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WILD EDIBLE MUSHROOMS OF NAGALAND, INDIA: A POTENTIAL FOOD RESOURCE

Toshinungla Ao, Chitta Ranjan Deb^{*} and Neilazonuo Khruomo

Department of Botany, Nagaland University, Lumami 798 627, Nagaland, India

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ABSTRACT

Wild edible mushrooms (WEM) are known for its medicinal and nutritional value across the globe. WEM have become one of the most prized after food especially in the developed countries where people are mostly health conscious. The present study throws light on the diverse flora of WEMs of Nagaland and how it can be income generator for the tribal people with proper research in this aspect. Till now, the knowledge of distinguishing between edible and non-edible varieties is only confined to people who go for mushroom hunting. As such the indigenous knowledge remains with only those few people involved. The current data can pave the way for future research work and also make people aware of the many varieties of WEMs available in the state. A total of 33 WEMs were collected and identified during the peak mushroom season of the state i.e. from end May to September of every study year.

^{*} Corresponding author

E-mail: debchitta@rediffmail.com (Chitta Ranjan Deb)

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1 Introduction

Wild edible fungi have been collected and consumed by people for thousands of years. Wild edible fungi are important sources of nutrition and medicines. Around 2000 species of mushrooms are considered safe for human consumption and about 650 of these possess medicinal properties (Rai et al., 2005). Mushrooms have a long association with humankind and provide profound biological and economical impact. Since time immemorial, wild mushrooms have been consumed by man (Das, 2010). Edible mushrooms have high content of proteins, vitamins, minerals, fibers, trace elements and low/no calories and cholesterol (Murugkar & Subbulakshmi, 2005). Mushrooms have been used in folk medicine for thousands of years and are considered to be Nutraceuticals while others can produce potent Neutraceuticals (Ribeiro et al., 2005). Due to its traditional usage, *Trametes versicolor* has been considered among the 25 major medicinal macrofungi worldwide (Boa, 2004) and polysaccharo-peptides purified from this species, show experimental immune-modulatory and anti-cancer effects (Cheng & Leung, 2008). Besides, mushrooms are known to be rich sources of various bioactive substances like anti-bacterial, anti-fungal, anti-viral, anti-parasitic, anti-oxidant, anti-inflammatory, anti-proliferative, anti-cancer, anti-tumour, cytotoxic, anti-HIV, hypo-cholesterolemic, anti-diabetic, anti-coagulant, hepatoprotective compounds, among others (Wasser & Weis, 1999; Ajith & Janardhanan, 2007).

Mushrooms are a boon for progress in developing countries like India with rich biodiversity especially in the field of food, medicine and unemployment (Wani et al., 2010). World production of mushroom exceeds 3 million tons worth a market value of U.S \$ 10 billion. Netherlands, Poland, Ireland and Belgium are major exporting countries of fresh mushrooms in the world. China is the largest exporter of preserved mushrooms and Netherlands and Spain are the other major countries (Harsh & Joshi, 2008). Germany, U.S.A and France are considered to be major importing countries of prepared and preserved mushrooms. Till 2008 India ranked 6th as an exporter of mushrooms. India has a great potential to be an important producer of mushroom in the future and currently ranks 54th in the world in producing mushrooms. Edible mushrooms are valuable sources of nutrients and bioactive compounds in addition to its rich flavors and culinary features.

Recently mushrooms have become increasingly popular as functional foods for its potential beneficial effects on human health (Guillamon et al., 2010). Modern pharmacological research confirms large parts of traditional knowledge regarding the medicinal effects of mushrooms due to their antifungal, antibacterial, antioxidant and antiviral properties (Wani et al., 2010). Wild edible mushrooms are not well documented in many countries, poorly studied and underutilized though they are rich source of non wood forest product. There is no systematic survey and study on mushroom

harvest, its market and income generation potential (Tibuhwa, 2013). The FAO of the UN has emphasized the adoption of mushrooms as an ideal food for developing countries and its contribution to global food security.

Wild edible mushrooms are used as food and medicine by the indigenous tribes of Similipal Biosphere Reserve (SBR) of Odisha, India. More than ten ethnic groups of SBR were found to be mycophilic and have extensive traditional mycological knowledge (Sachan et al. 2013). The mushrooms identified in the SBR are native to many parts of India which were reported by some authors in the North-Eastern hills of India (Verma et al., 1995; Singh et al., 2007; Tanti et al., 2011); North Western Himalayas (Atri et al., 1997) and Kanyakumari district (Davidson et al., 2012). The northeast region of India is known for its rich biodiversity. The high humidity during monsoon period provides ideal agro-climatic conditions for the growth of mushrooms. The people of Nagaland are highly known for coveting wild edible mushrooms. Mushrooms are highly prized delicacy of the state. Very few works has been done on wild edible mushrooms in Nagaland (Kumar et al., 2013). In most of these reports the mushroom resources are ill presented. The purpose of the present study was to bring to light the rich diversity of WEMs of Nagaland and its potential as a valuable food resource.

