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*Research Article*

# Molecular identification and proximate composition of wild edible wood growing mushrooms of Mizoram, North East India for food safety and livelihood

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**Abstract**
Exploring the nutritional attributes of wild edible mushrooms can be vital in addressing global food security. However, there is a dearth of studies on wild edible mushrooms regarding their identification, nutritional status, and molecular characterization in Mizoram, North East India, an integral landscape of the Indo-Burma hotspot region. In the present study, samples of wild edible wood-growing mushrooms were collected from the Mamit and Champhai District of Mizoram. The present study investigated the identities and phylogenetic relationships of the eight fungal species using molecular approaches. The mushrooms were identified up to the species level based on fungal sequences with known identities in GenBank, viz. *Auricularia delicata*, *Laetiporus sulphureus*, *Panus roseus*, *Lentinus squarrosulus*, *Pleurotus cystidiosus*, *Pleurotus djamor*, *Pleurotus pulmonarius* and *Schizophyllum commune*. Further, the identified mushrooms were analysed for macro and micro-nutritional values to assess their suitability for human dietary intake. Results revealed that the collected wild edible mushrooms were rich sources of protein (17.79 - 36.46 g/100 g), carbohydrates (58.14 - 33.77 g/100 g) and fibres (5.63 - 8.32 g/100 g), while the amount of fat (1.93 - 2.77 g/100 g) was low. In addition to bio-molecules, the mushroom samples contained appreciable amounts of essential minerals. Therefore, the selected mushrooms can be used as a potential foodstuff and may also be used as a supplementary protein diet to maintain human health and help achieve food security and sustainable development goals. The present results encourage bio-prospecting, and the need to explore wild edible mushrooms further, especially in the least explored global biodiversity hotspots for sustainable livelihood.

**Keywords:** Epixylic, Food, Molecular identification, Nutrients, Wild edible mushrooms

## INTRODUCTION

Wild edible mushrooms are a promising food source that can address global issues like food security and sustainability. These wild edible mushrooms can be cultivated in various environments, yielding high yields per unit area by simple utilization of organic waste materials. Their high nutritional properties contribute to

improved health and well-being, combating malnutrition. Cultivation of wild edible mushrooms aligns with UNSDGs such as zero hunger (SDG 2) and health and well-being (SDG 3) (Pandey *et al.,* 2018; El-Ramady *et al.,* 2022). WEM and the fruiting body of higher fungi have been used as a food source by human society since ancient times (Mattila *et al*., 2001; Karunarathna *et al*., 2024). There has been an increasing trend in the consumption of wild edible mushrooms due to their rich nutritional value (Gunasekara *et al*., 2021; Thachunglura *et al*., 2023), along with both low and high-molecular-weight carbohydrates (Zhou *et al*., 2016), making them a favored delicacy in numerous countries. Edible mushrooms have been valued for their role in sustaining health, primarily due to their significant protein content, essential amino acids, fibers, carbohydrates, vitamins, and minerals (Li *et al*., 2021; Wang and Zhao, 2023). Mushrooms provide a range of health benefits, such as antioxidants, antimicrobial properties, anticancer effects, cholesterol regulation, and immune system stimulation (Hyde *et al*., 2019; Galappaththi *et al*., 2022; Maaloul *et al*., 2023). Edible mushrooms, in particular, contain a high level of beneficial compounds like polyphenols, polysaccharides, vitamins, and carotenoids, which make them a great source of antioxidants. Both edible and medicinal mushrooms are highly valued for their natural abundance of antioxidants, which contribute significantly to overall health and vitality (Kozarski *et al*., 2015; Mwangi *et al*., 2022; Khumlianlal *et al*., 2022). Mushrooms are also one of the most significant natural sources of food consumed by the tribal people in India (Agrahar-Murugkar and Subbulakshmi, 2005; Sargunam *et al*., 2012; Zothanzama *et al*., 2018; Khumlianlal *et al*., 2024).

Mizoram, an ecologically relevant state within the Indo-Burma biodiversity hotspot, showcases rich biodiversity, with diverse flora and fauna, including many endemic species (Rai and Lalramnghinglova, 2011; Lalarzovi and Lalnuntluanga, 2022). The high humidity during the monsoon season in Mizoram creates an ideal atmospheric environmental condition that supports the abundant growth and diversity of edible macrofungi (Lalrinawmi *et al*., 2017; Chawngthu *et al*., 2024; Thachunglura *et al*., 2024a). In various parts of the world, the study of wild edible mushrooms for their nutritional properties has unveiled diverse, sustainable food sources and health benefits, enriching global dietary knowledge (Bernas *et al*., 2006; Ouzouni *et al*., 2009; Atri *et al*., 2013; Sudheep and Sridhar, 2014; Paloi *et al*., 2023). Past studies have identified several wild edible mushrooms based on their morphology and molecular characteristics (Lallawmsanga *et al*., 2016; Zothanzama *et al*., 2018; Zohmangaiha *et al*., 2023; Thachunglura *et al*., 2024b); however, such studies are scant in the context of Mizoram, North East India. To this end, data and knowledge on the nutritional value of wild edible mushrooms in Mizoram are very scarce, fragmentary, and quiet compared to the higher plants. Most of the frequently used edible wild mushrooms are collected by the marginal section of society and sold in local and city markets (Zothanzama *et al*., 2018). However, a large number of wild edible mushrooms remain unidentified in Mizoram, and explicit characterization of their nutritional value and reliable identification is urgently required.

In recent times, considering the increasing interest of people in the dietary consumption of mushrooms, the bio-prospecting of mushrooms in the Indo-Burma biodiversity hotspot is extremely essential in terms of their assessment for nutritional quality and suitability for consumption. The reduction in fertile arable land and increased food insecurity raises the marketing value of wood-growing mushrooms and Mizoram is no exception. Therefore, wild edible mushrooms require serious research to provide knowledge and awareness to the people and other stakeholders about mushroom cultivation. In light of these knowledge gaps, the present study aimed to identify the molecular characteristics and determine the proximate chemical composition of Mizoram's wild edible wood-growing mushroom fungal species to assess their nutritive potential.

## MATERIALS AND METHODS

### Sample collection, transportation and processing

The samples of wood-growing wild edible mushrooms were collected in the fields from Mamit and Champhai Districts of Mizoram. Mamit District lies between 23.8377° N 92.5396° E in northwestern Mizoram. It is characterized by hilly terrain and lush green forests, while Champhai District in the east is marked by its mountainous landscapes, steep slopes, and proximity to the India-Myanmar border, and lies between 23.6357° N, 93.1780° E (Fig. 1). The collected samples were cleaned with a plastic knife to remove forest debris. The collected mushrooms were identified *in situ* if possible and morphological observations such as pileus, lamellae, stipe, spore print and color were assessed from fresh samples (Largent and Stuntz, 1977; Lodge *et al*., 2004; Zothanzama, 2011) or else the specimens were retained for later identification and photographs were taken in the field. The samples were carefully labelled and kept in air-tight containers before transporting to the laboratory. The fleshy collected mushroom samples were oven-dried at 45° C for 3 days to obtain a constant weight and ground into fine powder for proximate analysis.

