KAVAKA 62(1):70-75 (2026) DOI: 10.36460/Kavaka/62/1/2026/70-75

Morphological, Molecular, Nutritional and GC-MS based characterization of *Collybiopsis gibbosa* with Antioxidant and Antibacterial activities

Gourab Kumar Barman[1], Ishita Ray[1], Jyotsna Das[2], Dipanwita Saha[3] and *Aniruddha Saha[1]

[1] *Molecular Plant Pathology and Fungal Biotechnology Laboratory, Department of Botany, University of North Bengal, West Bengal, India-734013*

[2] *Department of Botany, Alipurduar University, West Bengal, India-736122*

[3] *Plant Biotechnology Laboratory, Department of Biotechnology, University of North Bengal, West Bengal, India-734013*

**Corresponding author:* asahanbu@yahoo.co.in

(Submitted on August 18, 2025; Accepted on March 23, 2026)

ABSTRACT

Collybiopsis gibbosa is a little-known wild mushroom, with no comprehensive study reported so far from India. In the present investigation, specimens were collected from bamboo substrates and identified based on morphology and ITS-rDNA sequencing, which clustered the isolate within the *Collybiopsis* clade.The fruiting bodies contained appreciable amounts of carbohydrates and proteins, along with significant levels of phenolics and flavonoids. The methanolic extract exhibited strong antioxidant potential, demonstrating concentration-dependent DPPH radical scavenging activity. Antibacterial activity was observed against *Staphylococcus aureus*, *Bacillus subtilis*, and *Salmonella typhimurium*, with inhibition zones ranging from 11.1-14.2 mm.

Mineral profiling demonstrated high potassium (3383 mg/100 gm), magnesium (201 mg/100 gm), calcium (72 mg/100gm), iron (46.8 mg/100gm), and zinc (49 mg/100gm), along with trace levels of other essential elements. GC-MS analysis identified 30 compounds, dominated by fatty acids and their derivatives, including cis-13-Octadecenoic acid (55.28% peak area), n-Hexadecanoic acid (17.34%), and Octadecanoic acid (3.98%), as well as sterols such as ergosterol (2.66%). Many of these metabolites are known for antimicrobial, antioxidant, and pharmacological properties.This study provides the first detailed report on the morphology, molecular identity, nutritional composition, bioactivity, and chemical profiling of C. gibbosa from India

Keywords: *Collybiopsis gibbosa*, ITS sequencing, antioxidant, antibacterial, minerals, GC-MS

INTRODUCTION

Fungi are important organisms that contribute significantly to nutrient cycling, organic matter decomposition, and ecosystem stability (Hawksworth & Lucking 2017). In recent years, wild edible mushrooms have gained considerable scientific attention due to their ecological importance as well as their nutritional and medicinal potential. Recent studies have highlighted mushrooms as rich sources of bioactive compounds such as phenolics, flavonoids, polysaccharides, and terpenoids, which exhibit antioxidant, antimicrobial, and therapeutic activities (Sadi *et al*. 2026, Okumus *et al*. 2025).

Edible mushrooms, whether wild or cultivated, are highly valued for their unique flavor, aroma, texture, and delicacy. Their fruiting bodies are appreciated for both culinary and medicinal purposes. They are excellent sources of essential fatty acids, vegetable proteins, vitamins, and minerals, contributing to human nutrition and food security (Singh *et al*. 2025, Mahajon *et al*. 2026). Furthermore, wild mushrooms play an integral role in forest ecosystems by contributing to organic matter dynamics, soil carbon cycling, and overall soil health. Despite their ecological and economic importance, many wild mushroom species remain underexplored, particularly in tropical and subtropical regions with high fungal diversity (Ye *et al*. 2026, Zhang *et al*., 2021).

Collybiopsis is a genus within the family Omphalotaceae, consisting of species that were historically misclassified under *Collybia*, *Marasmius*, and *Marasmiellus* due to their morphological similarities (Petersen & Hughes 2021, Kim *et al*. 2022). Recent molecular phylogenetic studies have provided greater clarity on its taxonomy, confirming its distinction from *Gymnopus* and *Marasmiellus* (Oliveira *et al*. 2019; Petersen & Hughes 2021).

