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Nutrient Analysis of Selected Wild Edible Mushrooms Collected from Aizawl Mizoram, India

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Present study aims to identify and evaluate nutritional properties and mineral content of three wild edible mushrooms (WEM): Phallus indusiatus Ventenat (1798), Schizophyllum commune Fries (1815) and Termitomyces heimii Natarajan (1979). The sample was collected during the monsoon season in 2021-2022 from Aizawl District, Mizoram, India. Following collection, the samples were thoroughly cleaned to remove any debris and properly labelled. The collected specimens were identified using standard methods based on macroscopic and microscopic characteristics. Three samples were selected and oven-dried at 45 - 50 °C for three days in a Hot Air Oven (HOA) for further analysis. Analysis revealed that three species of wild edible mushrooms are rich in protein (15.93 – 30.36 g/100g in dw) and carbohydrates (39.05 – 55.24 g/100g in dw), have low fat content, and contain substantial amounts of essential minerals (2.16 – 4.56 g/100g in dw). This study provides data on the nutritional properties and mineral composition of three wild edible mushrooms collected from Mizoram, India.

Keywords: Foods Supplements; Macrofungi; Minerals; Nutrients; Wild Edible Mushrooms

Fungi are incredibly diverse in their morphology, ecological niches, metabolic processes, and evolutionary relationships [1]. They play an important role in the emerging bio-economy, helping enhance resource efficiency, create renewable alternatives to fossil fuels, repurpose waste into valuable food and feed, combat lifestyle diseases and antibiotic resistance by bolstering gut health, fortify crops against climate change, and serve as hosts for the development of new biological properties and nutritional value, showing potential to be used as a dietary nutritional supplement [2]. A mushroom is a macrofungus with a distinctive fruiting body, which can be found either above ground (epigeous) or below ground (hypogeous) and large enough to be seen with the naked eye and to be picked by hand [3].

WEM are not only valued as culinary delicacies but are also appreciated for their rich nutritional content, having been consumed by various cultures around the world for centuries. [4-6]. They are a natural source of vitamins, minerals, and other beneficial compounds that contribute to overall health and well-being [7-9]. Additionally, they are an excellent source of carbohydrates and protein, while being remarkably low in fat and calories. [10-12]. With such a well-rounded nutritional

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profile, consuming edible mushrooms is linked to numerous health benefits, including improved immune function, prevention of chronic diseases, and cardiovascular health [13,14]. The high nutritional value of wild edible mushrooms makes them a valuable addition to a healthy diet.

Mizoram, a small state in the north-eastern region of India, is located within the Indo-Burma biodiversity hotspot, renowned for its diverse flora and fauna. The heavy precipitation (annual rainfall of 1551.6 mm in 2021) in the region provides a suitable environment for numerous wild mushroom species [15-16], adding to its rich biodiversity. Previous studies on macrofungi have predominantly focused on their taxonomy, phylogeny, and diversity [17]. There has been little research into the nutritional properties of wild edible mushrooms, with only a few studies conducted in this field [9,10]. Previous studies have shown that edible wild mushrooms found in Mizoram are nutritionally significant, and comparable to other commonly consumed vegetables. However, there are still many wild edible mushrooms in the region that remain unexplored in terms of their nutritional content. Limited consumption of wild edible mushrooms among the people of Mizoram is due to lack of extensive research on macrofungi in the region. The present study aims to address this research gap by investigating the nutritional value of various mushroom species found in Mizoram.

MATERIALS AND METHODS

Collection, Storage, Identification and Samples Preparation

Basidiomata were collected from the Mizoram University campus (23.7338° N, 92.6680° E) in Aizawl during the 2021-2022 rainy seasons. Following collection, the samples were thoroughly cleaned to remove any debris and properly labelled. The collected specimens were identified using standard methods based on macroscopic and microscopic characteristics [18-20]. Vouchers number are given to the specimens and stored in Department of Environmental Science, Mizoram University. Three samples were selected and oven-dried at 45 - 50 °C for three days in a Hot Air Oven (HOA). After drying, without separating the cap and pileus, the samples were crushed into a fine powder and stored in a freezer at 4 °C before evaluating their nutritional properties.

