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RESEARCH ARTICLE

Rich yet undocumented ethnopharmacological practices of socio-culturally diverse indigenous ethnic tribes of Arunachal Pradesh, India

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Abstract

The use of wild edible mushrooms (WEM) for food and medicine is deeply rooted in the traditional knowledge systems of Arunachal Pradesh, yet remains undocumented, particularly in the Siang region. This study aims to bridge this gap by identifying frequently used WEM, documenting their usage and compiling associated indigenous knowledge. From April 2022 to January, 2025, 300 informants aged 25 to 83 years were interviewed. Data were analyzed using the cultural importance index (CI) and factor informant consensus (F_{ic}) to assess the significance of WEM and the consistency of knowledge sharing. Results revealed profound ethnopharmacological wisdom among the Monpa and Galo tribes, with a folk taxonomy based on morphological traits, aroma and habitat. Seven mushroom species were catalogued, with *Ophiocordyceps sinensis*, *Schizophyllum commune* and *Termitomyces microcarpus* being the most commonly utilized *O. sinensis* had the highest CI (1.0), indicating its cultural importance. Over 99 % of the documented WEM were new records for culinary and medicinal uses in the region. Higher knowledge about WEM was found among females, elders and those with no formal education. This study highlights the importance of conserving and scientifically validating indigenous fungal knowledge. Future efforts should focus on cultivating WEM and educating locals to sustain traditional practices and biodiversity, in line with the Biological Diversity Act of India.

Keywords: ethnopharmacological; folk taxonomy; folk medicine; *Ophiocordyceps sinensis*; traditional knowledge; wild edible mushrooms

Introduction

Human beings, particularly ethnic tribes, have long relied on wild mushrooms for various purposes due to their deep cultural association with natural resources that dates back to prehistoric times. These associations persist today in the form of folk medicine and traditional culture. In rural India, many people depend heavily on conventional medicine systems, as modern healthcare facilities are often either unavailable or prohibitively expensive (1). This enduring reliance on traditional practices underscores the importance of preserving and documenting the ethnopharmacological knowledge that continues to play a vital role in the health and well-being of these communities. The edible fleshy fungus growing in natural habitats and not cultivated is classified as a wild edible mushroom (WEM). WEM boast a long and captivating history, dating back 300 million years, with fossilized wood as evidence. Prehistoric humans likely gathered these fungi for food. Adapting to their environments, wild macro-fungi thrive as saprophytes, parasites and symbionts based on their nutritional needs (2). However, traditional knowledge of wild edible and medicinal mushrooms has diminished globally due to inadequate documentation. Indian tribal communities, however, still retain extensive traditional knowledge, utilizing nearly 283 species of wild mushrooms out of the 2189 documented worldwide (3).

In the Siang region, home to the indigenous Monpa and Galo tribes, this knowledge remains significantly under-documented. These ethnic tribes are renowned for their unique cultural practices; however, traditional knowledge about mushrooms is scarce and is mainly retained by a few elderly individuals. Thus, conducting an ethnopharmacological study to document the uses and diversity of WEM in this region is crucial. Quantitative analysis of traditional knowledge, utilising the cultural importance index and factor informant consensus, has gained increasing popularity in recent times. Essentially, these analyses reveal the degree of consensus within an ethnic community regarding a particular species or body of knowledge, as well as the most commonly used species. The present quantitative ethnopharmacological study is the first of its kind from North East India.

Methodology

Study area

The study was conducted in the Siang region of Arunachal Pradesh, focusing on four representative villages viz., Menchuka, Aalo, Basar and Tirbin (Fig. 1). These villages, predominantly inhabited by the Monpa and Galo ethnic tribes, were selected following a detailed reconnaissance. Situated at altitudes ranging from 131 m to over 3829 m, these villages are characterized by East Himalayan sub-tropical wet hill forests and alpine zones. This dense vegetation area experiences a wide range of climatic and geographical variations. The monsoon season extends from April to September, bringing an average annual rainfall of 2910 mm. During this period, temperatures range from a minimum of 1 °C to a maximum of 35 °C, providing a conducive environment for a diverse array of wild fungi.

Collection and identification of fungi

Systematic and periodic surveys of different locations in the siang region were conducted. Detailed field records were made for habitats and hosts and photographs of collection sites and fruit bodies were taken to study wild fleshy fungi. Macroscopic features were studied using fresh material, while microscopic structures were observed in dried material with 5 % potassium hydroxide (KOH) and Congo Red. Microcharacters were observed with a Leica DM500 microphotographic unit. Identification and confirmation were conducted using relevant mycokeys, manuals, monographs and books, as well as online resources such as www.mycokey.com and www.mushroomexpert.com. Further verification was performed by taxonomists from ICAR-Directorate of Mushroom Research (DMR), Solan (HP), India. Vouchers were preserved at the ICAR-Mushroom Research and Training Centre in Basar.