Species within *Collybiopsis* are generally characterized by collybioid to pleurotoid basidiocarps, free to slightly decurrent gills, a central to slightly eccentric stipe, and white spore prints. Microscopically, they exhibit ellipsoid to oblong, hyaline, and inamyloid basidiospores, along with distinct pileipellis structures (Oliveira *et al*. 2019). Unlike *Marasmius*, which exhibits marcescence (reviving after drying), *Collybiopsis* and *Gymnopus* do not possess this trait (Petersen & Hughes 2021).

The taxonomic history of *Collybiopsis gibbosa* has undergone revisions across regions. In Thailand, it was correctly classified under *Collybiopsis* (Phonrob *et al*. 2024), whereas in Singapore, Indonesia (Java), and Africa (Sao Tome), it was originally misclassified as *Marasmius gibbosus* until molecular phylogenetics confirmed its reassignment (Desjardin & Perry 2017).

Materials and Methods

1. Study area

The study was conducted in West Bengal, India, a region known for its tropical and subtropical climate, which supports diverse fungal species. The mushroom specimens were collected from a bamboo grove near decayed bamboo stumps in Naxalbari, Darjeeling, Pin code-734434, West Bengal, India, (Latitude 26.711024, Longitude 88.306892). The area is characterized by high humidity, moderate rainfall, and organic matter-rich soil, providing an ideal environment for fungal growth.

2. Sample Collection

Mushroom fruiting bodies were collected from decayed bamboo substrates in August, September, and October 2024. Samples were photographed in their natural habitat, carefully harvested, and stored in sterile paper bags to minimize contamination. The specimens were then transported to the laboratory for further examination.

3. Morphological study

Macroscopic features such as cap shape, size, color, gills, and stipe characteristics were documented using a camera. Microscopic features were analyzed by preparing slides stained with cotton blue to observe spores, basidia, and other structures under a compound microscope.

4. Molecular Identification

Genomic DNA was extracted from fresh fruiting body using the CTAB method (Sharma *et al*., 2003). The internal transcribed spacer (ITS) region of rDNA was amplified using universal primers ITS1 (5′-TCCGTAGGTGAACCTGCGG-3′) and ITS4 (5′-TCCTCCGCTTATTGATATGC -3′). PCR products were purified and sequenced commercially. The obtained sequence was deposited in GenBank (Accession No. PV186861).

5. Phylogenetic Analysis

The obtained ITS sequence was compared with related sequence was compared with related sequences using BLASTn. Multiple sequence alignment was performed with ClustalW in MEGA11 software. A phylogenetic tree was constructed using the Neighbor-Joining method with 1000 bootstrap replicates to confirm the taxonomic position of *C. gibbosa*.

6. Ethnobotanical Survey

Local villagers who frequently forage for wild mushrooms were interviewed semi-structured. Participants were asked about their knowledge of the mushroom, including its local name, collection practices, preparation methods, and consumption. Verbal consent was obtained before the interviews.

7. Preparation of Mushroom Extract

Following the protocol of Barros *et al*., 2007 methanol extract was prepared with little modifications. The collected fruiting bodies were washed, shade dried, and powdered. Ten grams of mushroom powder was soaked in 100 mL methanol and incubated in a shaking incubator for 18 h at room temperature. The extract was filtered through Whatman No. 1 filter paper and evaporated to dryness in a water bath. The dried extract was stored at 4º C until further use.

8. Antibacterial Assay

The antibacterial activity of the methanolic extract was tested against *Bacillus subtilis* (ATCC®11774™), *Staphylococcus aureus* (ATCC®11632™) and *Salmonella typhimurium* (ATCC®25241™) using the agar well diffusion method (Manandhar *et al*., 2019). All bacterial strains were procured in Kwik-Stick™ format from Microbiologics, USA, and maintained on nutrient agar slants at 4ºC until further use. Bacterial cultures were swabbed onto nutrient agar media plates, and 7 mm wells were filled with 100 µL of mushroom extract (sample, SA), solvent (methanol, CN), and standard antibiotic streptomycin (AB, 10 µg/mL). Plates were incubated at 37ºC for 24 h, and the zone of inhibition was measured in millimetres.

9. Proximate Composition

Carbohydrate content was determined by the anthrone method (Yemm and willis, 1954) and protein content was estimated by the Lowry method (1951) using bovine serum albumin as a standard. Results were expressed as percentage dry weight (DW).