### Molecular analysis of specimens

DNA was extracted using the Cetyltrimethylammonium

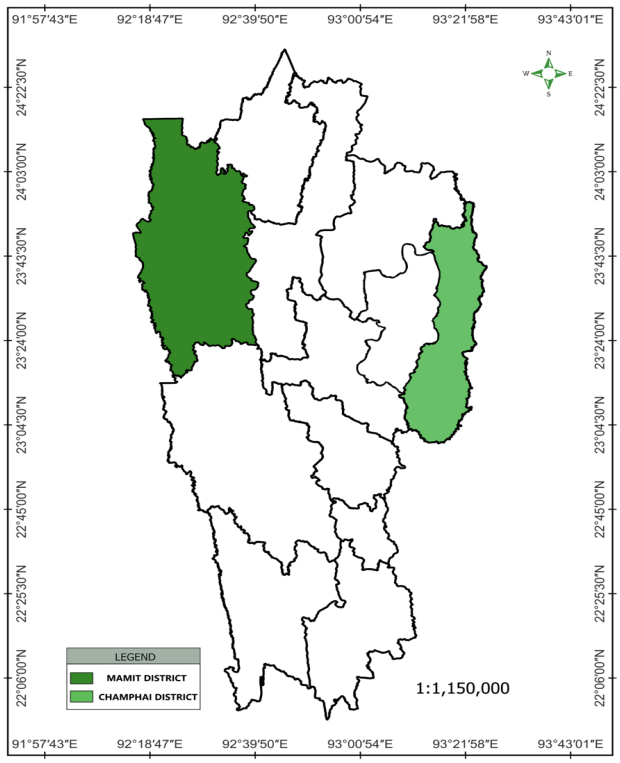


**Fig. 1.** *Map of Mizoram indicating the study site Mamit District and Champhai District*

Bromide (CTAB) method (Zothanzama *et al*., 2018). A small amount of fungal tissue was homogenized in CTAB lysis buffer, incubated at 65°C for cell lysis, and purified with chloroform. The supernatant was transferred to a new tube, mixed with isopropanol, and incubated at -20°C to precipitate DNA. After centrifugation, the DNA pellet was washed with 70% ethanol, air-dried, and resuspended in 100 µL of sterile water.

Polymerase Chain Reaction (PCR) amplification targeted the Internal transcribed spacer (ITS) region using primers ITS1-F and ITS4 (White *et al*., 1990). Reactions (25.5 µL) contained GoTaq Green MasterMix (Promega), primers (1 µL each, 5 µM), template DNA (1 µL), and nuclease-free water. Thermocycling conditions included initial denaturation (94°C, 5 min), 35 cycles of denaturation (94°C, 1 minute), annealing (52°C, 1 minute), extension (72°C, 1 minute), and final elongation (72°C, 5 minute). Amplicons were visualized via agarose gel electrophoresis and sequenced bidirectionally using Sanger sequencing. Consensus sequences were aligned in BioEdit (Hall, 1999) and compared to GenBank entries via BLASTn (Altschul *et al*., 1990). Phylogenetic trees were constructed in rAxML GUI using ClustalW-aligned sequences (Larkin *et al*., 2007).

### Phylogenetic analysis

Phylogenetic analysis of the eight fungal isolates was performed using ITS gene data with Maximum Likelihood (ML) and Neighbor-Joining (NJ) in rAxML GUI. Alignment gaps were treated as missing data, and NJ trees were based on total character differences with 1,000 bootstrap replicates.

### Analytical methods

Moisture, protein, fat, crude fiber and ash content of the identified mushroom samples were determined on a dry weight basis using the standard methods of the Association of Official Analytical Chemists (AOAC, 2000). The moisture content was determined by drying the sample at 105 °C, and 2 g was taken in a porcelain crucible and placed into a hot air oven (HAO) at 105 ºC for 3 h. The sample was cooled in a desiccator, and the difference between the sample weight before and after drying was used to measure the moisture content percentage. Total nitrogen (N) was determined by the microKjeldahl method, and protein content was calculated as total N × 6.25. Fat content was determined by extracting the sample using the Soxhlet apparatus with petroleum ether for 14 h; crude fibre was determined by acid and alkali digestion. The ash content was determined by incinerating the known weight of samples in porcelain crucibles in a muffle furnace at 550 °C for 6 h.

The total carbohydrate was calculated by difference (total carbohydrates (%) = 100 − [moisture (%) + protein (%) + fiber (%) + fat (%) + ash (%)] (Raghuramulu *et al*., 2003) and energy value was calculated by following the equation given by Crisan and Sands (1978) conversion factors: [Energy value (kcal/100 g) = (2.62 x % protein) + (8.37 x % fat) + (4.2 x % carbohydrate)] Eq.1.

Minerals such as calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na) and zinc (Zn) were evaluated using an Atomic absorption spectrophotometer (Shimadzu AA-7000; Shimadzu Corporation, Japan) after dry ashing of the sample (Isildak *et al*., 2004) with detection of limits ranges between 0.01 to 0.09 ppm.

### Statistical analysis

The analysis of all the mushrooms was done in triplicate on a dry weight basis. All the experimental results were the mean of three replicates, and the data were expressed as Mean ± standard deviation. Statistical analysis was conducted using the GraphPad Prism 5.0 (GraphPad Software, Inc., USA). Statistical analysis was done by one-way analysis of variance (ANOVA) with Tukey's multiple comparisons test ($P < 0.05$).

## RESULTS AND DISCUSSION

### Identification of specimen

The nucleotide sequences of the mushrooms blasted against sequences from GenBank database revealed the identification of eight representative fungal isolates

**Table 1.** Showing list of mushroom species, their collection site, family, and order

| Species | Collection Site | Family | Order |
|---|---|---|---|
| *Auricularia delicata* (Mont. ex Fr.) Henn. | Mamit District | Auriculariaceae | Auriculariales |
| *Laetiporus sulphureus* (Bull.) Murrill | Champhai District | Laetiporaceae | Polyporales |
| *Panus roseus* (Karun., K.D. Hyde & Zhu L. Yang) *N. Vinjusha* & T.K.A. Kumar | Mamit District | Panaceae | Polyporales |
| *Lentinus squarrosulus* Mont. Singer | Mamit District | Polyporaceae | Polyporales |
| *Pleurotus cystidiosus* O.K. Mill | Mamit District | Pleurotaceae | Agaricales |
| *Pleurotus djamor* (Rumph. ex Fr.) Boedijn | Mamit District | Pleurotaceae | Agaricales |
| *Pleurotus pulmonarius* (Fr.) Quél. | Champhai District | Pleurotaceae | Agaricales |
| *Schizophyllum commune* Fr. | Champhai District | Schizophyllaceae | Agaricales |

from Mizoram. According to the blast, samples mostly resembled with *Auricularia delicata* (JZT-VL/016), *Laetiporus sulphureus* (JZT-VL/011), *Panus roseus* (JZT-VL/012), *Lentinus squarrosulus* (JZT-VL/018), *Pleurotus cystidiosus* (JZT-VL/019) *Pleurotus djamor* (JZT-VL/023), *Pleurotus pulmonarius* (JZT-VL/009) and *Schizophyllum commune* (JZT-VL/007). The fruiting bodies of the collected sample are represented in Fig. 2, and their phylogenetic tree is given in Fig. 3.

Among the identified species, some species (*A. delicata*, *La. sulphureus*, *L. squarrosulus*, *Pl. djamor*, *Pl. pulmonarius*, and *S. commune*) are recognized as having high nutritional value and are widely consumed in various parts of the world (Mortimer *et al*., 2014; Bandara *et al*., 2019; Torres-Martínez *et al*., 2022; Wang *et al*., 2023). However, it appears that many of these species are not traditionally consumed by the people of Mizoram. On the other hand, *L. squarrosulus* and *S. commune* are only known to be commonly consumed by the indigenous people of Mizoram. Species like *A. delicata*, *P. roseus* and *Pl. pulmonarius* are consumed only by a small population in the region. Limited knowledge of mycology restricts the consumption of wild edible mushrooms in Mizoram (Zothanzama *et al*., 2018). The collection site and their respective family and order are mentioned in Table 1.

The ITS1-5.8S-ITS2 DNA sequences of the eight fungal isolates were compared with 34 reference sequences of fungal species from the database. The species, voucher numbers, GenBank accession numbers, and localities of the 34 corresponding sequences used for the analysis to construct the phylogenetic tree are presented in Table 2. In the Maximum Likelihood tree generated, the specimens of the different species of fungi clustered with their related species with high support values. Clade A included *La. sulphureus* alongside the specimen JZT-VL/011. Clade B comprised *Lentinus* and *Panus* species, which were closely related in the phylogenetic tree. Clade C was formed by *A. delicata*, while clade D contained *Pleurotus* species. Clade E grouped *S. commune* with the present species, exhibiting strong support. *Amanita spissacea* was used as an outgroup. Blast search showed that each isolate is <96% identity with query coverage of <96%.

