Sist. Nizsh. Rast.* 37: 182 (2004); *Daedalea commune* (Fr.) P. Kumm., *Der Führer in die Pilzkunde*: 53 (1871).

This mushroom was 1.3–1.8 cm x 1.3–1.7 cm and formed colonies, with gray and brown hairs at immature and mature stages (Figure 11a-b). Lamella gills had widely spaced and split edges, while basidiospores (Figure 12a) were 4–5.1 µm x 2–2.4 µm and ellipsoid. Furthermore, the hyphae (Figure 12b) lacked clamp connections. The fruiting bodies were



Figure 13. Field photograph of *Phallus indusiatus* with some insect feeding (circle) on it (a and b)

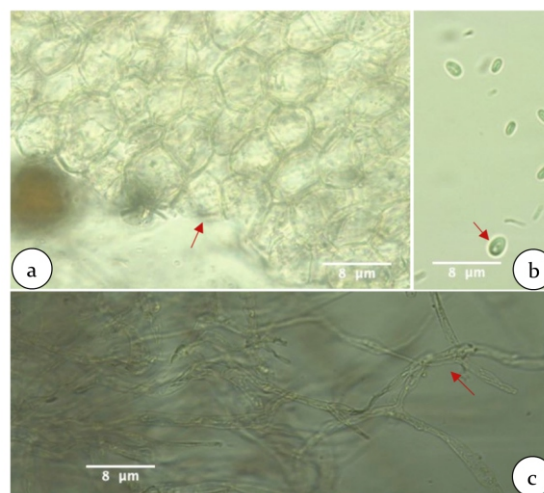


Figure 14. Microscopic features (arrow) of *Phallus indusiatus*: (a) Indusium cells (400x); (b) Basidiospores (1000x); (c) Hyphae (400x)

eaten by insects (Figure 11c-d). *S. commune* was considered edible and was consumed in many countries in Southeast Asia. Previous mycophagous research by Sawada et al. (2014) reported that monkeys could eat *S. commune*. Specimen examined was found at 6°33'12.1"S 106°43'22.7"E, on stumps, January 2024, collected by I. Dianita and N. Syahbani.

Phallus indusiatus

The taxonomy of *Phallus indusiatus* is described along with its morphological traits (Figure 13–14) as

follows.

Taxonomy: *Phallus indusiatus* Vent., Mém. Inst. nat. Sci. Arts 1: 520 (1798).

Obligate Synonym: *Dictyophora indusiata* (Vent.) Desv., J. Bot. Agric. 2: 92 (1809); *Hymenophallus indusiatus* (Vent.) Nees, System der Pilze und Schwämme: 251 (1817).

The fruiting body measured 10.5–11 cm in height and consisted of a conical pileus, stipe, and veil (Figure 13a). The pileus, 2.5–2.9 cm x 2–3 cm, was conical to bell-shaped, with a gradient coloration from light brown to dark brown or black, a rough surface texture,

and distinct wrinkles. The stipe, 6.5–8.2 cm x 1–2 cm, was cylindrical, soft to fleshy, white, and brittle. Basidiospores (Figure 14b) measured 2.4–3.5 μm x 1.5–2.4 μm and were ellipsoid. Furthermore, indusium cells were regular (Figure 14a), measuring 8.4–10.6 μm , and the hyphae (Figure 14c) possessed clamp connections. *Phallus indusiatus* produced epigeous fruiting bodies that facilitate rapid water absorption from the surrounding environment to promote rapid growth. The mushroom-eating behavior of stinkhorn (Figure 13b) had been known for more than a century, and almost all species of the Phallaceae depended on insects that function as spore dispersers (Fulton 1883). According to Sawada et al. (2014), the fruit body of *P. impudicus* could be eaten entirely by monkeys. The specimen examined was found at $-6^{\circ}33'40.6''\text{N}$ $106^{\circ}43'41.5''\text{E}$, $6^{\circ}33'14.6''\text{S}$ $106^{\circ}43'25.4''\text{E}$, on soil, January 2024, collected by I. Dianita and N. Syahbani.

