

# Ethnomycological knowledge, nutritional and nutraceutical potential of wild edible macrofungi of Northeast India

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## Abstract

North-East India with warm and humid climatic conditions favors the growth of a wide range of macrofungal species. Some wild edible macrofungi are consumed as food by the ethnic communities in this region. These wild macrofungi are identified as edible and inedible based only on the rich and unique indigenous knowledge system of local tribes of North-east India. Wild edible macrofungi are consumed due to their appetizing taste and sweet aroma. The wild edible macrofungi are nutritionally very rich and are a good source of protein, carbohydrates, minerals, trace elements, and dietary fiber. Similarly, they contain a low amount of fat. This article assesses the ethnomycological beliefs on the palatability of the wild edible macrofungi; DNA barcoding based scientific identification of the wild species; traditional knowledge to avoid the mycetism; and the nutritional and nutraceuticals potential of the wild macrofungal species.

**Citation:** Gogoi I, Borthakur A, Neog B. 2023. Ethnomycological knowledge, nutritional and nutraceutical potential of wild edible macrofungi of Northeast India. *Studies in Fungi* 8:12 <https://doi.org/10.48130/SIF-2023-0012>

## Introduction

Macrofungi are the group of fungi that produces large fruit bodies which can be seen with the naked eye<sup>[1]</sup>. Most of the macrofungi belong to the larger sub-divisions-Ascomycota and Basidiomycota, based on the structure of their fruit bodies. They are found in a large variety of habitats; with humid and favorable ecological conditions. They mostly prefer habitats like lawns, meadows, hilltops, marshes, swamps, dung, soil and rotting logs. Due to their high nutritive value, macrofungi find a place in the dietary component of humans as well as animals<sup>[2-4]</sup>. Apart from its nutritive food value many reports also suggest their medicinal importance across the globe<sup>[5,6]</sup>. Out of 75,000 species of fungi 15,000 belong to macrofungi<sup>[7]</sup>. In India about 27,000 fungal species were reported which include both the macrofungi and microfungi species<sup>[8]</sup>. North-east India is very rich in biodiversity and its untapped bioresources have been identified as the Indo-Burma Mega hot spot region<sup>[9]</sup>. However, very little is explored from this region so far. The climatic conditions favor Northeast India to host wide varieties of macrofungi species. This region is inhabited by 148 varieties of indigenous ethnic communities like Ahoms, Apatani, Boros, Deories, Garos, Kacharis, Khasis, Kuki, Miri, Mishings, Mizo, Monpa, Moran, Naga, Nishi and Tai phake. These indigenous people have a unique lifestyle that is very close to nature and they mostly use natural resources to meet their basic needs. They have great knowledge on wild edible mushrooms; they collect the mushrooms from the wild and use them both as food and medicines. However, the identification of edible mushrooms to that of non-edible is enumeration based on the indigenous knowledge system which needs better scientific based understanding. A handful of research has been done on taxonomy and diversity of macrofungi in India during

past few years,<sup>[10,11]</sup> but a very little research on ethnomycological aspects has been done in the rest of India. However, in Northeast India a few numbers of researches has been done on ethnomycological knowledge of the ethnic tribes of this region<sup>[12-15]</sup>. This ethnomycological knowledge has been passed on to generations orally without much documentation and very little scientific research has been carried out on this knowledge. Among the diverse wild edible macrofungi found in North-East India, scientific research has been conducted only on a very few species and a vast number of them are still unexplored. The present article aims to review the ethnobotanical and ethnomedicinal characteristics of the wild mushrooms or macrofungi along with some scientific basis for authentic identification of these wild macrofungi which are best known for their uses among the indigenous ethnic communities for nutritional and medicinal properties.