**Proximate composition of wild edible mushrooms**

The results of the nutritive value of selected wild edible wood-growing mushrooms are shown in Table 3. In this context, it can be noted that the growth characteristics, stage of development and post-harvest condition of edible mushrooms may influence their nutritional value (Klomklung et *al*., 2014; Valverde *et al*., 2015; Dawadi *et al*., 2022).

Edible mushrooms had approximately 90% of moisture and 10% of dry matter, while fresh and dried mushrooms had approximately 90% of dry matter and 10% of moisture (Kurtzman, 1975; Crisan and Sands,


**Fig. 2.** *Fruiting body of (A) Auricularia delicata (B) Laetiporus sulphureus (C) Panus roseus (D) Lentinus squarrosulus (E) Pleurotus cystidiosus (F) Pleurotus djamor (G) Pleurotus pulmonarius (H) Schizophyllum commune*

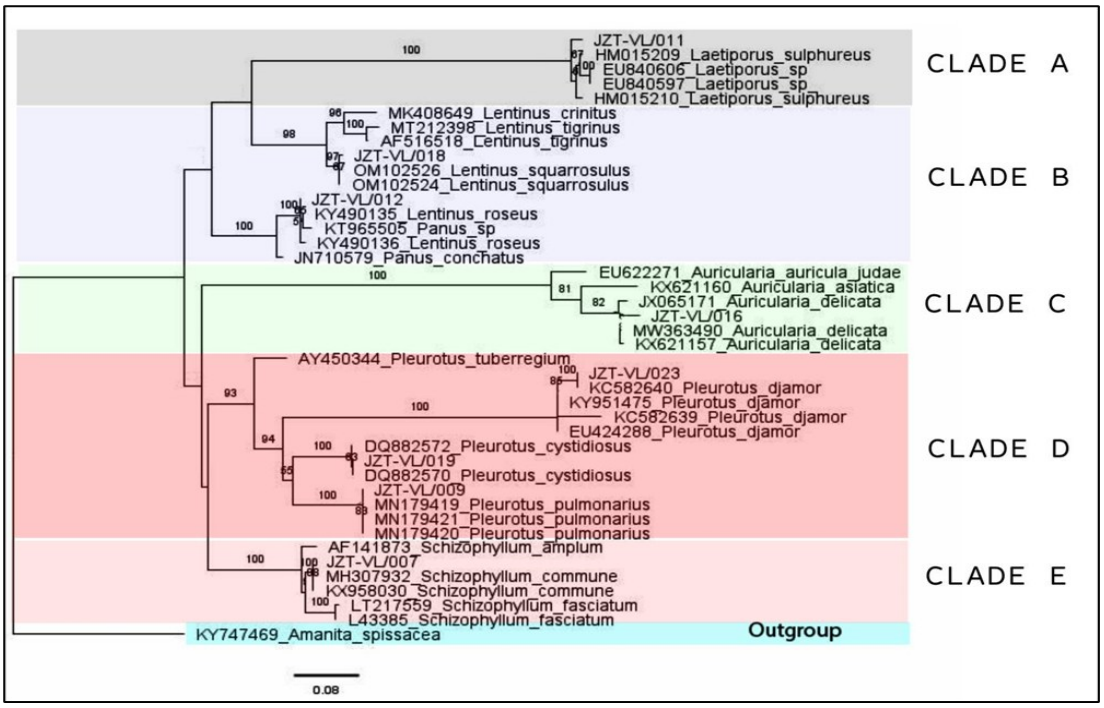


**Fig. 3.** *Phylogenetic tree - Evolutionary history inferred by using the Maximum Likelihood method based on the GTR-GAMMA model. Tree is drawn to scale, with branch lengths measured in the number of substitutions per site. Analysis involved 42 nucleotide sequences. Evolutionary analyses were conducted in raxmlGUI 2.0*

1978). Moisture content is vital to sustain mushrooms' physical and chemical properties (Shams *et al*., 2022). There was considerable variation in the moisture content of the mushrooms analysed in the present study, ranging from 8.06% in *S. commune* to 12.39% in *A. delicata*.

The protein contents of the studied wild edible mushrooms were generally high and varied from 17.79 g/100 g in *A. delicata* to 36.46 g/100 g in *P. roseus*. Particularly, *P. roseus*, *L. squarrosulus*, *Pl. cystidiosus*, *Pl. djamor* and *Pl. pulmonarius* exhibited protein content ranging from 32.96 to 34.12 g/100g, which is consistent with the 19–35% protein range reported by several authors (Chang and Buswell, 1996; Rugolo *et* al., 2023; Sousa *et al*., 2023). Analysis of *La. sulphureus* by Teke *et al*. (2021) showed 8.62 g/100 g crude protein, which is substantially low in comparison to the protein content (21.29 g/100 g) obtained in the Indian sample of *La. sulphureus*. However, it aligns with the report by Saha *et al.* (2014) on *La. sulphureus* (21 g/100 g). It is known that protein content varies widely according to the type of mushrooms, the level of nutrient nitrogen and location (Bernas *et al*., 2006; Kaur *et al*., 2022).

Fats contents were relatively low in the studied mushrooms, ranging from 1.93 g/100 g in *S. commune* to 2.77 g/100 g in *Pl. pulmonarius*. Interestingly, the fat content values of *L. squarrosulus* (2.67 g/100 g) in the present study were lower when compared with the study of Nwanze *et al*. (2006), who noted considerably higher fat content in *L. squarrosulus* stipe (6.01 g/100 g) and pileus (6.56 g/100 g). However, the present results of *S. commune* (1.21 g/100 g) and *L. squarrosulus* ( 2.31 g/100 g) fat contents are consistent with Gunasekara *et al*. (2021) for *L. squarrosulus* (2.31 g/100 g) and *S. commune* (1.21 g/100 g). Mushrooms are known to be low in fats, and the lower fat content values of the present study were also in agreement with several studies on different mushroom species (Agrahar-Murugkar and Subbulakshmi, 2005; Pushpa and Purushothama, 2010; Lallawmsanga *et al*., 2016). Mushrooms, characterized by their low fat content and abundant essential unsaturated fatty acids, are ideal for the human diet and health (Nakalembe *et al*., 2015).

Maximum value of fiber was recorded for *L. squarrosulus* (8.32 g/100 g), while minimum was noted in the case of *S. commune* (5.63 g/100 g). These results on fiber contents were in agreement with earlier reports of Silva *et al*. (2002) for *Pl. pulmonarius*, Rai and Sohi (1988) for *Lentinus* and *Panus* species, Raman *et al*. (2020) for *Pl. djamor* and Luangharn *et al*. (2014) for *La. sulphureus*. Fibers in mushrooms are vital as they can promote healthy digestion, aid in maintaining a healthy weight, and support heart health. The ash content of the mushrooms consists of unburnable inorganic salts, with phosphorus and potassium being the main components. However, ash content does not provide direct information about the macronutrient value of mushrooms, such as proteins, fats and carbohydrates (Mattila *et al*., 2001; Ouzouni *et al*., 2009; Sifat *et al*., 2020). It is an indication of the mineral content of the mushrooms. The ash content