Analysis of Nutrients and Minerals

The nutritional compositions of the mushrooms were expressed on percentage dry weight basis. The samples were analysed for moisture, fat, protein, ash, and crude fiber contents using the standard methods provided by AOAC [21]. A dry powdered mushroom sample weighing 1 g was placed in a porcelain crucible and then subjected to ashing at 450°C for 5-6 hours. Afterward, the resultant ash was dissolved in 2 mL of concentrated

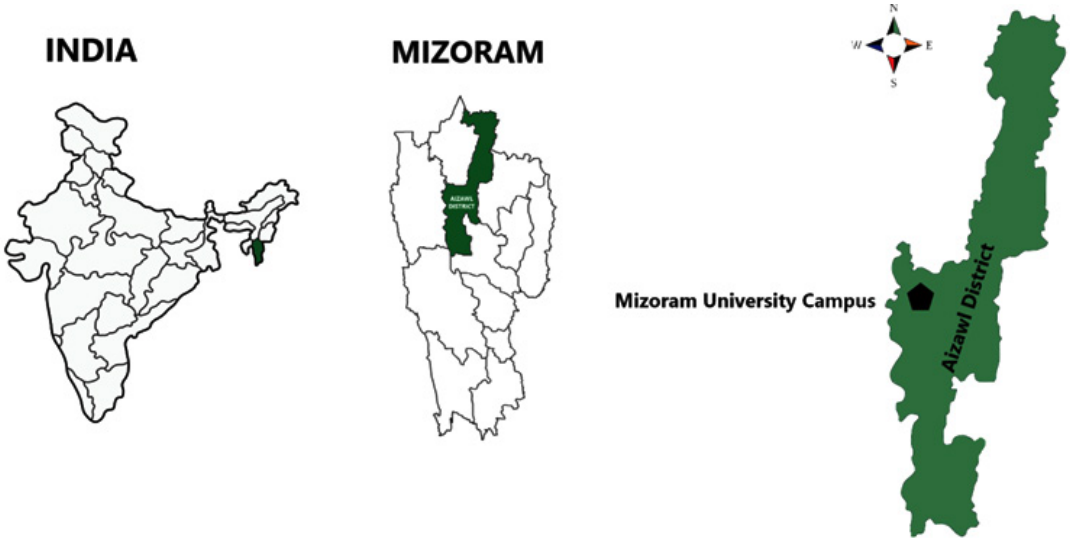

Fig. 1. Map of study sites showing Mizoram University campus

HNO_3 and subjected to heating for 1 minute followed by cooling. Subsequently, it was filtered through a Whatman No. 42 filter paper into a 50 mL volumetric flask and diluted to volume with triple deionized water. A blank was prepared using the same procedure [21,22]. Mineral concentrations, such as calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and zinc (Zn), were assessed using an atomic absorption spectrophotometer (AAS) [21].

RESULTS AND DISCUSSION

The nutrient and mineral analysis was conducted on a dry weight basis, with each parameter being analysed three times to obtain the mean result. The Mizo people are familiar with these three common wild edible mushrooms: *Schizophyllum commune* (Local name: Pasi, Specimen Voucher No - TPZ/18/023), *Phallus indusiatus* (Local name: Phungsahmim, Specimen Voucher No - TPZ/18/006), and *Termitomyces heimii* (Local name: Pasawntlung, Specimen Voucher No - TPZ/18/012) which are widely consumed across various regions of Mizoram [9]. These three wild edible mushrooms were chosen due to their abundance in the Aizawl District and their fruiting bodies and proximate compositions were shown in Table 1.