10. Phytochemical Estimation

- **Total phenolic content (TPC):** Determined using the Folin-Ciocalteu reagent with gallic acid as standard; results expressed as mg gallic acid equivalent (GAE) per g extract (Kadam *et al*., 2013).

- **Total Flavonoid Content (TFC):** Determined by the aluminium chloride colorimetric method (Atanassova *et al*., 2011) using quercetin as standard; results expressed as mg quercetin equivalent (QE) per g extract.

11. Antioxidant Activity

The antioxidant potential was evaluated by DPPH free radical scavenging assay (Brand-Williams *et al*., 1995). Different concentrations of extract (100-500 µg/mL) were mixed with 0.1 mM DPPH solution and incubated in the dark for 30 min. Absorbance was measured at 517 nm, and percentage inhibition was calculated. The percentage radical scavenging activity was calculated using the following formula:

$$\%\ \text{Scavenging} = \frac{Control\ Absorbance - Sample\ Absorbance}{Control\ Absorbance} \times 100$$

The results were expressed as percentage inhibition against extract concentration, and IC_{50} values (concentration of required to inhibit 50% of DPPH radicals) were determined.

12. Mineral Analysis

Mineral composition was determined by Atomic Absorption Spectrophotometry (AAS). The analysis was outsourced to the Department of Agricultural Chemistry and Soil Science, Uttar Banga Krishi Vishwavidyalaya (UBKV), West Bengal, where standard protocols (AOAC, 2019) were followed to quantify essential minerals in the samples. Samples were digested using a nitric acid-perchloric acid mixture, and elements such as K, Ca, Mg, Na, Fe, Zn, Cu, Mn, Cr, Ni, Pb, and Cd were quantified. Results were expressed in mg per 100 g dry weight.

13. GC-MS Analysis

GC-MS analysis of the methanolic extract was performed at IIT Madras using an Agilent system equipped with an HP-5MS capillary column. Helium was used as the carrier gas, and the oven program was set from -60ºC to 325ºC. Mass spectra were compared with the NIST library for compound identification. Results were expressed as retention time (RT), compound name, molecular formula, and peak area percentage.

14. Statistical analysis

All experimental analyses were carried out in triplicate (n = 3). The data obtained were presented as mean values along with their corresponding standard deviation (mean ± SD).

Results

Morphological and Molecular Identification

Description

The pileus is pale beige to light brown, with slight variation in intensity depending on age and environmental conditions. The immature fruiting body is convex and usually has a distinct dome-shaped umbo. When mature, it becomes umbonate to umbilicate, with a smooth surface and a 5-8 cm diameter. The pileal margin is decurved, irregular, and obtuse. Lamellae (Gills) white to off-white, free to adnexed, closely spaced, 2.5-3.5 cm long. The stipe is off-white to pale beige, matching slightly lighter than the cap, tapering apex and wider base, 5-7 cm long, 0.3-0.5 cm in diameter, hollow. The spore print was observed on a dark surface and appeared white (Figure.1). Basidiospores are ellipsoid to ovoid, smooth, hyaline, and thin-walled, measuring 3-6 × 2-4 µm. Basidia seen few, clavate, four-spored, measuring 14-18 × 2-5 µm (**Figure 2**). These morphological features align with descriptions of *C. gibbosa* in previously published studies.

Phylogenetic Analysis

The ITS region of the collected sample was successfully amplified, producing a sequence of approximately 650 base pairs. BLAST analysis of query sequence (Accession No. PV186861) confirmed a 99.64% similarity to *Collybiopsis* *gibbosa* sequences available in GenBank (Accession No. OR818031). Phylogenetic analysis using the Neighbor-joining method placed the specimen within the *C. gibbosa* clade with bootstrap support, confirming its taxonomic placement (**Figure 3**).

Ethnobotanical Observations

Interviews with local villagers revealed that *C. gibbosa* is known by the local name 'Bash Kukri' and is commonly collected during its fruiting season. According to the villagers, the mushroom is consumed after boiling with spices such as curry or it may also be consumed as fried. They also reported that it is considered as a seasonal delicacy and was being consumed by the local community for generations without any reported adverse health effects.

Nutritional and phytochemical composition

Proximate analysis revealed appreciable levels of carbohydrates (42±0.3 gm/100gm Dry weight) and proteins (25±0.4 gm/100gm Dry weight). The methanolic extract contained 22±0.3 mg GAE/gm phenolics and 6±0.1 mg QE/gm flavonoids (**Table 1**).