**Table 2.** List of the mushroom species used for phylogenetic analysis, along with their voucher numbers, GenBank accession numbers, and localities

| No | Voucher | Accession Number | Species Name | Locality |
|---|---|---|---|---|
| 1 | FUM-093 | KY951475 | *Pleurotus djamor* | Malaysia |
| 2 | ABM1049204 | KC582640 | *Pleurotus djamor* var. *roseus* | Malaysia |
| 3 | ABM1049203 | KC582639 | *Pleurotus djamor* var. *roseus* | Malaysia |
| 4 | CBS 665.85 | EU424288 | *Pleurotus djamor* | China |
| 5 | OR1214 | KY747469 | *Amanita cf. spissacea* | Belgium |
| 6 | A.S-E 2018-03-04.1 | MH307932 | *Schizophyllum commune* | Luxembourg |
| 7 | 15R-5-F01 | KX958030 | *Schizophyllum commune* | China |
| 8 | CBS267.60. | LT217559 | *Schizophyllum fasciatum* | Spain |
| 9 | CBS 267.60 | L43385 | *Schizophyllum fasciatum* | Mexico |
| 10 | | AF141873 | *Schizophyllum amplum* | Sweden |
| 11 | Blao clone A 1 | DQ882570 | *Pleurotus cystidiosus* | Japan |
| 12 | S396 clone A | DQ882572 | *Pleurotus cystidiosus* | Japan |
| 13 | | AY450344 | *Pleurotus tuberregium* | USA |
| 14 | LE(BIN)0861 SBI | AF516518 | *Lentinus tigrinus* | USA |
| 15 | SR1352 | MT212398 | *Lentinus tigrinus* | India |
| 16 | LSQBot | OM102524 | *Lentinus squarrosulus* | Philippines |
| 17 | LSQOs | OM102526 | *Lentinus squarrosulus* | Philippines |
| 18 | EF58b | MK408649 | *Lentinus crinitus* | Brazil |
| 19 | HKAS 94714 | KY490136 | *Lentinus roseus* | China |
| 20 | HKAS 94715 | KY490135 | *Lentinus roseus* | China |
| 21 | X1234 | JN710579 | *Panus conchatus* | Finland |
| 22 | FBD167 | KT965505 | *Panus* sp. | Vietnam |
| 23 | CNSBlitz0098 | JX065171 | *Auricularia delicata* | USA |
| 24 | clone rlc-526 | MW363490 | *Auricularia delicata* | China |
| 25 | MFLU162117 | KX621157 | *Auricularia delicata* | Thailand |
| 26 | BBH895 | KX621160 | *Auricularia asiatica* | Thailand |
| 27 | NW486 | EU622271 | *Auricularia auricula-judae* | China |
| 28 | NSK 1014215 | MN179421 | *Pleurotus pulmonarius* | Russia |
| 29 | NSK 1014280 | MN179420 | *Pleurotus pulmonarius* | Russia |
| 30 | NSK 1014279 | MN179419 | *Pleurotus pulmonarius* | Russia |
| 31 | LAE10-LS04 | HM015210 | *Laetiporus sulphureus* | Poland |
| 32 | LAE09-LS03 | HM015209 | *Laetiporus sulphureus* | Poland |
| 33 | KATRIN-2 | EU840606 | *Laetiporus* sp. | Sweden |
| 34 | RVP2 | EU840597 | *Laetiporus* sp. | Sweden |

was highest in *P. roseus* (7.74 g/100 g) and lowest in *Pl. cystidiosus* (5.84 g/100 g). The recorded values of ash content were similar to the report of Khan *et al*. (2013) for *Pl. djamor*, Okwulehie *et al*. (2014) for *Pl. pulmonarius*, Ao and Deb (2019) for *S. commune* and *La. sulphureus*. Wide variation in ash content of the present investigation might be due to the fact that the relatively young mushrooms' fruiting bodies were noted to have higher ash content than the mature ones (Kalmis *et al*., 2011).

Carbohydrate content was found to be abundant in all tested samples, constituting mushroom's main nutritional value, ranging from 33.77 g/100 g in *P. roseus* to 58.14 g/100 g in *S. commune*. In the present nutritional analysis on carbohydrate content, the results of *S. commune* was reasonably higher as compared with previous studies of Kumar *et al*. (2013) for *S. commune* (32.43 g/100 g), while it was quite similar to those reported by Rampinelli *et al*. (2010) for *Pl. djamor* and Vishwakarma *et al*. (2017) for *Pl. cystidiosus.*

**Table 3.** Showing proximate composition of wild edible wood growing mushrooms on dry weight basis

| Mushroom Species | Moisture (g/100 g) | Protein (g/100 g) | Fat (g/100 g) | Fiber (g/100 g) | Ash (g/100 g) | CHO (g/100 g) | Energy Kcal/100 g |
|---|---|---|---|---|---|---|---|
| *Auricularia delicata* | 12.39 ±0.18$^{a}$ | 17.79 ± 1.01$^{c}$ | 1.96 ± 0.16$^{b}$ | 6.52 ± 0.20$^{abc}$ | 6.31 ± 0.07$^{bc}$ | 54.73 ± 1.46$^{a}$ | 293.3 ± 2.53$^{ab}$ |
| *Laetiporus sulphureus* | 9.25 ±0.19$^{c}$ | 21.29 ± 0.50$^{c}$ | 2.05 ± 0.14$^{ab}$ | 7.01 ± 0.32$^{abc}$ | 6.58 ± 0.31$^{bc}$ | 54.17 ± 0.53$^{a}$ | 300.5 ±1.96$^{a}$ |
| *Panus roseus* | 11.83 ± 0.12$^{ab}$ | 36.46 ± 0.50$^{a}$ | 2.20 ± 0.09$^{ab}$ | 7.99 ± 0.34$^{a}$ | 7.74 ± 0.18$^{a}$ | 33.77 ± 0.56$^{c}$ | 255.8 ±1.49$^{d}$ |
| *Lentinus squarrosulus* | 10.24 ± 0.11$^{bc}$ | 34.10 ± 0.87$^{ab}$ | 2.67 ± 0.17$^{ab}$ | 8.32 ± 0.54$^{a}$ | 7.18 ± 0.14$^{ab}$ | 36.58 ± 1.00$^{c}$ | 268.7 ± 4.67$^{cd}$ |
| *Pleurotus cystidiosus* | 10.19 ± 0.11$^{bc}$ | 33.54 ± 1.34$^{ab}$ | 2.15 ± 0.19$^{ab}$ | 6.03 ± 0.19$^{b}$ | 5.84 ± 0.12$^{c}$ | 42.24 ± 1.14$^{b}$ | 278.0 ± 9.35$^{bc}$ |
| *Pleurotus djamor* | 10.21 ± 0.04$^{bc}$ | 32.96 ± 0.50$^{b}$ | 2.71 ± 0.16$^{ab}$ | 8.29 ± 0.24$^{a}$ | 7.04 ± 0.41$^{ab}$ | 38.35 ± 0.43$^{bc}$ | 270.1 ± 3.45$^{cd}$ |
| *Pleurotus pulmonarius* | 11.36 ± 1.11$^{ab}$ | 34.12 ± 0.88$^{ab}$ | 2.77 ± 0.13$^{a}$ | 8.21 ± 0.14$^{a}$ | 5.98 ± 0.12$^{bc}$ | 38.19 ± 0.64$^{bc}$ | 272.8 ± 1.36$^{bcd}$ |
| *Schizophyllum commune* | 8.06 ±0.05$^{d}$ | 19.59 ± 0.47$^{c}$ | 1.93 ± 0.21$^{b}$ | 5.63 ± 0.67$^{c}$ | 6.99 ± 0.19$^{ab}$ | 58.14 ± 1.45$^{a}$ | 310.7 ±2.53$^{a}$ |

Each value is expressed in mean ± SD, (n = 3); In each column, different letters mean significant differences between species ($p < 0.05$)

Therefore, wild edible mushrooms are a good source of carbohydrates and their contents vary greatly and generally range from 28.38 g/100 g to 84.48 g/100g on a dry weight basis (Wang *et al*., 2001; Pushpa and Purushothama, 2010; Shin *et al*., 2007). Carbohydrates are an essential part of a healthy diet and provide an important energy source for the human body. Energy values ranged from 255.8 Kcal/100 g in *P. roseus* to 310.7 Kcal/100 g in *S. commune*. This was in agreement with the results of Manjunathan and Kaviyarasan (2010) and Nakalembe *et al*. (2015). The average nutritional values across eight samples indicated 10.44 ± 1.4 (g/100 g) of moisture, 26.34 ± 12.46 (g/100 g) of proteins, 2.31 ± 0.35 (g/100 g) of fat, 7.25 ± 1.10 (g/100 g) of fibre, 6.71 ± 0.65 (g/100 g) of ash, 44.52 ± 9.60 (g/100 g) of carbohydrates, and an energy value of 281.24 ± 18.5 (Kcal/100 g).