The nutritional value of mushrooms is closely related to moisture and environmental conditions. A number of variables affect the nutritional value of different species of mushrooms, including growth conditions such as soil type, climate, and nutrient availability, as well as species differences resulting from distinct genetic makeup. Furthermore, as mushrooms mature and grow, their nutritional composition may change depending on their stage of development [9]. Nutrient levels are also impacted by post-harvest treatment, which includes techniques for processing, preparation, and storage. Additionally, certain mushrooms develop symbiotic partnerships with particular

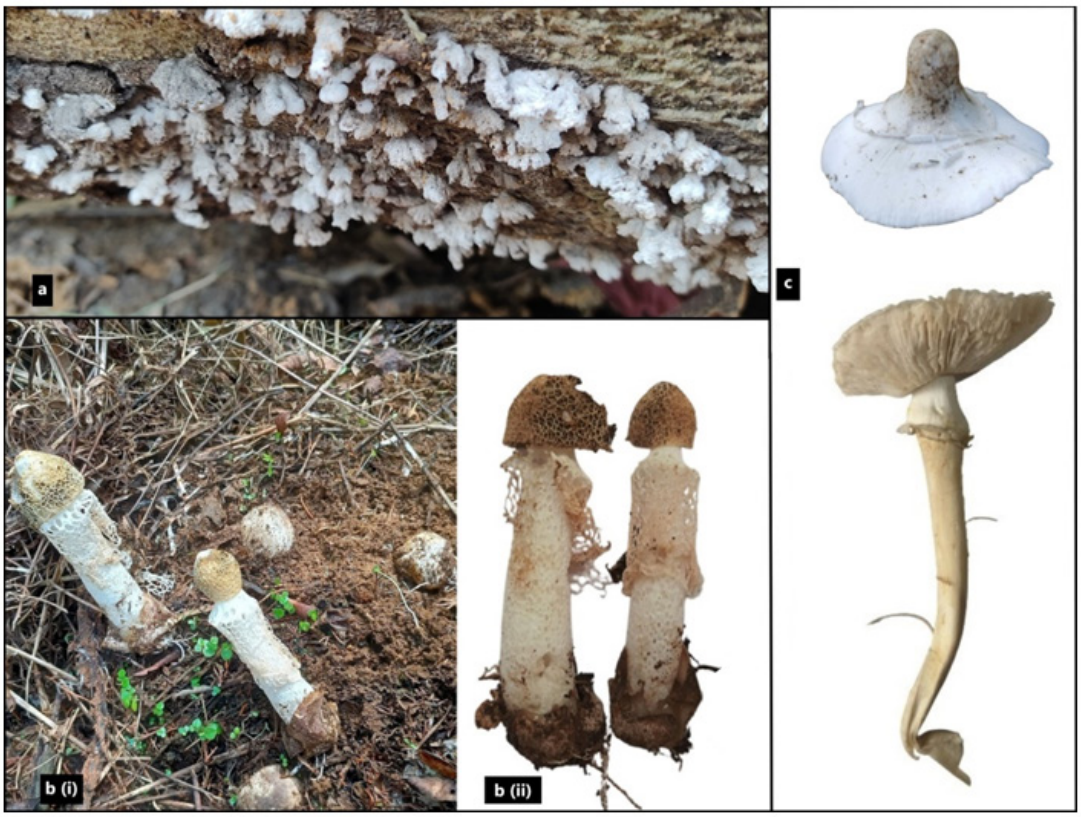

Fig. 2. Fruiting bodies of collected wild edible mushrooms (a) *Schizophyllum commune* (b) *Phallus indusiatus* (c) *Termitomyces heimii*

Table 1. Proximate analysis of collected wild edible mushrooms from Aizawl, Mizoram

Species	Moisture (fw)	Moisture (dw)	Ash	Fat	Crude fiber	Protein	Carbohydrate
Phallus indusiatus	91.59 ±1.22	11.63±1.24	7.55±0.47	4.56±0.34	5.09±0.29	15.93±1.25	55. 24
Schizophyllum commune	71.58±0.77	12.98±0.29	6.05±0.35	2.16±0.28	6.18±0.24	19.26±0.61	53.37
Termitomyces heimii	87.53±1.29	9.59±0.26	8.41±0.36	3.89±0.29	7.70±0.2	30.36±1.06	39.05