2 Materials and Methods

Survey Area

Nagaland is located in the North Eastern region of India with total geographic area of 16,579 sq Km. Nagaland shares borders with Myanmar in the East, Assam in the West, Arunachal Pradesh and a part of Assam in the North and Manipur in the South. It lies between 93°15' to 95°15' E and 25°10' to 27°4' N. According to the meteorological data of the state the average annual rainfall ranges between 2000-2500 mm while, temperature during summer ranges from 16-31°C and drops as low as 4°C during winter. During the present study regular surveys and collection were carried out in various districts and market areas of Nagaland from October 2013–May 2015 during the peak mushroom season of the state. Forest areas and market places of Mokokchung, Zunheboto, Kohima, Tuensang, Phek and Wokha were surveyed during this period. Local markets were surveyed to know about the wild varieties sold during the season and regular mushroom collectors were interviewed to gain more knowledge about the hunting areas.

Wild edible mushrooms were collected in silver foil/collection boxes and brought to the laboratory for identification. Mushrooms with leathery texture were preserved in 4% (v/v) formaldehyde solution and mushrooms with soft texture were preserved in 2% (v/v) formaldehyde solution and maintained as herbarium specimens.

Table 1 List of Wild Edible Mushrooms (WEM) found in Nagaland, India.

Name of Species (Family)	Habitat	Season of collection	Accession No
<i>Auricularia auricula-judae</i> (Bull.) Quél (Auriculariaceae)	On dead stumps and branches of sub-tropical and temperate trees especially <i>Alnus</i> species.	End May-November	NUBOT-TA-AA-01
<i>A. polytricha</i> (Mont.) Sacc (Auriculariaceae)	In clusters on rotten or dead and decaying stumps and twigs	September-November	NUBOT-TA-AP-02
<i>Cantharellus cibarius</i> (Fr.) (Cantharellaceae)	Found under <i>Lithocarpus</i> in sub-tropical forests	End June-October	NUBOT-TA-CC-03
<i>Lactarius piperatus</i> (L.) Pers. (Russulaceae)	Under sub-tropical semi-evergreen forests	June-October	NUBOT-TA-LP-04
<i>Lactarius volemus</i> (Fr.) (Russulaceae)	Under sub-tropical semi-evergreen forests including pine	June-October	NUBOT-TA-LV-05
<i>Lentinula edodes</i> (Berk.) Pegler (Omphalotaceae)	On trunks of Oak trees	June-July	NUBOT-TA-LE-06
<i>Hericium cirrhatum</i> (Pers.) Nikol (Hericaceae)	On trunks of semi-evergreen and temperate trees	June-July	NUBOT-TA-HC-07
<i>Dacryopinax spathularia</i> (Schwein) G. W. Martin (Dacrymycetaceae)	On dead and decaying logs in large groups	June-July	NUBOT-TA-DS-08
<i>Schizophyllum commune</i> Fr. (Schizophyllaceae)	On branches of dead wood and cut timber	April-August	NUBOT-TA-SC-09
<i>Strobilomyces strobilaceus</i> (Scop.) Berk (Boletaceae)	Grows in association with semi-evergreen and coniferous trees	June-September	NUBOT-TA-SS-12
<i>Amanita strobiliformis</i> (Paulet ex Vittad.) (Amanitaceae)	Under sub-tropical semi evergreen forest trees	June-August	NUBOT-TA-AS-19
<i>Boletus edulis</i> Bull. (Boletaceae)	Under coniferous and semi-evergreen forest types	August-September	NUBOT-TA-BE-22
<i>Tricholoma imbricatum</i> (Fr.) P. Kumm. (Tricholomataceae)	In coniferous woods, especially with pine	July-August	NUBOT-TA-TI-27
<i>Pleurotus pulmonarius</i> (Fr.) Quél. (Pleurotaceae)	In clusters on cut timber and fallen logs	June-September	NUBOT-TA-PP-28
<i>Clavaria fragilis</i> Holmsk. (Clavariaceae)	Grows in clusters on ground amongst leaf litters and in fields	August-November	NUBOT-TA-CF-35