Antioxidant Activity

The extract demonstrated concentration dependent DPPH radical scavenging activity, reaching 72% inhibition at 500 µg/mL with an IC_{50} value of ~ 280 µg/mL (**Table 1**; **Figure 4**).

Antibacterial Activity

The methanolic extract inhibited *Staphylococcus aureus*, *Bacillus subtilis*, and *Salmonella typhimurium*. The zone of inhibition ranged from 11.1-14.2 mm, whereas streptomycin (positive control) showed larger inhibition zones and methanol (negative control) exhibited no activity (Table 2; Figure 5).

Mineral Composition

Mineral analysis indicated high levels of potassium (3383 mg/100gm), magnesium (201 mg/100gm), calcium (72 mg/100gm), iron (46.8 mg/100 gm), and zinc (49 mg/100gm) (Table 3).

GC-MS Profiling

GC-MS analysis of the methanolic extract revealed 30 compounds. The dominant peaks corresponded to cis-13-Octadecenoic acid (55.28%), n-Hexadecanoic acid (17.34%), and Octadecanoic acid (3.98%). Ergosterol (2.66%) and 13-Docosenamide (1.27%) were also detected (Table 4).

Discussion

The present study provides a comprehensive characterization of *Collybiopsis gibbosa*, integrating its morphological, molecular, nutritional, and biochemical features with bioactivity assays. The analysis revealed appreciable levels of proteins and carbohydrates, indicating its significance as a source of essential macronutrients. Similar nutritional profiles have been reported in commonly consumed edible mushrooms such as *Agaricus bisporus*, *Lentinula edodes*, and *Pleurotus ostreatus*, where proteins and carbohydrates constitute the major contributors to their dietary importance (Rocha *et al*., 2025). In addition to its nutritional value, *C. gibbosa* exhibited notable antioxidant activity, reaching 72% inhibition at 500 µg/mL, with an IC_{50} value of approximately 280 µg/mL. Comparable antioxidant properties have been documented in the aforementioned edible mushrooms, where high phenolic and flavonoid contents are closely associated with strong free radical scavenging activity (Rocha *et al*., 2025). Similar findings have also been reported in wild edible mushrooms such as *Pleurotus ostreatus* which are recognized for their rich phenolic and flavonoid contents (Kruzselyi *et al*., 2020).

The methanolic extract also exhibited promising antibacterial activity against both Gram-positive and Gram-negative bacteria, with inhibition zones ranging from 11.1 to 14.2 mm. Among the tested strains, *Staphylococcus aureus* was the most sensitive. These findings are consistent with previous reports where on edible mushrooms, where solvent extracts have demonstrated inhibitory effects against a broad spectrum of bacterial pathogens. In particular, similar antibacterial activity has been observed in *Termitomyces striatus*, where methanolic extracts showed effectiveness against both Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus* (Sitati *et al*., 2021). In particular, compounds such as n-hexadecanoic acid and cis-13-octadecenoic acid, which were identified in the GC-MS profile of *C. gibbosa*, have been previously reported for their antimicrobial and anti-inflammatory properties (Trinh *et al*., 2025; Nurhayat *et al*., 2023). The detection of ergosterol further adds to the pharmacological relevance, as this sterol has been implicated in antimicrobial and antioxidant mechanisms (Rangsinth *et al*., 2023).

The nutritional and mineral composition analysis revealed appreciable levels of proteins and carbohydrates, along with high potassium and magnesium content, which supports its ethnobotanical use as a seasonal edible mushroom. The ethnomycological knowledge documented in the present study, where villagers consume *C. gibbosa* as a local delicacy without adverse health effects, is consistent with the findings of earlier reports on wild mushrooms contributing to food security and traditional healthcare in rural communities (Fongnzossie *et al*, 2020).

Conclusions

The present investigation provides the first comprehensive report on *Collybiopsis gibbosa* from India, integrating its morphology, molecular identity, nutritional composition, bioactive potential, and chemical constituents. The methanolic extract of *C. gibbosa* demonstrated significant antioxidant activity and antibacterial activity against both Gram-positive (*Staphylococcus aureus*, *Bacillus subtilis*) and Gram-negative (*Salmonella typhimurium*) bacteria, with inhibition zones ranging between 11.1-14.2 mm. These findings suggest that *C. gibbosa* is a promising source of bioactive compounds with potential pharmaceutical applications.