Each Value is expressed in mean ± SD, (n = 3)

plants, which affect the mushrooms' nutrient absorption and overall nutritional composition [23]. Microwaving and grilling were also identified as the optimal methods for preserving the nutritional integrity of mushrooms [24]. In this study, the highest moisture content in fresh weight was found in *Phallus indusiatus* (91.59%), while the lowest was found in *Schizophyllum commune* (71.58%). However, in dried weight, the highest moisture content was found in *Schizophyllum commune* (12.98 %), and the lowest was found in *Termitomyces heimii* (9.59 %). The moisture concentrations were in line with the study of others. Ash content of the sample was found to be highest in *Termitomyces heimii* (8.41 %) and lowest in *Schizophyllum commune* (6.05 %). It is known that mushrooms with high ash content contain more minerals [25]. Fat content was found to be highest in *Phallus indusiatus* (4.56 %) and lowest in *Schizophyllum commune* (2.16 %).

Fiber is a component of carbohydrates, and its presence in mushrooms is an important characteristic and contributes significantly to a healthy human diet [26]. It is also known that fungal proteins have superior digestive properties, can regulate blood lipid and cholesterol levels, improve immunity, and promote gut health [27]. In the present study, crude fiber and protein was highest in *Termitomyces heimii* (7.70 % and 30.36), followed by *Schizophyllum commune* (6.18 % and 19.26 %) and lowest in *Phallus indusiatus* (5.09 % and 15.93 %). Carbohydrate was found to be the dominant component in the dried fruiting bodies, consistent with their prevalence as the dominant constituent in other studies as well[12]. *Phallus indusiatus* (55.24 %) had the highest carbohydrate content, followed by *Schizophyllum commune* (53.37 %), and *Termitomyces heimii* (39.05 %) had the lowest content.

Compared to other studies, our findings for *Termitomyces heimii* were consistent with the protein content reported from Sri Lanka[5]. However, their study reported higher ash content (13.58%) and fat content (12.35%) than what we observed in our sample. For *Schizophyllum commune*, their study found a protein content of 14.41%, while our study reported a higher protein content of 19.26%. This indicates that our sample had more protein compared to their findings. With an average protein content ranging from approximately 14.0

Table 2. Mineral content of the collected wild edible mushrooms

Species	Elements				
	Calcium	Iron	Magnesium	Potassium	Zinc
Phallus indusiatus	1.2±0.8	3.35±0.39	0.65±0.69	135.93±1.14	0.85±0.1
Schizophyllum commune	4.39±0.2	6.84±0.13	1.12±0.98	92±0.48	1.87±0.11
Termitomyces heimii	6.43±6.01	12.78±0.23	6.825±0.57	182.25±1.38	2.2±0.06

to 33.6 g/100g dry weight, mushrooms are known to have more naturally occurring bioactive proteins and peptides than most vegetables[9]. Moreover, a study from another district in Mizoram reported an even higher protein content of 30.33% for *Schizophyllum commune*[10], which is significantly higher than our observations. This variation highlights how nutritional content can differ even within the same species, reflecting the impact of local environmental and growing conditions.

The mineral content of the collected three WEM were presented in Table 2. Potassium (K) is the most abundant mineral compared to other elements. Mushrooms contain significant amounts of potassium and calcium, which makes them known as key minerals [28].

Minerals are crucial for numerous bodily functions, including the formation of strong bones, the transmission of nerve impulses, and the regulation of muscle function. They also support metabolic processes and help maintain fluid balance. By fulfilling these essential roles, minerals contribute significantly to overall health, helping to prevent deficiencies and ensuring a long, healthy life[29]. In the current study, it was found that *Termitomyces heimii* had the highest mineral concentrations, followed by *Schizophyllum commune*, while *Phallus indusiatus* had the lowest. Particularly, *Phallus indusiatus* had a higher potassium concentration than *Schizophyllum commune*. Although *Phallus indusiatus* had a higher ash level, *Schizophyllum commune* contained more minerals. This discrepancy could be the absence of numerous additional mineral components from the examination, including sodium, manganese, phosphorus, and selenium etc.