Ethnopharmacological data collection

The ethnopharmacological study was conducted between April 2022 and January, 2025. Data were collected from 300 informants (150 females and 150 males) through semi-structured questionnaire interviews and lively discussions with indigenous ethnic tribes (75 informants from each village). The study began with an immersive reconnaissance survey, fostering bonds with village headmen and community groups to build trust and familiarity. All informants were interviewed at least twice to gather information on traditional usage, edibility status, historical background, commercial importance of fleshy fungi, methods of preservation and reasons for lower biodiversity of wild edible fungi in the region. Interviews and discussions were conducted in various local dialects. Verification of the macrofungal species was conducted during the rainy season, with informants accompanying the researchers to confirm species and gather related information. Identified specimens and pre-existing photographs were also utilized for verification.

Data analysis

The data collected through interviews on the number of uses cited by the informants were analyzed using the cultural importance index (CI) and factor informant consensus (F_{ic}) according to standard mathematical formulas (4). Analysis of variance (ANOVA) was applied to compare the means of different attributes related to informants, such as gender, age and education, with respect to the collection of WEM. The data were normalized using log transformation. Fisher's least significant difference (LSD) was applied as a multiple range test to compare the significant number of WEM collected by informants when the ANOVA value was significant at $P < 0.05$.

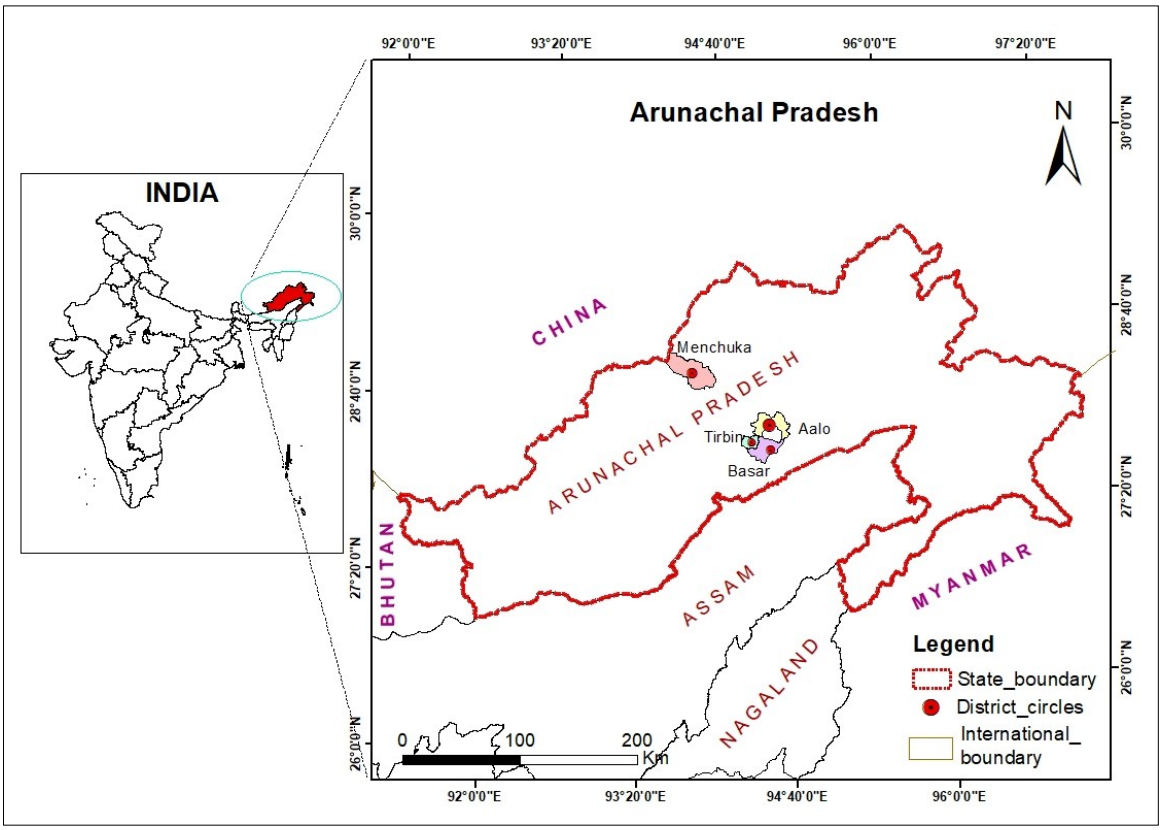

Fig. 1. Location map of the study area and sampling points (Menchuka, Aalo, Tirbin and Basar).