The nutritional and mineral richness, particularly high potassium, magnesium, and protein content, further highlights its value as a functional food. GC-MS profiling revealed several biologically active metabolites such as cis-13-octadecenoic acid, n-hexadecanoic acid, and ergosterol, which are known for their antimicrobial, antioxidant, and pharmacological properties.

Overall, the study not only establishes the ethnobotanical relevance of *C. gibbosa* as an edible mushroom but also scientifically validates its medicinal potential. Future research focusing on compound isolation, and possible cultivation strategies may open avenues for its utilization in nutraceutical and pharmaceutical industries.

Acknowledgements

The authors are thankful to UGC-SAP and DST-FIST facilities of Department of Botany for providing necessary instrumental support. Financial support received by GKB from UGC in the form of JRF-NET fellowship is greatly acknowledged. The authors gratefully acknowledge the Indian Institute of Technology (IIT) Madras, Tamil Nadu, India, for providing GC-MS analytical facilities. We also thank the Department of Agricultural chemistry and Soil Science, Uttar Banga Krishi Viswavidyalaya (UBKV), West Bengal, India, for conducting the mineral analysis.

References

Atanassova, M., Georgieva, S. and Ivancheva, K. 2011. Total phenolic and total flavonoid contents, antioxidant capacity and biological contaminants in medicinal herbs. Journal of the University of Chemical Technology & Metallurgy., ***46*(1)**: 81-88.

Barros, L., Calhelha, R.C., Vaz, J.A., *et al*. 2007. Antimicrobial activity and bioactive compounds of Portuguese wild edible mushrooms methanolic extracts. *European Food Research and Technology*, ***225*(2)**: 151-156; Doi: 10.1007/s00217-006-0394-x.

Brand-Williams, W., Cuvelier, M. E. and Berset, C. L. W. T. 1995. Use of a free radical method to evaluate antioxidant activity. LWT-*Food science and Technology*. ***28*(1)**: 25-30; Doi: https://doi.org/10.1016/S0023-6438(95)80008-5.

Desjardin, D.E. and Perry, B.A. 2017. The gymnopoid fungi (Basidiomycota, Agaricales) from the Republic of Sao Tome and Principe, West Africa. *Mycosphere*, **8**: 1317-1391; Doi: 10.5943/mycosphere/8/9/5.

Fongnzossie, E. F., Nyangono, C. F. B., Biwole, A. B., *et al*. 2020. Wild edible plants and mushrooms of the Bamenda Highlands in Cameroon: ethnobotanical assessment and potentials for enhancing food security. *Journal of ethnobiology and ethnomedicine*, ***16*(1)**: 12; Doi: https://doi.org/10.1186/s13002-020-00362-8.

Hawksworth, D.L. and Lucking, R. 2017. Fungal diversity revisited: 2.2 to 3.8 million species. *Microbiology spectrum*, **5**: 10-1128; Doi: 10.1128/microbiolspec.FUNK-0052-2016.

Kadam, S.U., Tiwari, B.K. and O'Donnell, C.P. 2013. Application of novel extraction technologies for bioactives from marine algae. Journal of agricultural and food chemistry., ***61*(20)**:4667-4675; Doi: 10.1021/jf400819p.

Kruzselyi, D., Moricz, A. M. and Vetter, J. 2020. Comparison of different morphological mushroom parts based on the antioxidant activity. LWT., **127**: 109436; Doi: https://doi.org/10.1016/j.lwt.2020.109436.

Mahajon, B., Nath, R., Thakur, S. K., *et al*. 2026. Fungi as Therapeutics: Bridging Traditional Wisdom and Modern Medicine. *New Zealand Journal of Botany*, **64(1)**: e70012; Doi: https://doi.org/10.1002/nzb2.70012.

Manandhar, S., Luitel, S. and Dahal, R.K. 2019. In vitro antimicrobial activity of some medicinal plants against human pathogenic bacteria. Journal of tropical medicine., **2019**: 1895340; Doi: https://doi.org/10.1155/2019/1895340.

Nurhayat, O. D., Putra, I. P., Sibero, M. T., *et al.* 2023. First identification of potential bioactive compounds from ethanol extracts of *Lepista sordida* from Indonesia. *In IOP Conference Series: Earth and Environmental Science*, **1271**: 012058; Doi: 10.1088/1755-1315/1271/1/012058.