Macrofungi have the capability to accumulate high levels of mineral elements[30] even in soil with low concentrations of metals. The concentration of minerals correlates directly with factors such as species, geographical region of growth, fruiting body maturation period, substrates, and proximity to pollution sources[31,32]. As a result, numerous mushrooms exhibit elevated levels of heavy metals, which can adversely affect human health upon consumption and potentially lead to severe health issues or even death. These heavy metals can cause a range of problems, including organ damage, neurological issues, and other serious health conditions, depending on the type and concentration of the metals involved[33].

In general, all three samples are nutritional-rich, with *Termitomyces heimii* having the highest nutritional content. The high nutritional content observed in *Termitomyces heimii* could be attributed to several interrelated factors. Optimal soil conditions and environmental factors, such as soil pH, levels of moisture, and nutrient availability, may contribute to its enhanced nutritional profile. Additionally, the symbiotic relationships *Termitomyces heimii* forms with certain organisms likely facilitate improved nutrient uptake and absorption. All species of *Termitomyces* are definitely edible and possess unique food value owing to their texture, flavor, nutrient content, and beneficial medicinal properties[34]. The developmental stage at harvest further influences its nutritional composition, with optimal harvesting times potentially improving nutrient levels[9]. Lastly, adaptations to environmental stressors could drive the species to accumulate higher nutrient levels as a survival strategy.

CONCLUSION

The Mizo people hold a high regard for these three types of wild edible mushrooms, particularly *Termitomyces heimii* and *Schizophyllum commune*. *Schizophyllum commune* is found abundantly during the summer season, and many

locals sun-dry or air-dry them for sale in local markets throughout the year when mushrooms are less available. These wild edible mushrooms are essential for the Mizo people, and it is clear that all the three species are rich in both macro and micronutrients, providing significant nutritional value to the community. However, further research is necessary to expand our understanding of other wild edible mushrooms as well as more nutritional parameters.

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Conflict of Interest

The author declare no conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Approval Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Authors' contributions

Laltanpuia Renthlei, Zohmangaiha Chawngthu, and VL Thachunglura collected and identified the samples, with Joshua Khumlianlal joining to assist in analysing the nutrients and minerals content. Laltanpuia Renthlei, Joshua Khumlianlal, and Madhurima draft the manuscript, which was later reviewed and rewritten by John Zothanzama and BP Mishra.