## Ethnomycological knowledge on palatability of wild edible macrofungi

On the very onset of monsoon showers, a variety of wild macrofungi grows in the entire Northeastern region of India. Among those wild-grown macrofungi, many of them are being identified as edible or inedible by the indigenous communities of the region. These wild-grown macrofungi are being gathered from the wild and consumed as food and also sold in the local markets as fresh fruit bodies or in dried form. However, the overall ethnic traditional knowledge on identification of edible macrofungi needs proper scientific investigation. There are many reports of casualties in the past due to wrong identification of the wild macrofungi, these casualties are often encountered among the people of tea tribe communities due

to lack of proper knowledge of the wild macrofungi. Some of the identifying criteria that have been followed by the ethnic communities to identify and collect the wild-grown edible macrofungi and these criteria are also in agreement with some other pieces of literature published previously<sup>[13–17]</sup>.

a) Edible macrofungi have a clear distinct ring on the stalk at maturity whereas non-edible does not have a ring and has black gills.

b) Edible ones have a familiar and pleasant odor but poisonous ones have a peculiar unpleasant odor.

c) Edible are light-colored and turn brown on breakage whereas inedible ones are brightly colored and turn black on breakage.

d) If put into saltwater along with lemon juice, the edible macrofungi don't turn the solution blackish as seen by the poisonous ones.

e) The macrofungi with some pieces of brinjal flowers are soaked in water for some time, if the water turns blackish it is considered poisonous and if the color of the water doesn't change it is considered edible.

f) When a silver, gold, or copper article is dipped with some pieces of wild macrofungi in water, and the water turns blackish, then it is considered poisonous otherwise edible.

g) When garlic flakes take a dark color when added to water along with some pieces of macrofungi, they are considered as non-edible.

h) When cooked along with brinjal, if no color change occurs then they are edible and if unusual color appears, then they are considered non-edible.

i) Macrofungi growing on animal excreta or vomit are usually considered unpalatable.

j) When soaked with rice if the color changes it is considered unpalatable.

k) Offseason macrofungi are usually considered inedible and poisonous.

l) One that illuminates in light is usually considered poisonous.

m) Ones that grow on living trees are considered inedible for the suspicious accumulation of toxic substances.

Thus the above mentioned identification criteria are folklore and may not be true for all found macrofungi.

### Indigenous knowledge to avoid mycetism

Wild macrofungi form a part of the cuisine of the ethnic people of the Northeastern region of India. Due to many traditionally known health benefits it is consumed by the indigenous people of the region. However, some species are morphologically similar to the poisonous variants. Therefore wrong identification and consumption of poisonous wild mushrooms is life threatening, usually termed as mycetism<sup>[18]</sup>. To avoid such mycetism, the indigenous people of these regions adopt certain traditional methods. For example Khashi tribes dip a red-hot iron rod into the mushroom recipe<sup>[19]</sup>. Similarly, to remove toxins from the doubtful species they cook mushrooms with a large amount of garlic and ginger, even using vinegar while cooking<sup>[14]</sup>. Again, few ethnic groups believe that mixing the terrestrial species with that of the epiphytic macrofungi and cooking both together would cause mushroom poisoning, thus they never cook them together<sup>[19]</sup>. Cooking wild mushroom species with some sour herbs i.e. *Hibiscus*

*sabdariffa*, *Hibiscus acetosella*, *Hibiscus cannabinus*, *Polygonum chinense*, *Solanum lycopersicum* and *Solanum indicum* is believed to be another remedy to toxicity neutralization<sup>[17]</sup>. The Khashi tribe of Meghalaya consume sour fruits of few plant species such as *Garcinia landaefolia*, *Antidisma* sp. etc. to reduce mycetism<sup>[19]</sup>. However, the traditional knowledge to reduce or avoid mycetism are confined to the local ethnic person, which needs further authentic scientific investigation. But traditionally these wild edible mushrooms occupy important place in the food habits of the ethnic tribes of India<sup>[20]</sup>.