Nutrition Components

Among the seven mushroom types in this research, *L. sajor-caju* produced the most significant number of fruit bodies, enabling a more robust assessment of its nutritional content and anti-microbial activity. The *L. sajor-caju* served as a nutritious food source for humans, and its fruiting bodies are highly beneficial (Table 2). The protein content could be compared with rice and corn, which contain 8.0% and 9.18%, respectively (Winarti et al. 2023). This protein level was lower than the protein content of *L. sajor-caju*, which insects consumed. Furthermore, *L. sajor-caju* was low in fat and could serve as a good alternative. Food proteins had slight flavors that captured and trapped aroma compounds (Pérez et al. 2023). According to Barros et al. (2019) proteins could bind or absorb flavor compounds, thereby influencing taste perception during con-

Table 2. Nutritional composition of *Lentinus sajor-caju*

Nutrients	Amount
Moisture Content (%)	10.74
Ash content (%)	4.26
Crude Fat content (%)	1.37
Crude Protein content (%)	11.63
Crude Fiber content (%)	30.03
Total Carbohydrates (%)	72.02
Energy values (kcal)	346.89

*Represented in 100 g of dry weight; kcal = kilocalorie

sumption. The presence of protein as a flavor carrier provided and maintained food flavor substances. *L. sajor-caju* had a high carbohydrate content, as the main class of important biological macromolecules and an energy source, which stimulated the immune system (Reneses et al. 2016). The level of carbohydrates was higher compared to *T. heimi* (22.81%) and wild *S. commune* (69.13%) on a dry-weight basis (Gunasekara et al. 2021). Chun et al. (2021) reported that mushroom crude extract showed antioxidant and anti-proliferation activity in the water extract. Therefore, animals consuming mushrooms benefited from high carbohydrate and protein content, which contributed significantly to meeting nutritional requirements.

Antibacterial Activities

Mushroom extract served as an environmentally friendly and safer alternative to disease-resistant antimicrobials. *L. sajor-caju* had the best ability to inhibit *C. albicans*, followed by MRSA and EPEC after 48 hours of incubation. Davis & Stout (1971) classified inhibition zones into four categories: very strong (>20 mm), strong (10–20 mm), moderate (5–10 mm), and no response (<5 mm). The antibacterial analysis indicated that the *L. sajor-caju* extract exhibited potent inhibitory activity against *C. albicans*. In contrast, it had the lowest average clear zone diameter against (EPEC), as summarized in Table 3. According

Table 3. Antibacterial activity of *Lentinus sajor-caju* to some pathogenic microbes

No.	Extract Concentration (mg/ml)	Extract Concentration (mg/ml)		
		<i>Candida albicans</i>	EPEC	MRSA
1	0.8 mg/l	11.67 $\pm$ 1.67 ^d	5.33 $\pm$ 3.53 ^{abc}	10.97 $\pm$ 1.67 ^{cd}
2	1 mg/ml	11.67 $\pm$ 1.20 ^d	5.33 $\pm$ 3.53 ^{abc}	8.30 $\pm$ 0.00 ^{bcd}
3	5 mg/ml	8.33 $\pm$ 4.40 ^{bcd}	6.67 $\pm$ 0.67 ^{bcd}	9.30 $\pm$ 0.00 ^{bcd}
4	10 mg/ml	-	5.00 $\pm$ 0.58 ^{ab}	9.97 $\pm$ 1.20 ^{bcd}
5	15 mg/ml	-	5.67 $\pm$ 0.67 ^{bc}	9.63 $\pm$ 0.67 ^{bcd}
6	20 mg/ml	-	5.67 $\pm$ 0.33 ^{bc}	9.63 $\pm$ 0.33 ^{bcd}
7	Positive control/Chloramphenicol (30 μg /disc)	-	19.00 $\pm$ 0.00 ^e	28.00 $\pm$ 1.53 ^f

Note: EPEC = Enteropathogenic *Escherichia coli*, MRSA = Methicillin-resistant *Staphylococcus aureus*

to Breijyeh et al. (2020), EPEC had cell walls containing lipopolysaccharides that protect it against antibiotics. Future research should focus on the pure extract of *L. sajor-caju*. The differences in the average inhibition zones of *C. Albicans*, EPEC, and MARS might be due to secondary metabolites and the type of microbe. According to Wang et al. (2022), differences in the average diameter of the clear zone reflected variations in the secondary metabolites produced by individual microbes. Therefore, the *L. sajor-caju* mushroom had the potential to act as an antibacterial by consuming the species, thereby suppressing the growth of pathogenic microbes.

Conclusion

Mycophagy exploration at IPBUCF identified seven mushroom species, *Panus lecomtei*, *Lentinus sajor-caju*, *Gymnopilus* sp., *Termitomyces* sp., *Marasmius* sp., *Schizophyllum commune*, and *Phallus indusiatus* that were consumed by invertebrates, such as caterpillars and insects. This research encountered that data and information on animal mycophagy were still limited. *L. sajor-caju* was rich in carbohydrates, serving as a potential energy source for invertebrates, and showed vigorous antifungal activity against *Candida albicans*, while moderately inhibiting EPEC and MRSA growth. This current research provided a basic framework for future mycophagy analyses and bioprospection in Indonesia.

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