REFERENCES

1. Chugh R.M., Mittal P., Mp N., Arora T., Bhattacharya T., Chopra H., Cavalu S., Gautam, R.K. Fungal Mushrooms: A Natural Compound With Therapeutic Applications. Front. Microbiol. 2022; 13: 925387. Available from: https://doi.org/10.3389/fphar.2022.925387
2. Lange L. The importance of fungi and mycology for addressing major global challenges. IMA fungus. 2014;5(2):463–471. https://doi.org/10.5598/imafungus.2014.05.02.10
3. Chang ST. Mushrooms and Mushroom Cultivation. In eLS, (Ed.). 2001. https://doi.org/10.1038/npg.els.0000370
4. Valverde M.E., Hernández-Pérez T., and Paredes-López O. Edible mushrooms: improving human health and promoting quality life. Int. J. Microbiol. 2015; 376387. https://doi.org/10.1155/2015/376387
5. Gunasekara N.W., Nanayakkara C.M., Karunarathna S.C., Wijesundera R.L.C. Nutritional aspects of three Termitomyces and four other wild edible mushroom species from Sri Lanka. Chiang Mai J. Sci. 2021; 48: 1236–1246.
6. Li H., Tian Y., Menolli N., Ye L., Karunarathna S.C., Perez Moreno J., Rahman M.M., Rashid M., … Mortimer P.E. Reviewing the world's edible mushroom species: A new evidence based classification system. Compr. Rev. Food Sci. Food Saf. 2021; 20(2): 1982–2014. Portico. https://doi.org/10.1111/1541-4337.12708
7. Dimopoulou M., Kolonas A., Mourtakos S., Androutsos O., and Gortzi O. Nutritional Composition and Biological Properties of Sixteen Edible Mushroom Species. Appl. Sci. 2022; 12(16):8074. https://doi.org/10.3390/app12168074
8. Cheung P.C.K. The nutritional and health benefits of mushrooms. Nutr. Bull. 2010; 35: 292-299. https://doi.org/10.1111/j.1467-3010.2010.01859.x
9. Thachunglura V.L, Rai P.K, Zohmangaiha, Laltanpuia R, Vanlalmalsawmi R, Lallawmkima B, Khumlianlal J, and Zothanzama J. Nutritional composition and mineral contents of common edible wild mushrooms from Mamit and Champhai Districts of Mizoram, India. *Food Agricultural Sciences and Technology,* 2024; 10(1): 42-58.
10. Lallawmsanga, Passari A.K., Mishra V.K., Leo V.V., Singh B.P., Valliammai Meyyappan G., Gupta V.K., Uthandi S., Upadhyay R.C. Antimicrobial Potential, Identification and Phylogenetic Affiliation of Wild Mushrooms from Two Sub-Tropical Semi-Evergreen Indian Forest Ecosystems. PLOS ONE, 2016; 11(11): e0166368. https://doi.org/10.1371/journal.pone.0166368
11. Ho L.H., Asyikeen Zulkifli N., and Tan T.C. Edible Mushroom: Nutritional Properties,

Potential Nutraceutical Values, and Its Utilisation in Food Product Development. An Introduction to Mushroom. 2020. https://doi.org/10.5772/intechopen.91827