<i>Tremella fuciformis</i> Berk. (Tremellaceae)	On dead or fallen branches of broadleaved trees	September-November	NUBOT-TA-TF-37
<i>Lentinus squarrosulus</i> Mont. Singer (Polyporaceae)	On dead stumps of trees like Oak	June-August	NUBOT-TA-LS-40
<i>Hygrocybe conica</i> (Schaeff.) P. Kumm (Hygrophoraceae)	In grass in fields after burning the area	June-July	NUBOT-TA-HC-41
<i>Russula heterophylla</i> (Fr.) Fr. (Russulaceae)	Under <i>Lithocarpus</i> and <i>Castanopsis</i> in sub-tropical forests	October-January	NUBOT-TA-RH-44
<i>Suillus luteus</i> (L.) Roussel (Suillaceae)	Under coniferous especially pine	September-November	NUBOT-TA-SL-46
<i>Xerocomellus chrysenteron</i> (Bull.) Šutara (Boletaceae)	Under sub-tropical semi-evergreen forests including pine	July-November	NUBOT-TA-XC-48
<i>Suillus pictus</i> (Peck) A.H. Sm. & Thiers (Suillaceae)	Under sub-tropical semi-evergreen forests	June-November	NUBOT-TA-SP-49
<i>Laccaria tortilis</i> (Bolton) Cooke (Hydnangiaceae)	On bare soil in damp woods	August-November	NUBOT-TA-LT-51
<i>Melanoleuca grammopodia</i> (Bull.) M. (Tricholomataceae)	Found to grow on leaf mulch or composted soil in fields	June-October	NUBOT-TA-MG-61
<i>Aleuria aurantia</i> (Pers.) Fuckel (Pyronemataceae)	Found to grow in groups on soil amongst grasses or on bare soil or at roadside	August-November	NUBOT-TA-AA-62
<i>Macrolepiota albuminosa</i> (Berk.) Pegler (Agaricaceae)	Grows on termite mounds in grassy fields	May-August	NUBOT-TA-MA-63
<i>Termitomyces heimii</i> Natarajan (Lyophyllaceae)	Found to grow on termite mounds and clayey soil	May-August	NUBOT-TA-TH-64
<i>Lentinus sp.</i> (Polyporaceae)	Grows on tree trunks and dead barks of Oaks	End May-June	NUBOT-TA-L-69
<i>Termitomyces eurhizus</i> (Berk.) R. Heim (Lyophyllaceae)	Grows in groups on ground in termite mount soil	July-August	NUBOT-TA-TE-71
<i>Lycoperdon perlatum</i> Pers. (Agaricaceae)	Grows in fields, roadsides, in woods and amongst fallen leaf litter	End April-September	NUBOT-TA-LP-72
<i>Laetiporus sulphureus</i> (Bull.) Murr. (Polyporaceae)	Grows on dead stumps as well as living tree trunk of hardwoods and oaks	July-September	NUBOT-TA-LS-73
<i>Coprinus comatus</i> (O.F. Müll.) Pers. (Agaricaceae)	Grows amongst grasses in sub-tropical forests	May-October	NUBOT-TA-CC-74
<i>Pleurotus citrinopileatus</i> Singer (Pleurotaceae)	Grows on trunks of hardwood	June-August	NUBOT-TA-PC-75

Figure 1 Some of the wild edible mushrooms of Nagaland; a. *Auricularia polytricha*, b. *Aleuria aurantia*, c. *Auricularia judae*, d. *Cantharellus cibarius*, e. *Coprinus comatus*, f. *Dacryopinax spathularia*, g. *Laetiporus sulphureus*, h. *Lactarius volemus*, i. *Laccaria tortilis*, j. *Lactarius piperatus*, k. *Lentinula edodes*, l. *Lycoperdon perlatum*, m. *Macrolepiota albuminosa*, n. *Pleurotus citrinopileatus*, o. *Pleurotus pulmonarius*, p. *Schizophyllum commune*, q. *Termitomyces eurrhizus*, r. *Termitomyces heimi*, s. *Tremella fuciformis*, t. *Tricholoma imbricatum*.

A part of the collected materials were dried at 40-72°C using blowing hot air and kept for future references, characterization and documentation. The habitat, odor, morphology, spore print and adaptation to the environment studied prior to the preservation of the collected macro fungi. Identification of the collected mushrooms was done by standard microscopic

methods (Roy & De, 1996) and by studying the macroscopic and microscopic characters (David, 1986; Das, 2009; Philips, 2006). The mushroom specimens were deposited in the herbarium of Department of Botany, Nagaland University, Lumami, India with the accession numbers as mentioned in Table 1.