### Scientific knowledge for identification of wild edible macrofungi

As mentioned earlier, the Northeastern region of India is home to many species of wild macrofungi, the ambient climatic condition of the region favors their growth and propagation. Northeast India witnessed mushroom poisoning related deaths every year. One such report of 53 casualties of mushroom poisoning was mentioned from the state of Meghalaya only during a period of 5 years i.e. 2014–2019<sup>[21]</sup>. Morphological similarities of the edible ones from the inedible ones are the root cause of such casualties. Thus to avoid such cases, authentic identification of the wild macrofungi based on scientific knowledge is of utmost necessity. At present, there is no definite rule to test the difference between the edible ones and the poisonous ones. This problem is solved only by the experience of the elderly people of the local ethnic communities. Molecular biological approach and further biotechnological interventions could be a better step to resolve the issue. DNA barcodes have been suggested for the same. According to previous research, the ITS region of the fungal species is the most reliable barcode for the purpose as compared to others such as 18SrDNASmall Subunit, RNA polymerase II Large Subunit, RNA polymerase II Second Largest Subunit, Cytochrome oxidase I, etc.<sup>[13,22,23]</sup>. Thus to help this out and for proper identification of the wild edible macrofungi, the researchers of these regions need to scientifically identify the macrofungi using scientific methods such as DNA barcoding considering the ITS region (ITS-1 and ITS-2) of the fungi and then develop a database with proper identifying characters and pictures and make it available to everyone to help them out with easy identification of the edible ones from the poisonous ones<sup>[24]</sup>.

### Nutritional and nutraceutical potential of wild macrofungi

Wild macrofungi have been used as food and medicine since ancient times, they are in general referred to as vegetarian meat as they are rich in protein content, carbohydrate and contain less fat compared to other cereals, pulses, fruits, and vegetables. The protein content is very high in mushrooms i.e. usually ranges from 20%–35% dry weight. Cereals are deficient in two essential amino acids viz. Lysine and tryptophan but mushrooms are rich in these two amino acids apart from most of the essential amino acids.

Mushrooms are also very much rich in Vitamin B complex and Vitamin C. They also contain folic acid and Vitamin B12 which are usually not found in green vegetables. Minerals like sodium, potassium, and phosphorus are also abundant in them. Like other vegetables, mushrooms also contain about

## Traditional knowledge of wild macrofungi

90% moisture and are low in calories which makes them very healthy for human consumption. In general, the carbohydrate content in cultivated mushrooms varies from 4%–5% which includes mannitol 0.95%, reducing sugar 0.27%, glycogen 0.59%, hemicellulose 0.91%, 20%–40%, starch is almost absent<sup>[3,4]</sup>. A few pieces of research have revealed that wild edible macrofungi like the cultivated ones are also very nutritious and contain a high quantity of proteins, minerals, amino acids, trace elements, etc., and contain a low amount of fats. Edible macrofungi are also a rich source of dietary fiber<sup>[25]</sup>.

The knowledge of edibility or inedibility of the wild mushrooms is a mere enumeration of the indigenous knowledge system and some of such identification criteria have already been mentioned above. Studies of wild edible macrofungi have revealed that they are rich in protein 2.00 g/100 g, carbohydrate 4.38 g/100 g – 16.02 g/100 g, moisture 53 g/100 g – 90.00 g/100 g, ash content 2 g/100 g – 13.00 g/100 g, fat 0.23 g/100 g – 5.65 g/100 g; they are also reported to be very rich in mineral composition viz. Fe, Mg, Zn, Cu, Mn, Ca, etc., and contain low amounts of Cd<sup>[20,26,27]</sup>. Wild edible macrofungi are also reported to be very rich in dietary fiber<sup>[2]</sup> and contain a very low amount of lipids<sup>[28]</sup>. Two species of wild edible macrofungi that are very commonly consumed by the ethnic communities of the entire Northeastern part of India viz. *Schizophyllum commune* and *Lentinus edodes*, were studied by Longvah & Deosthale in 1998 and found that both the species are nutritionally very rich, it was also reported that their protein content was 16% and 23% respectively and had a low amount of fat i.e. 2% in both the fungal species, essential amino acid content was reported to be 34% and 39% in *Schizophyllum commune* and *Lentinus edodes*<sup>[29]</sup>.