12. Khumlianlal J., Huidrom S., Sharma K.C., Thachunglura V.L., and Indira S. Proximate Analysis and Mineral Content of Wild Edible Mushrooms from Manipur, India. Int J Curr Microbiol Appl Sci. 2024; 13(3): 269–275. https://doi.org/10.20546/ijcmas.2024.1303.026
13. Ma G., Yang W., Zhao L., Pei F., Fang D., and Hu Q. A critical review on the health promoting effects of mushrooms nutraceuticals. Food Sci. Hum. Wellness. 2018;7(2), 125–133. https://doi.org/10.1016/j.fshw.2018.05.002
14. Bell V., Silva C.R.P.G., Guina J., and Fernandes T.H. Mushrooms as future generation healthy foods. Front. Nutr. 2022; 9. https://doi.org/10.3389/fnut.2022.1050099
15. Lalrinawmi, Vabeikhokhei J.M.C, Zothanzama J, Zohmangaiha. Edible mushrooms of Mizoram. Science vision. 2017; 17 (3): 172—181. https://doi.org/10.33493/scivis.17.04.01
16. Chawngthu Z., Tluanga L., Zothanzama J., Thachunglura V.L., Lalbiakmawia B., Renthlei L. Wood rotting polyporales from the biodiversity reserves within the Indian subtropical habitat. Indian J Microbiol Res. 2023; 10(3): 140–148. https://doi.org/10.18231/j.ijmr.2023.025
17. Zohmangaiha, Vabeikhokhei J.M.C., Zothanzama J., and Lalrinawmi H. Ganoderma Species of Mizoram, India. Int J Curr Microbiol Appl Sci. 2019; 8(04):2871-9. http://dx.doi.org/10.20546/ijcmas.2019.804.335
18. Natarajan N.K. South Indian Agaricales v: *Termitomyces heimii*. Mycologia, 1979; 71: 853-855. http://dx.doi.org/10.2307/3759201.
19. Calonge F.D. A tentative key to identify the species of Phallus. Boletin de La Sociedad Micologica de Madrid, 2005;29:9–18. https://digital.csic.es/handle/10261/92117
20. Phillips R., Foy N., Kibby G., and Homola R.L. Mushrooms and other fungi of North America. Richmond Hill Firefly Books, 2010.
21. Official Methods of Analysis of AOAC International; AOAC International: Rockville, MD, USA, 2016.
22. Isildak Ö., Turkekul I., Elmastas M., Tuzen M. Analysis of heavy metals in some wild-grown edible mushrooms from the middle black sea region, Turkey. Food Chemistry. 2004;86(4):547–52. http://dx.doi.org/10.1016/j.foodchem.2003.09.007
23. Kalac P. Chemical composition and nutritional value of European species of wild growing mushrooms: a review. Food Chem. 2009;113:9–16. https://doi.org/10.1016/j.foodchem.2008.07.077
24. Roncero-Ramos I., Mendiola-Lanao M., Pérez-Clavijo M., and Delgado-Andrade C. Effect of different cooking methods on nutritional value and antioxidant activity of cultivated mushrooms. Int J Food Sci Nutr. 2017;68(3):287-297. https//doi.org/10.1080/09637486.2016.1244662
25. Thachunglura V.L., Rai P.K., Zohmangaiha, Lalbiakmawia B., Lalmuansangi, and Zothanzama J. *Pleurotus giganteus* as a Valuable Source of Nutrients. Ind. J. Sci. Technol. 2023; 16(sp1), 89–94. https://doi.org/10.17485/IJST/v16sp1.msc12
26. Ao T., Deb C.R. Nutritional and antioxidant potential of some wild edible mushrooms of Nagaland, India. J. Food Technol. 2019; 56(2), 1084–1089. https://doi.org/10.1007/s13197-018-03557-w
27. Ayimbila F., Keawsompong S. Nutritional Quality and Biological Application of Mushroom Protein as a Novel Protein Alternative. Curr. Nutr. Rep. 2023;12(2), 290–307. https://doi.org/10.1007/s13668-023-00468-x
28. Gençcelep H., Uzun Y., Tunçtürk Y., and Demirel K. Determination of mineral contents of wild-grown edible mushrooms. Food Chem. 2009; 113(4), 1033–1036. https://doi.org/10.1016/j.foodchem.2008.08.058
29. Gharibzahedi S.M.T., Jafari S.M. The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. Trends Food Sci Technol. 2017;62, 119–132. https://doi.org/10.1016/j.tifs.2017.02.017
30. Falandysz J. and Borovièka J. Macro and trace mineral constituents and radionuclides in mushrooms: health benefits and risks. Appl Microbiol Biotechnol. 2013; 97(2), 477–501. https://doi.org/10.1007/s00253-012-4552-8
31. Gucia M., Jarzyñska G., Rafa³ E., Roszak M., Kojta A.K., Osiej I., Falandysz J. Multivariate analysis of mineral constituents of edible Parasol Mushroom (Macrolepiota procera) and soils beneath fruiting bodies collected from Northern Poland. Environ Sci Pollut Res. 2012;19:416-31. https://doi.org/10.1007/s11356-011-0574-5
32. Bellettini M.B., Fiorda F.A., Maieves H.A., Teixeira G.L., Ávila S., Hornung P.S., Júnior A.M., and Ribani R.H. Factors affecting mushroom Pleurotus spp. Saudi J. Biol. Sci. 2019;26(4), 633–646. https://doi.org/10.1016/j.sjbs.2016.12.005
33. Fu Z, Liu G, Wang L. Assessment of potential

human health risk of trace element in wild edible mushroom species collected from Yunnan Province, China. Environ Sci Pollut Res. 2020; 27(23):29218-29227. https://doi.org/10.1007/s11356-020-09242-w.

34. Paloi S., Kumla J., Paloi B.P., Srinuanpan S., Hoijang S., Karunarathna S.C., Acharya K., Suwannarach N., Lumyong S. Termite Mushrooms (Termitomyces), a Potential Source of Nutrients and Bioactive Compounds Exhibiting Human Health Benefits: A Review. Journal of fungi (Basel, Switzerland), 2023;9(1), 112. https://doi.org/10.3390/jof9010112