3 Results

A total of 33 Wild Edible Mushroom (WEM) species belonging to Auriculariaceae, Cantharellaceae, Russulaceae, Polyporaceae, Hericiaceae, Dacrymycetaceae, Schizophyllaceae, Boletaceae, Amanitaceae, Tricholomataceae, Pleurotaceae, Clavariaceae, Tremellaceae, Hygrophoraceae, Suillaceae, Hydnangiaceae, Pyronemataceae, Agaricaceae and Lyophyllaceae were collected and identified as per various literatures (Table 1). Besides edible mushrooms, 9 species are used for medicinal purpose to cure different diseases (Table 2). Figure 1 shows some of the common wild edible mushrooms of Nagaland. Market surveys revealed that WEM are highly coveted food resource in Nagaland. The local people prepare soups, chutney, salads and various side dishes from mushrooms. During the season, there is high demand of edible varieties of WEMs and these are sold ranging from 50-250 INR per packet at local markets. The prize varies depending on popularity, taste and demand. Some popular varieties available at local markets during the season are *Schizophyllum commune*, *Lentinus edodes*, *L. squarrosulus*, *Termitomyces heimi*, *T. eurhizus*, *Auricularia auricula-judae*, *Lactarius volemus*, and *Pleurotus pulmonarius*. *S. commune* and *L. edodes* are sold in dried form throughout the year till stocks last with the local people.

Discussions

Nagaland is one of the North Eastern states of India which is agro-climatically very rich and supports the growth of many wild mushrooms. Unfortunately till date there is no systematic survey of wild edible mushrooms in the state. Indigenous knowledge possessed by the local people about WEMs will provide significant opportunities to develop micro-enterprises and entrepreneurship. This can be a means of achieving sustainability. Mushroom hunting is not gender oriented in the state i.e. both men and women are equally involved. Folk taxonomy through traditional knowledge and experience is usually used to identify edible mushrooms from poisonous ones. Naming of the species is done in local dialect to keep

memory and transfer the knowledge from one generation to the next. The study promotes awareness to harvest and exploit this underutilized local resource, which will provide nutritious food and employment opportunities especially to the disadvantaged groups (i.e. unemployed and old people) (Kumar et al., 2013; Sachan et al. 2013; Tanti et al., 2011; Tibuhwa, 2013).

The exploitation of WEM would contribute significantly in boosting the economy and at the same time, food security is checked. Mushrooms are a source of income generator especially for rural areas. The cultivation of WEM hardly causes any effect on the environment in fact they act as ecological indicators. As such the study calls for awareness and cooperation from forest conservers to allow mushroom gatherers to freely collect this non wood forest resource which is highly underutilized. The present work also highlights the ethno-medicinal potential of the state. The uses (nutritional and medicinal values, nutraceuticals and neutraceutical compounds) of WEM is likely to be lost if these are not properly documented and screened. Further studies need to be carried out in order to assess the ethno-medicinal potential of WEMs for discovery of novel compounds for their pharmaceutical applications.

The present work may lead to the creation of a database for WEM of the state as no such work has been carried out in depth. The first phase of this study enumerates the wild edible mushrooms of Nagaland. Works on nutritional analysis, molecular profiling of wild edible mushrooms is in progress. During recent times, cultivated mushrooms have gained much attention because of the many health benefits of mushrooms but unfortunately in remote regions of the world like Nagaland no such markets are available for the local people to enjoy the highly popular cultivated mushrooms. In such circumstances, the wild edible mushrooms which are available in the state should be brought to light so that the people can reap the benefits of consuming edible mushrooms like the rest of the world. Moreover, with proper research and infrastructure facilities, WEM can be commercialized which can play a key role in the socio-economic upliftment of the people.

Table 2 Medicinal uses of WEM as described by other researchers.

Name of the species	Medicinal uses
<i>Auricularia auricula-judae</i>	Anti-tumor, anticoagulant, hypocholesterolemic
<i>Auricularia polytricha</i>	Anti-coagulant, hypocholesterolemic
<i>Pleurotus pulmonarius</i>	Anti-HIV, hyperglycemic
<i>Cantharellus cibarius</i>	Anti-microbial
<i>Schizophyllum commune</i>	Anti-cancer (drug- Schizophyllan)
<i>Lentinula edodes</i>	Anti-tumor, anti-HIV, natural antidote
<i>Lactarius piperatus</i>	Anti-tumor, anti-bacterial, anti-oxidant
<i>Lycoperdon perlatum</i>	Antimicrobial and Antifungal (lycoperdic acid)
<i>Lentinus squarrosulus</i>	Used as nutraceutical

Sources: Chang & Miles, 2004; Das, 2010; Patel et al., 2012; Sachan et al., 2013; Sharma & Atri, 2014.

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Conflict of Interest

Authors would hereby declare that there is no conflict of interests.

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