Table 4 presents the mineral content of eight wild edible mushrooms. Among these minerals, potassium was identified as the most abundant, followed by iron and calcium, while manganese was the least abundant mineral found in the mushrooms. *L. squarrosulus* exhibited the highest potassium (1925.50 mg/100 g), calcium (221.22 mg/kg), iron (216.91 mg/kg), magnesium (115.62 mg/kg), and zinc (221.61 mg/kg) levels, while *A. delicata* recorded the lowest contents of potassium (1204.09 mg/100 g), calcium (57.44 mg/kg), iron (65.06 mg/kg) and magnesium (23.97 mg/kg). Regarding zinc, *S. commune* had the lowest content (36.97 mg/kg). Lastly, *S. commune* showed the highest sodium (215.58 mg/kg) and manganese (23.37 mg/kg) levels, while *P. roseus* had the lowest sodium (115.83 mg/kg) content, and *Pl. cystidiosus* had the lowest manganese content (6.25 mg/kg). The analyzed mushrooms fulfil a significant portion of the daily requirements for various essential minerals, aligning with findings from several studies in the literature (Isildak *et al*., 2004; Gençcelep *et al*., 2009; Teke *et al*., 2021).

The mineral contents in wild edible mushrooms can vary significantly due to several factors, including the species of mushroom, the environmental conditions in which they are grown, and the substrate they feed on (Liu *et al*., 2022; Mleczek *et al*., 2024). Nutrient availability in the soil, climate, and the presence of specific microorganisms can all influence the mineral uptake and accumulation in mushrooms. Moreover, harvesting methods and post-harvest processing may also affect the final mineral content of these fungi, highlighting the importance of understanding the ecological context in which wild mushrooms grow. To our knowledge, the present study provides an initial insight into the nutritional chemistry of wild edible mushrooms in a global biodiversity hotspot. Elucidating the nutritional value of wild edible mushrooms bears a tight interrelationship with food security and the livelihood of local indigenous people.

**Table 4.** Showing contents of essential minerals in wild edible mushrooms (mg/kg or mg/100g in dw)

| Mushroom Species | Ca (mg/kg) | Iron (mg/kg) | Magnesium (mg/kg) | Manganese (mg/kg) | Potassium (mg/100g) | Sodium (mg/kg) | Zinc (mg/kg) |
|---|---|---|---|---|---|---|---|
| *Auricularia delicata* | 57.44 ±0.98$^{h}$ | 65.06 ±0.878$^{h}$ | 23.97 ±0.37$^{h}$ | 22.78 ±0.58$^{ab}$ | 1204.09 ±3.33$^{h}$ | 179.28 ±0.73$^{b}$ | 75.68 ±0.57$^{g}$ |
| *Laetiporus sulphureus* | 179.61 ±0.77$^{c}$ | 203.74 ±0.64$^{b}$ | 45.74 ±0.39$^{d}$ | 15.96 ±0.64$^{d}$ | 1752.13 ±4.07$^{c}$ | 157.58 ±0.68$^{d}$ | 165.42 ±0.97$^{c}$ |
| *Panus roseus* | 98.78 ±0.41$^{f}$ | 114.82 ±0.83$^{f}$ | 38.93 ±0.45$^{f}$ | 14.45 ±0.23$^{ef}$ | 1252.33 ±1.43$^{g}$ | 115.83 ±0.39$^{h}$ | 181.95 ±0.82$^{b}$ |
| *Lentinus squarrosulus* | 221.22 ±0.72$^{a}$ | 216.91 ±1.28$^{a}$ | 115.62 ±0.84$^{a}$ | 22.99 ±0.44$^{ab}$ | 1925.50 ±0.7$^{a}$ | 148.12 ±0.68$^{e}$ | 221.61 ±1.07$^{a}$ |
| *Pleurotus cystidiosus* | 195.16 ±0.92$^{b}$ | 174.04 ±0.66$^{c}$ | 57.07 ±0.79$^{b}$ | 6.25 ±0.27$^{g}$ | 1457.28 ±1.32$^{e}$ | 124.19 ±0.29$^{g}$ | 134.95 ±0.29$^{e}$ |
| *Pleurotus djamor* | 144.43 ±0.68$^{e}$ | 157.06 ±0.65$^{d}$ | 48.11 ±0.74$^{e}$ | 13.29 ± 0.56$^{f}$ | 1422.68 ± 0.68$^{f}$ | 145.6 ± 0.64$^{f}$ | 162.1 ±0.29$^{d}$ |
| *Pleurotus pulmonarius* | 163.08 ±0.78$^{d}$ | 143.34 ±0.55$^{e}$ | 53.4 ±0.24$^{c}$ | 21.95 ±0.38$^{b}$ | 1821.74 ±1.4$^{b}$ | 166.25 ±0.82$^{c}$ | 85.41 ±1.18$^{f}$ |
| *Schizophyllum commune* | 78.41 ±0.95$^{g}$ | 70.22 ±0.88$^{g}$ | 34.47 ±0.71$^{g}$ | 23.37 ±0.55$^{a}$ | 1642.39 ±2.22$^{d}$ | 215.58 ±0.84$^{a}$ | 36.97 ±0.63$^{h}$ |

Each value is expressed in mean ± SD, (n = 3); In each column, different letters mean significant differences between species ($p < 0.05$)

## Conclusion

Molecular analysis in the present study confirmed the presence of eight wild edible mushroom species in Mizoram. The study also evaluated the nutritional chemistry and phylogenetic insight of eight species of wild edible mushrooms belonging to five different families. The wild edible mushrooms were observed to be an excellent source of macronutrients and micronutrients. These mushrooms were found to be rich in macronutrients and micronutrients, making them a valuable source of human nutrition. Additionally, they support immune health and contribute to food security by addressing malnutrition and diversifying diets, especially in regions with limited food availability. More research is warranted on the antioxidant properties of the eight wild edible mushrooms to provide a better understanding of their potential health benefits and food safety implications. This will help expand the knowledge of wild edible mushrooms and increase their market value for food security/-safety.

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## Conflict of interest

The authors declare that they have no conflict of interest.

## REFERENCES

1. Agrahar-Murugkar, D. & Subbulakshmi, G. (2005). Nutritional value of edible wild mushrooms collected from the Khasi hills of Meghalaya. *Food Chemistry*, 89(4), 599–603. https://doi.org/10.1016/j.foodchem.2004.03.042.
2. Altschul, S. F., Gish, W., Miller, W., Myers, E. W. & Lipman, D. J. (1990). Basic local alignment search tool. *Journal of Molecular Biology*, 215(3), 403–410. https://doi.org/10.1016/s0022-2836(05)80360-2.
3. Ao, T. & Deb, C. R. (2019). Nutritional and antioxidant potential of some wild edible mushrooms of Nagaland, India. *Journal of Food Science and Technology*, 56(2), 1084–1089. https://doi.org/10.1007/s13197-018-03557-w.
4. AOAC. (2000). Official methods of analysis. 17th edn. Methods 925.10, 65.17, 974.24, 992.16. Gaithersburg, MD: The Association of Official Analytical Chemists.
5. Atri, N. S., Sharma, S. K., Joshi, R., Gulati, A. & Gulati, A. (2013). Nutritional and Neutraceutical composition of five wild culinary-medicinal species of genus *Pleurotus* (Higher

Basidiomycetes) from Northwest India. *International Journal of Medicinal Mushrooms*, 15(1), 49–56. https://doi.org/10.1615/intjmedmushr.v15.i1.60.