Results

A total of 300 informants participated in the study on wild edible mushrooms (WEM) in the Siang region. Most informants were up to 60 years old (60 %) and literate (66.67 %). However, significant demographic differences were observed in WEM knowledge. Female informants reported significantly more WEM species (mean = 5.4 ± 4.5) than males (mean = 2.2 ± 1.5), indicating a stronger traditional knowledge base among women, likely due to their active involvement in foraging activities. Elderly individuals cited more WEM species (mean = 5.6 ± 4.6) and medicinal uses (mean = 6.3 species/person) compared to younger groups (mean = 2.8 species/person), highlighting their critical role in preserving ethnomycological knowledge. Illiterate informants also reported more WEMs (mean = 5.8 ± 1.8) than literate ones, suggesting that traditional ecological knowledge may decline with increased levels of formal education. Statistical analysis confirmed significant correlations between WEM knowledge and demographic variables ($P < 0.001$), emphasising the need to document and preserve indigenous knowledge, particularly among women, elders and less formally educated individuals (Table 1). In the lush landscapes of surveyed areas, an ethnopharmacological expedition documented seven wild edible mushroom (WEM) species belonging to seven families and four orders (Table 2). *Ophiocordyceps sinensis*, *Schizophyllum commune* and *Auricularia polytricha* emerged as the most commonly utilised fungi among WEM (Table 3; Fig. 2). Notably, over 99 % of these WEM species were newly recorded as culinary and medicinal mushrooms for Arunachal Pradesh, highlighting their novelty and potential significance in traditional practices and economies.

Folk taxonomy in the region is based on morphological features, aroma and habitat (Table 4). The Galo community avoids mixing epiphytic and terrestrial mushrooms to prevent poisoning and uses *Garcinia lancfolia* fruits as a remedy, demonstrating a knowledgeable approach to mushroom foraging and use. This highlights the importance of traditional knowledge in ensuring the safe and effective use of wild fungi. The intergenerational transfer of mushroom foraging knowledge is a cherished tradition, starting from a young age and enriched by a unique system of folk taxonomy. Mushrooms are given local names based on their colour, shape and size, often drawing imaginative comparisons to the body parts of wild and domestic animals. These folk taxonomies reflect a deep connection with the natural environment and illustrate how traditional knowledge systems are shaped by the ways people relate to and interpret their surroundings, preserving biodiversity and strengthening cultural heritage. Local ethnic tribes, such as the Monpa and Galo, actively harvest mushrooms for sustenance and trade, showcasing them throughout the year in local markets. Medicinal macro-fungi, used both fresh and dried, feature in traditional recipes and health tonics (Table 5). For preservation during winter, mushrooms are sun-dried on rooftops or in open areas. The prime foraging season begins with the monsoon rains, which enhance growth in forests, decaying wood, shifting cultivation fields and rotting plant matter, as well as termite mounds, highlighting the cultural and economic significance of mushrooms in these communities.

The highest CI was recorded for *O. sinensis* (CI 1.0), followed by *S. commune* (CI 0.98) and *Termitomyces microcarpus* (CI 0.96) (Table 6). The maximum consensus

Table 1. Analysis of different attributes of wild edible mushrooms (WEM)

Attributes	Informants	No. of informants	No. of WEM	ANOVA	
				F value	*P* value
Gender	Female	150	$5.4^{a} \pm 4.5$	26.76	< 0.001
	Male	150	$2.2^{b} \pm 1.5$		
Age	Up to 60 years	180	$2.9^{b} \pm 1.8$	22.42	< 0.001
	> 60 years	120	$5.6^{a} \pm 4.6$		
Education	Illiterate	100	$5.8^{a} \pm 1.8$	30.53	< 0.001
	1-10 class	150	$4.2^{b} \pm 1.5$		
	10-12 class	30	$3.8^{c} \pm 1.2$		
	> 12 class	20	$1.7^{c} \pm 0.8$		

The values of WEMs given in the table are mean ± SD. Fisher's least significant difference (LSD) was applied as multiple-range test when analysis of variance (ANOVA) was found significant at $P < 0.05$. Similar alphabets in a column for an attribute show that the values do not vary significantly

Table 2. Identification of wild edible mushrooms (WEM)