Okumus, E., Canbolat, F., and Acar, I. 2025. Evaluation of antioxidant activity, anti-lipid peroxidation effect and elemental impurity risk of some wild *Agaricus* species mushrooms. *BMC Plant Biology*, **25(1):** 476; Doi: https://doi.org/10.1186/s12870-025-06520-y.

Oliveira, J.J., Vargas-Isla, R., Cabral, T.S., *et al.* 2019. Progress on the phylogeny of the Omphalotaceae: *Gymnopus* s. str., *Marasmiellus* s. str., *Paragymnopus* gen. nov. and *Pusillomyces* gen. nov. *Mycological Progress*, **18**: 713-739; Doi: https://doi.org/10.1007/s11557-019-01483-5.

Petersen, R.H. and Hughes, KW. 2021. *Collybiopsis* and its type species, *Co. ramealis*. *Mycotaxon*, **136**, 263-349; Doi: https://doi.org/10.5248/136.263.

Phonrob, W., Kumla, J., Suwannarach, N., *et al.* 2024. Five new records of *Collybiopsis* (Agaricales, Omphalotaceae) in Thailand: a significant addition to the species diversity and global distribution of the genus. *Phytotaxa*, **650**: 213-235; Doi: https://doi.org/10.11646/phytotaxa.650.3.3.

Rangsinth, P., Sharika, R., Pattarachotanant, N., *et al.* 2023. Potential beneficial effects and pharmacological properties of ergosterol, a common bioactive compound in edible mushrooms. *Foods*, ***12*(13)**: 2529; Doi: https://doi.org/10.3390/foods12132529.

Rocha, E. M. D., Avila, S., Lima, J. J. D., *et al.* 2025. Nutritional value and antioxidant activity of *Agaricus bisporus*, *Lentinula edodes* and *Pleurotus ostreatus* mushrooms. *Anais da Academia Brasileira de Ciências*, **97(4)**, e20241454; Doi: https://doi.org/10.1590/0001-3765202520241454.

Sadi, G., Cicek, M., Kol, S., *et al.* 2026. Comparative analysis of cell growth inhibitory potential and biological activities of six wild edible mushrooms from Turkiye. *Plant Biosystems*, **160(1)**:1; Doi: https://doi.org/10.1007/s44473-025-00015-2.

Sharma, R., Mahla, H. R., Mohapatra, T., *et al.* 2003. Isolating plant genomic DNA without liquid nitrogen. *Plant Molecular Biology Reporter*, ***21*(1)**: 43-50; Doi:10.1007/BF02773395.

Singh, A., Singh, G., Kapoor, R., *et al.* 2025. Wild Edible Mushrooms of Jharkhand: Nutrient-Dense Seasonal Foods to Improve Dietary Diversity among Indigenous Communities. *Current research in nutrition and food science*, **13(1):**61; Doi: 10.12944/CRNFSJ.13.1.4.

Sitati, C. N., Ogila, K. O., Waihenya, R. W., *et al.* 2021. Phytochemical profile and antimicrobial activities of edible mushroom *Termitomyces striatus*. *Evidence Based Complementary and Alternative Medicine*, **2021(1):** 3025848; Doi: https://doi.org/10.1155/2021/3025848.

Trịnh, B.A., Nguyen, H.T.D., Nguyen, N.A., *et al.* 2025. Assessment of Mycochemical composition and biological activities of extracts from *Humphreya endertii*. *Research Journal of Biotechnology*, **20:** 5; Doi: https://doi.org/10.25303/205rjbt1350141.

Ye, Z., Zhu, X., Zhi, Y., *et al.* 2026. The role of forest mushroom systems in soil fungal community reorganization and carbon fractions. *Agriculture, Ecosystems & Environment*, **397**, 110073; Doi: https://doi.org/10.1016/j.agee.2025.110073.

Yemm, E. W. and Willis, A. 1954. The estimation of carbohydrates in plant extracts by anthrone. *Biochemical journal*, ***57*(3):** 508; Doi: 10.1042/bj0570508.

Zhang, Y., Mo, M., Yang, L., *et al.* 2021. Exploring the species diversity of edible mushrooms in Yunnan, Southwestern China, by DNA barcoding. *Journal of Fungi*, ***7*(4),** 310; Doi: https://doi.org/10.3390/jof7040310.

.