6. Bandara, A., Rapior, S., Mortimer, P. E., Kakumyan, P., Hyde, K. D. & Xu, J. (2019). A review of the polysaccharide, protein and selected nutrient content of Auricularia, and their potential pharmacological value. *Mycosphere*, 10(1), 579–607. https://doi.org/10.5943/mycosphere/10/1/10.
7. Bernas, E., Jaworska, G. & Lisiewska, Z. (2006). Edible mushrooms as a source of valuable nutritive constituents. *Acta Scientiarum Polonorum, Technologia Alimentaria*, 5 (1); 5-20.
8. Crisan, E. V. & Sands, A. (1978) "Nutritional Value of Edible Mushroom," In: Chang, S.T. and Hayer, W. A. Eds., Biology and Cultivation of Edible Mushrooms, Academic Press, New York, pp. 137-168..
9. Dawadi, E., Magar, P. B., Bhandari, S., Subedi, S., Shrestha, S. & Shrestha J. (2022). Nutritional and post-harvest quality preservation of mushrooms: A review. *Heliyon*, 5;8(12):e12093. https://doi.org/10.1016/j.heliyon.e12093.
10. El-Ramady, H., Abdalla, N., Badgar, K., Llanaj, X., Törős, G., Hajdú, P., Eid, Y. & Prokisch, J. (2022). Edible mushrooms for sustainable and healthy human food: Nutritional and Medicinal Attributes. *Sustainability*, 14 (9):4941. https://doi.org/10.3390/su14094941.
11. Gençcelep, H., Uzun, Y., Tunçtürk, Y., & Demirel, K. (2009). Determination of mineral contens of wild-grown edible mushrooms, *Food Chemistry,* 113(4): 1033-1036. https://doi.org/10.1016/j.foodchem.2008.08.058.
12. Gunasekara, N. W., Nanayakkara, C. M., Karunarathna, S. C. & Wijesundera, R. L. C. (2021). Nutritional aspects of three *Termitomyces* and four other wild edible mushroom species from Sri Lanka. *Chiang Mai Journal of Science*, 48, 1236–1246.
13. Hall, T.A. (1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucl.Acids.Symp*. Ser. 41:95-98.
14. Hyde, K.D., Xu, J., Rapior, S., Jeewon, R., Lumyong, S., Niego, A. G. T., Abeywickrama, P.D., Aluthmuhandiram, J.V.S., Brahamanage, R.S., Brooks, S., Chaiyasen, A., Chethana, K.W.T., Chomnunti, P., Chepkirui, C., Chuankid, B., de Silva, N.I., Doilom, M., Faulds, C., Gentekaki, E., Stadler, M. (2019). The amazing potential of fungi: 50 ways we canexploit fungi industrially. *Fungal Diversity*, 97(1), 1–136. https://doi.org/10.1007/s13225-019-00430-9
15. Chang, S. T. & Buswell, J. A. (1996).Mushroom Nutriceuticals. *World Journal of Microbiology and Biotechnology*, 12, 473-476. https://doi.org/10.1007/BF00419460.
16. Chawngthu, Z., Vabeikhokhei, J.M.C., Zomuanpuii, R., Mandal, S.D., & Zothanzama, J. (2021) A new species of *Ophiocordyceps* (Ophiocordycipitaceae) from Mizoram, India. *Phytotaxa*, 500(1), 11–20. https://doi.org/10.11646/phytotaxa.500.1.2
17. Chawngthu, Z., Thachunglura, V. L., Zothanzama, J. & Khumlianlal, J. (2024). Risk assessment of heavy metals in wild mushroom from Mizoram, India. *Environmental Pollution and Management*, 1, 147–151. https://doi.org/10.1016/j.epm.2024.09.001
18. Galappaththi, M.C.A., Patabendige, N.M., Premarathne, B.M., Hapuarachchi, K.K., Tibpromma, S., Dai, D.Q., Suwannarach, N., Rapior, S., & Karunarathna, S.C. (2022). A Review of Ganoderma Triterpenoids and Their Bioactivities., 13(1), 24. https://doi.org/10.3390/biom13010024
19. Isildak, Ö., Turkekul, I., Elmastas, M. & Tuzen, M. (2004). Analysis of heavy metals in some wild-grown edible mushrooms from the middle black sea region, Turkey. *Food Chemistry*, 86(4), 547–552. https://doi.org/10.1016/j.foodchem.2003.09.007
20. Kalmis, E., Yildiz, H., Ergonul, B., Kalyoncu, F. & Solak, M. H. (2011). Chemical composition and nutritional value of a wild edible ectomycorrhizal mushroom, *Tricholoma anatolicum*. *Turkey Journal of Biology*, 35: 627-633. https://doi.org/10.3906/biy-0909-100.
21. Karunarathna, S. C., Lu, W., Patabedige, N., Zhao, C.-L. & Hapuarachchi, K. K. (2024). Unlocking the therapeutic potential of edible mushrooms: *Ganoderma* and their secondary metabolites as novel antiviral agents for combating COVID-19. *New Zealand Journal of Botany*, 1–59. https://doi.org/10.1080/0028825x.2024.2384453
22. Karunarathna, S. C., Yang, Z. L., Zhao, R. -L., Vellinga, E. C., Bahkali, A. H., Chukeatirote, E. & Hyde, K. D. (2011). Three new species of *Lentinus* from northern Thailand. *Mycological Progress*, 10(4), 389–398. https://doi.org/10.1007/s11557-010-0701-6.
23. Kaur, J., Singh, J., Bhadariya, V., Gogna, S., Jarial, S., Rasane, P. & Sharma, K. (2022). Edible mushrooms: A source of quality protein. Wild Mushrooms, 169–192. https://doi.org/10.1201/9781003152583-8.
24. Khan, N., Ajmal, M., Nickten, J., Aslam, S. & Ali, M. (2013). Nutritional value of *Pleurotus* (Flabellatus) *djamor* (R-22) cultivated on sawdusts of different woods. *Pakistan Journal of Botany*. 45. 1105-1108. https://eprints.bbk.ac.uk/id/eprint/9517.
25. Khumlianlal, J., Huidrom, S., Sharma, K. C., Thachunglura, V. L. & Indira, S. (2024). Proximate Analysis and Mineral Content of Wild Edible Mushrooms from Manipur, India. *International Journal of Current Microbiology and Applied Sciences*, 13(3), 269–275. https://doi.org/10.20546/ijcmas.2024.1303.026
26. Khumlianlal, J., Sharma, K. C., Singh, L. M., Mukherjee, P. K., & Indira, S. (2022). Nutritional profiling and antioxidant property of three wild edible mushrooms from North East India. Molecules (Basel, Switzerland), 27(17), 5423. https://doi.org/10.3390/molecules27175423.
27. Klomklung, N., Karunarathna, S. C., Hyde, K. D. & Chukeatirote, E. (2014). Optimal conditions of mycelial growth of three wild edible mushrooms from northern Thailand. *Acta Biologica Szegediensis*, 58: 39-43.
28. Kozarski, M., Klaus, A., Jakovljevic, D., Todorovic, N., Vunduk, J., Petrović, P., Niksic, M., Vrvic, M. M. & van Griensven, L. (2015). Antioxidants of Edible Mushrooms. *Molecules (Basel, Switzerland)*, *20*(10), 19489–19525. https://doi.org/10.3390/molecules201019489.
29. Kumar, R., Tapwal, A., Pandey, S., Borah, R. K., Borah, D. & Borgohain, J. (2013). Macro-fungal diversity and nutrient content of some edible mushrooms of Nagaland, India. *Nusantara Bioscie*nce, 5(1):1-7. https://doi.org/10.13057/nusbiosci/n050101.
30. Kurtzman, R. H. (1975). Mushrooms as a source of food proteins. In: Protein Nutritional Quality of Foods and