Scientific name	Family	Order	Habitat	Fruiting
Auricularia polytricha	*Auriculariaceae*	*Auriculariales*	Epiphytic	May-Oct
Ophiocordyceps sinensis	*Ophiocordycipitaceae*	*Hypocreales*	Entomopathogenic	May-June
Ganoderma lucidum	*Ganodermataceae*	*Ganodermatales*	Epiphytic	April-Oct
Termitomyces microcarpus	*Lyophyllaceae*	*Agaricales*	Termitaria	July-August
Pleurotus pulmonarius	*Pleurotaceae*		Epiphytic	June-Sept
Schizophyllum commune	*Schizophyllaceae*		Epiphytic	May-Nov
Tricholoma imbricatum	*Tricholomataceae*		Terrestrial	July-August

Table 3. Wild edible mushrooms (WEM) and their informant's citations

Scientific name	Folk name	~ Price (per kg) in INR	Fruiting	Ethnomycological uses (Number of informants cited the fungi for a use)	Use report (UR)
Auricularia polytricha	Takek Marek	Rs. 1500	May-Oct	Culinary (260); medicine (23)	283
Ophiocordyceps sinensis	Yarsa gumba	Rs. 200 per piece (350 mg/piece)	May-June (fresh) Throughout the year (dried)	Medicine (300)	300
Ganoderma lucidum	-	-	April-Oct	Medicine (180)	180
Termitomyces microcarpus	Inyak	Rs. 1000	July-August	Culinary (280); medicine (10)	290
Pleurotus pulmonarius	Aatar	Rs. 400	June-Sept	Culinary (270); medicine (9)	279
Schizophyllum commune	Hubsi	Rs. 1500	May-Nov (fresh) Throughout the year (dried)	Culinary (240); medicine (53)	293
Tricholoma imbricatum	Inde	Rs. 1400	July-August	Culinary (250); medicine (19)	269

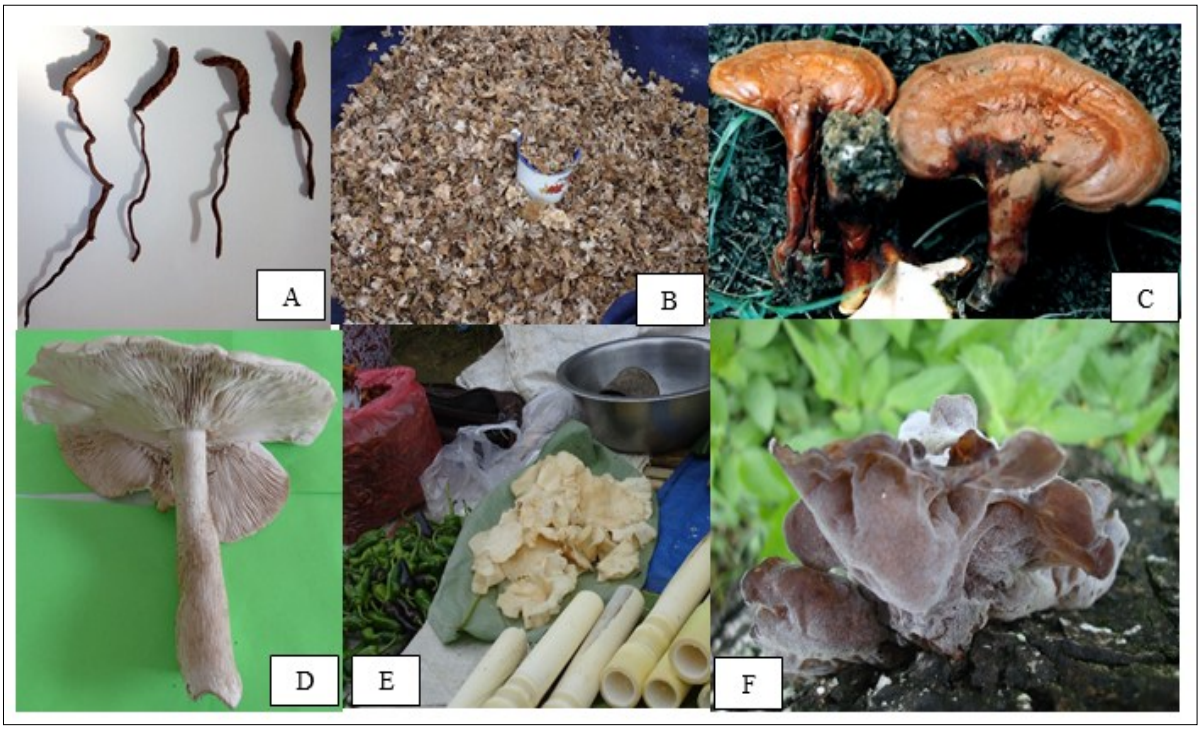

Fig. 2. Ethnopharmacologically important wild mushrooms; A. *Ophiocordyceps sinensis;* B. *Schizophyllum commune;* C. *Ganoderma lucidum;* D. *Tricholoma imbricatum;* E. *Pleurotus pulmonarius* and F. *Auricularia polytricha.*