Apart from the nutritive value, wild edible mushrooms are valuable from a medicinal point of view. Macrofungi species like *Ganoderma lucidum*, *Pleurotus ostreatus* are reported to contain bioactive compounds that are anti-cancer in nature<sup>[30]</sup>. *Agaricus bisporus* possess some medicinal benefits especially as anti-cancer, anti-cardiovascular disease, anti-diabetes, anti-oxidant, and anti-microbial<sup>[31]</sup>. *Lentinula edodes* and *Auricularia auricular* possess anti-oxidant, anti-microbial properties also lower blood glucose<sup>[32]</sup>. Wild edible macrofungi from Meghalaya were analyzed for their nutraceutical potential and it was found that they are good sources of protein, carbohydrate, minerals, antioxidants, anti-inflammatory and also possess antimicrobial activity<sup>[20]</sup>. Thus wild gathered macrofungi are rich sources of functional nutraceuticals and play a vital role in human health benefits.

## Discussion and conclusions

The North-eastern part of India, as mentioned earlier, is home to many wild species of macrofungi. At the very onset of the monsoon, a large number of them grow in the wild and they form a part of the daily routine food among the ethnic tribal communities of these regions. However due to morphological similarities they may misidentify the poisonous ones and may consume them which causes many casualties in this region every year.

There is no known universal test to check the edibility of the wild macrofungi and there are also no known authentic field guides to help identify the edibles from the rest of the wild-grown macrofungi that are found in these regions. Ambiguities in identification cause causality in the studied region; therefore, a database would help in the reduction of these casualties.

Thus DNA barcoding based identification of the different macrofungal species found in this region is most important for authentic identification because DNA barcode is a cost effective, rapid and most importantly reliable source of scientific identification of the macrofungal species, previous workers have suggested that DNA barcoding using ITS (ITS1 and ITS2) region is the most appropriate method for fungal identification<sup>[33]</sup> based on which a database could be developed to identify the edible ones accurately. Many reports have suggested that DNA barcoding considering the ITS (Internal Transcribed Spacer) region is one of the most trusted methods for the identification of the edible macrofungi<sup>[22–24,34]</sup>. Thus further scientific research in this area is necessary.

Regarding its food value and nutritional aspects, many research has been conducted previously and these reports have suggested that they are rich sources of proteins, carbohydrates, amino acids, and have low-fat content; they also contain a good amount of trace elements and minerals<sup>[2]</sup>. They have equal nutritional potential as compared to other vegetables<sup>[3]</sup> thus it can be used as an alternative source of food when food is scarce.

Even many of these wild edible macrofungal species are being sold in the local markets during the monsoon season<sup>[15,16,27]</sup> therefore they play a vital role in the uplift of the livelihood of the local people. There is also the potential of artificial cultivation of the nutritious wild edible macrofungi which can provide additional enterprise for farmers even to those without much land and also to the non-working women who can earn a livelihood even by staying at home as it does not need much hard labor; thus mushroom culture can improve the economic empowerment of the rural as well as the urban women<sup>[35]</sup>. But to date, not much effort has been made to standardize the culture conditions of the nutritious macrofungi which are found in the wild, further research in this area is much needed.

These macrofungi are important bioresources<sup>[36]</sup>. This rich and unique indigenous knowledge of the ethnic groups of the region must be documented as it is fading slowly from the younger generations and has become limited to the elderly people of the tribes in this modern era due to fast modernization.

## Acknowledgments

We are very much thankful to the members of the Life Sciences Department, Dibrugarh University, India for their valuable suggestions and help during the work.

## Conflict of interest

The authors declare that they have no conflict of interest.

## Dates

Received 12 December 2022; Accepted 2 May 2023; Published online 9 June 2023

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