Feeds, part 2. Ed. Friedman M, Marcel D. New York. pp. 305- 318.
31. Lallawmsanga, Passari, A. K., Mishra, V. K., Leo, V. V., Singh, B. P., Valliammai Meyyappan, G., Gupta, V. K., Uthandi, S. & Upadhyay, R. C. (2016). Antimicrobial Potential, Identification and Phylogenetic Affiliation of Wild Mushrooms from Two Sub-Tropical Semi-Evergreen Indian Forest Ecosystems. *Plos One*, 11(11), e0166368. https://doi.org/10.1371/journal.pone.0166368.
32. Lalrinawmi, H., Vabeikhokhei, J.M.C., Zothanzama, J. & Chawngthu, Z. (2017). Edible mushrooms of Mizoram. *Science Vision*. 17(4).172-181. https://doi.org/10.33493/scivis.17.04.01.
33. Lalzarzovi, S.T. & Lalnuntluanga (2022). Plant species diversity in a tropical semi-evergreen forest in Mizoram (northeastern India): assessing the effectiveness of community conservation. *Journal of Threatened Taxa*, 14(5): 21055–21067. https://doi.org/10.11609/jott.7549.14.5.21055-21067
34. Largent, D.L. & Stuntz, D.E. (1977). How to Identify Mushrooms to Genus I: macroscopic features. Indiana University, Mad River Press, 86 p.
35. Larkin, M. A., Blackshields, G., Brown, N. P., Chenna, R., McGettigan, P. A., McWilliam, H., Valentin, F., Wallace, I. M., Wilm, A., Lopez, R., Thompson, J. D., Gibson, T. J. & Higgins, D. G. (2007). Clustal W and Clustal X version 2.0. *Bioinformatics*, 23(21), 2947–2948. https://doi.org/10.1093/bioinformatics/btm404.
36. Li, H., Tian, Y., Menolli, N., Ye, L., Karunarathna, S. C., Perez□Moreno, J., Rahman, M. M., Rashid, M. H., Phengsintham, P., Rizal, L., Kasuya, T., Lim, Y. W., Dutta, A. K., Khalid, A. N., Huyen, L. T., Balolong, M. P., Baruah, G., Madawala, S., Thongklang, N. … Mortimer, P. E. (2021). Reviewing the world's edible mushroom species: A new evidence□based classification system. *Comprehensive Reviews in Food Science and Food Safety*, 20(2), 1982–2014. Portico. https://doi.org/10.1111/1541-4337.12708
37. Liu, S., Liu, H., Li, J. & Wang, Y. (2022). Research Progress on Elements of Wild Edible Mushrooms. *Journal of fungi (Basel, Switzerland)*, *8*(9), 964. https://doi.org/10.3390/jof8090964
38. Lodge, D.J., Ammirati, J., O'Dell, T.E. & Mueller, G.M. (2004). Collecting and Describing Macrofungi. In Biodiversity of Fungi: Inventory and Monitoring Methods, Mueller, G.M., Bills, G.F., Foster, M.S., Eds. New York, Academic Press, 128–158 p.
39. Luangharn, T., Hyde, K.D. & Chukeatirote, E. (2014). Proximate Analysis and Mineral Content of *Laetiporus sulphureus* Strain MFLUCC 12-0546 from Northern Thailand. *Chiang Mai Journal of Science,* 41(4) : 765-770.
40. Maaloul, A., Portillo-Lemus, L., Vitou, M., Rapior, S., Morel, S., & Fons, F. (2023). Antioxidant Potential of Several Polypores Mushrooms from the South of France. *International Journal of Medicinal Mushrooms*, 25(11), 1–10. https://doi.org/10.1615/IntJMedMushrooms.2023050126
41. Manjunathan, J. & Kaviyarasan, V. (2010). Nutrient distribution from a newly cultivated edible mushroom *Lentinus tuberregium* (Fr.) Tamil Nadu, India variation in mushroom energy value. *J. Chem. Pharm. Res*., 2(3):575-578.
42. Mattila, P., Konko, K., Eurola, M., Pihlava, J-M., Astola, J., Vahteristo, L., Hietaniemi, V., Kumpulainen, J., Valtonen, M. & Piironen, V. (2001). Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. *J. agric. Fd Chem*., 49, 2343–2348. https://doi.org/10.1021/jf001525d.
43. Mleczek, M., Siwulski, M., Budka, A., Niedzielski, P., Mleczek, P., Kuczyńska-Kippen, N., Budzyńska, S., Karolewski, Z., Kalač, P. & Jędryczka, M. (2024). Can the concentration of elements in wild-growing mushrooms be deduced from the taxonomic rank? *Environmental Research*, 252, 119079. https://doi.org/10.1016/j.envres.2024.119079
44. Mortimer, P. E., Xu, J., Karunarathna, S. C. & Hyde, K. D. (eds) (2014) Mushrooms for trees and people: a field guide to useful mushrooms of the Mekong region. The World Agroforestry Centre, East Asia, Kunming, China. 125 pp.
45. Mwangi, R. W., Macharia, J. M., Wagara, I. N. & Bence, R. L. (2022). The antioxidant potential of different edible and medicinal mushrooms. *Biomedicine & Pharmacotherapy*, 147, 112621. https://doi.org/10.1016/j.biopha.2022.112621.
46. Nakalembe, I., Kabasa, J. D. & Olila, D. (2015). Comparative nutrient composition of selected wild edible mushrooms from two agro□ecological zones, Uganda. *SpringerPlus*, 4:433. https://doi.org/10.1186%2Fs40064-015-1188-z.
47. Nwanze, P. I., Jatto, W., Oranusi, S. & Josiah, S. J. (2006). Proximate analysis of *Lentinus squarrosulus* (Mont.) Singer and *Psathyrella atroumbonata* Pegler. *African Journal of Biotechnology*, 5 (4), pp. 366-368.
48. Okwulehie, I.C., Urama, J. & Okorie, D. O. (2014). Chemical Composition and Nutritional Value of Mature and Young Fruiting-Bodies of *Pleurotus pulmonarius* Produced On Andropogon Gayanus Straw and Khaya Ivorensis Sawdust. *IOSR Journal of Pharmacy and Biological Sciences* (IOSR-JPBS), 9, 4(3), 72-77. https://doi.org/10.9790/3008-09347277.
49. Ouzouni, P.K., Petridis, D., Koller, W.D. & Riganakos, K.A. (2009). Nutritional value and metal content of wild edible mushrooms collected from West Macedonia and Epirus, Greece. *Food Chemistry*, 115(4), 1575–1580. https://doi.org/10.1016/j.foodchem.2009.02.014.
50. Paloi, S., Kumla, J., Paloi, B. P., Srinuanpan, S., Hoijang, S., Karunarathna, S. C., Acharya, K., Suwannarach, N., & Lumyong, S. (2023). Termite Mushrooms (Termitomyces), a Potential Source of Nutrients and Bioactive Compounds Exhibiting Human Health Benefits: A Review. *Journal of Fungi*, 9(1), 112. https://doi.org/10.3390/jof9010112
51. Pandey, V.V., Sharma, A., Kumar, M., Saxena, J., Kainthola, C., Pandey, A. (2018) Mushroom cultivation: Substantial key to food security. *Journal of Applied and Natural Science*, 10 (4): 1325-1331.
52. Pushpa, H. & Purushothama, K. B. (2010). Nutritional analysis of wild and cultivated edible medicinal mushrooms. *World Journal Dairy Food Science*, 5(2): 140-144.
53. Raghuramulu, N., Madhavan, N. K. & Kalyanasundaram, S. (2003). A Manual of Laboratory techniquesNational Institute of Nutrition. *Indian Council of Medical Research*, Hyderabad, India, pp. 56-58.

54. Rai, P.K. & Lalramnghinglova, H. (2011) Threatened and less known ethnomedicinal plants of an Indo-Burma hotspot region: conservation implications. *Environmental Monitoring and Assessment*, 178 (1): 53–62. https://doi.org/10.1007/s10661-010-1670-6.
55. Rai, R.D. & Sohi, H.S. (1988). How protein rich are mushrooms. *Indian Horticulture,* 33: 2–3.
56. Raman, J., Lakshmanan, H., Jan, K-Y., Oh, M., Oh, Y-L. & Im, J-H. (2020). Nutritional composition and antioxidant activity of pink oyster mushrooms (*Pleurotus djamor* var. *roseus*) grown on a paddy straw substrate. *Journal of Mushrooms*, 18(3):189-200. https://doi.org/10.14480/JM.2020.18.3.189.
57. Rampinelli, J.R., Silveira, M.L.L., Gern, R.M.M., Furlan, S.A., Ninow, J.L. & Wisbeck, E. (2010). Nutritional value of *Pleurotus djamor* cultivated in banana straw. *Alim.Nutr.Araraquara*, 21(2), 197-202. http://serv-bib.fcfar.unesp.br/.../928.
58. Rugolo, M., Mascoloti Spréa, R., Dias, M.I., Pires, T.C.S.P., Añibarro-Ortega, M., Barroetaveña, C., Caleja, C., & Barros, L. (2022). Nutritional Composition and Bioactive Properties of Wild Edible Mushrooms from Native Nothofagus Patagonian Forests. *Foods*, 11(21), 3516. https://doi.org/10.3390/foods11213516
59. Saha, D., Sundriyal, M., Sundriyal, R.C. (2014). Diversity of food composition and nutritive analysis of edible wild plants in a multi-ethnic tribal land, Northeast India; an important facet for food supply. *Indian Journal of Traditional Knowledge*, 13(4):698–705.
60. Sargunam, S.D., Johnsy, G., Samuel, A.S. & Kaviyarasan (2012) Mushrooms in the food culture of the Kaani tribe of Kanyakumari district. *Indian Journal of Traditional Knowledge*. 11(1), 150-153. http://nopr.niscair.res.in/.../13419.
61. Shams, R. Singh, J., Dash, K. K. & Dar, A.M. (2022) Comparative study of freeze drying and cabinet drying of button mushroom, Applied Food Research, 2(1). https://doi.org/10.1016/j.afres.2022.100084.
62. Shin, C. K., Yee, C. F., Shya, L. J. & Atong, M. (2007). Nutritional Properties of Some Edible Wild Mushrooms in Sabah. *Journal of Applied Sciences*, 7(15), 2216-2221. https://doi.org/10.3923/jas.2007.2216.2221.
63. Sifat, N., Lovely, F., Zihad, S.M.N.K., Hossain, M.G., Shilpi, J.A., Grice, I.D., Mubarak, M.S., & Uddin, S.J. (2020). Investigation of the nutritional value and antioxidant activities of common Bangladeshi edible mushrooms. Clinical Phytoscience, 6: 88. https://doi.org/10.1186/ s40816-020-00235-3.
64. Silva, S. O., da Costa S. M. G. & Clemente, E. (2002). Chemical composition of *Pleurotus pulmonarius* (Fr.) Quel., substrates and residue after cultivation. *Brazilian Archives of Biology and Technology*, 45(4):531–535. https://doi.org/10.1590/S1516-89132002000600018.
65. Sousa, A.S., Araújo-Rodrigues, H., & Pintado, M.E. (2023). The Health-promoting Potential of Edible Mushroom Proteins. *Current pharmaceutical design*, 29 (11), 804–823. https://doi.org/10.2174/1381612829666221223103756
66. Sudheep, N. M. & Sridhar, K. R. (2014). Nutritional composition of two wild mushrooms consumed by the tribals of the Western Ghats of India. *Mycology*, 5(2), 64–72. https://doi.org/10.1080/21501203.2014.917733.
67. Teke, A. N., Bi, M. E., Ndam, L. M. & Kinge, T. R. (2021) Nutrient and Mineral Contents of Wild Edible Mushrooms from the Kilum-Ijim Forest, Cameroon. *African Journal of Food Science*, 15(4), pp. 152-161. https://doi.org/10.5897/AJFS2021.2089.
68. Thachunglura, V. L., Rai, P. K., Chawgthu, Z., Lalbiakmawia, B., Lalmuansangi, & Zothanzama, J. (2023). *Pleurotus giganteus* as a Valuable Source of Nutrients. *Indian Journal of Science and Technology,* 16(sp1), 89–94. https://doi.org/10.17485/ijst/v16sp1.msc12
69. Thachunglura, V. L., Rai, P. K., Chawngthu, Z., Renthlei, L., Vanlalmalsawmi, R., Bochung, L., Khumlianlal, J. & Zothanzama, J. (2024a). Nutritional composition and mineral contents of common edible wild mushrooms from Mamit and Champhai Districts of Mizoram, India. *Food Agricultural Sciences and Technology*, 10(1), 42-58.
70. Thachunglura, V.L., Rai, P.K., Khumlianlal, J., & Zothanzama, J. (2024b) A checklist of wild mushrooms in Mizoram, Northeast India. *Plant Pathology & Quarantine*, 14(1), 125–142. https://doi.org/10.5943/ppq/14/1/11
71. Torres-Martínez, B. del M., Vargas-Sánchez, R. D., Torrescano-Urrutia, G. R., Esqueda, M., Rodríguez-Carpena, J. G., Fernández-López, J., Perez-Alvarez, J. A. & Sánchez-Escalante, A. (2022). *Pleurotus* Genus as a Potential Ingredient for Meat Products. *Foods*, 11(6), 779. https://doi.org/10.3390/foods11060779.
72. Valverde, M.E., Hernández-Pérez, T., & Paredes-López, O. (2015). Edible Mushrooms: Improving Human Health and Promoting Quality Life. *International Journal of Microbiology*, 1–14. https://doi.org/10.1155/2015/376387.
*73.* Vishwakarma, P., Singh, P. & Tripathi, N.N. (2017). In-vitro antioxidant activity and nutritional value of four wild oyster mushroom collected from North-Eastern Part of Uttar Pradesh. *Mycosphere*, 8(4): 592–602. https://doi.org/10.5943/mycosphere/8/4/8.
74. Wang, D., Sakoda, A. & Suzuki, M. (2001). Biological efficiency and nutritional value of *Pleurotus ostreatus* cultivated on spent beer grain. *Bioresource Technology*, 78(3), 293-300. https://doi.org/10.1016/S0960-8524(01)00002-5.
75. Wang, M. & Zhao, R. (2023). A review on nutritional advantages of edible mushrooms and its industrialization development situation in protein meat analogues. *Journal of Future Foods*, 3(1), 1–7. https://doi.org/10.1016/j.jfutfo.2022.09.001
76. Wang, X.G., Wei, S.Y., Qi, L.L., Yang, Z.F., Tang, J., Liu, Z.L., & Wu, S.J. (2023). Complete mitochondrial genomic sequence of *Auricularia delicata* (Auriculariaceae), an edible Chinese mushroom. *Mitochondrial DNA Part B*, 8 (10), 1109–1113. https://doi.org/10.1080/23802359.2023.2268759
77. White, T. J., Bruns, T., Lee, S. & Taylor, J. (1990). Amplification and direct sequencing of fungal ribosomal rna genes for phylogenetics. *PCR Protocols*, 315-322.
78. Zhou, S., Ma, F., Zhang, X. & Zhang, J. (2016). Carbohydrate changes during growth and fruiting in *Pleurotus ostreatus*. *Fungal Biology*, 120(6–7), 852–861. https://doi.org/10.1016/j.funbio.2016.03.007.
79. Zohmangaiha, Vabeikhokhei J. M. C., Zothanzama, J. & Lalrinawmi, H. (2019). Ganoderma Species of Mizoram, India. *International Journal of Current Microbiology and Applied Sciences*, 8(04): 2871-2879. https://

doi.org/10.20546/ijcmas.2019.804.335.

80. Zohmangaiha, C., Thachunglura, V.L., Lalnuntluanga, & Zothanzama, J. (2023). Morphological characterization and nutritional quality of *Lentinula edodes*. *Journal of Agriculture Food and Environment*, 4(3): 9-12. https://doi.org/10.47440/JAFE.2023.4302
81. Zothanzama, J. (2011). Wood Rotting Fungi of Mizoram .In H. Lalramnghinglova and F. Lalnunmawia (eds). Forest Resources of Mizoram: Conservation and Management. Department of Environmental Science, Mizoram University and Regional Centre, National Afforestation and Eco-development Board; North Eastern Hill University. 345: 326-345.
82. Zothanzama, J., Blanchette, A. R. & Lalrinawmi H. (2018). Identification of the Edible and Poisonous Mushrooms of Mizoram. Project Report – New Land Use Policy. Memo No. B.15012/1/2016. Govt of Mizoram.