(1.00 F_{ic}), with 1300 citations, was recorded for the use of fleshy fungus for culinary purposes (Table 7), whereas the minimum homogeneity was found for medicinal purposes (594 citations and 0.99 F_{ic}). An evaluation of traditional claims by counting users treating specific illnesses shows that local folk and traditional healers in Menchuka have long used *O. sinensis* to treat 20 ailments, including increasing longevity and curing erectile dysfunction (Table 8). These prolonged uses emphasize the fungi's medicinal significance. The reduction in forest areas (58.93 % of informants) is the primary reason for the lesser number of WEM in the study areas. Other prominent reasons include increasing shifting cultivation land (26.57 % of informants), lack of awareness about the local diversity of WEM among people (12.46 % of informants) and availability of fungal species in smaller quantities (2.04 % of informants).

Table 4. Folk taxonomy of macro-fungi

Ethnic tribes	Folk taxonomy criteria	
	Edible	**Poisonous**
Monpa	Milky juice exudes when any part of the fruiting body is broken. These macro-fungi, which mainly grow on pine trees, have a pleasant aroma.	Pink fluid exudes when the stipe is cut or broken. These macrofungi, which grow on animal excreta and have a peculiar, unpleasant odour, indicate a high toxin presence if cooked with brinjals and the curry turns dark green.
Galo	The macrofungi have a light grey pileus and a white stipe with a unique scent. They are safe for consumption if they are umbrella-shaped and grow on termite mounds and do not turn blackish when mixed with lemon juice and saltwater.	The poisonous species have brightly colored, powdery spores on the pileus with a characteristic odor; during foraging, dry salts are applied to the fruiting bodies and the fruiting body is cut with an iron knife or silver bangles to check for color change; garlic cloves turning dark when added to water with wild mushrooms indicate toxicity; and those that grow on living trees are considered inedible due to the potential accumulation of toxic substances.

Table 5. Ethnopharmacological uses of WEM

Scientific name	Ethnopharmacological uses
Ophiocordyceps sinensis	Local herders in the alpine forests of the Siang region first observed that their domestic animals became stronger and sturdier after consuming *O. sinensis* during grazing, which led to the discovery of its medicinal value. This prompted local people and herders to use the powdered fungus mixed with jaggery to enhance milk production, boost livestock vitality and improve reproductive capacity. Today, Monpa folk practitioners use *O. sinensis* either alone or in combination with other medicinal herbs, such as *Taxus baccata* leaf and Ginseng root decoctions, to treat various ailments. They prescribe specific doses based on extensive knowledge and experience, commonly advising the steeping of one piece of *Cordyceps* in a cup of hot water for an hour, to be consumed both in the morning and evening as a health tonic.
Schizophyllum commune	Fresh or dried fruiting bodies of *S. commune*, particularly favoured by the Monpa and Galo tribes in the siang region, are commonly incorporated into traditional recipes and health tonics. These mushrooms are frequently prepared as soups and are cherished for their therapeutic properties in alleviating coughs and colds.
Ganoderma lucidum	The presence of *G. lucidum* in a home is believed to be a positive omen, indicating prosperity and a harmonious environment. Many traditions associate this mushroom with health benefits and spiritual harmony, adding to its cultural significance beyond its medicinal properties.
Auricularia polytricha	The Galo and Monpa tribes have a traditional practice of using fresh and dried fruiting bodies of *A. polytricha*. They boil these mushrooms in water and then decant the resulting liquid to create a tonic. This simple yet effective method extracts beneficial compounds known to help with health issues such as weakness, low blood pressure and heart conditions.
Tricholoma imbricatum *Termitomyces microcarpus* *Pleurotus pulmonarius*	Fresh mushrooms, valued for their anti-inflammatory and antibacterial properties, are commonly used by the Galo and Monpa tribes to prepare delicious curries. The traditional method involves boiling the mushrooms in hot water, draining them and then frying them in edible oils. This cooking process not only enhances the flavour but also retains the beneficial properties of the mushrooms, making them a nutritious and flavourful addition to local cuisine.

Table 6. Cultural importance index (CI) for WEM of Siang region, Arunachal Pradesh

Scientific name	CI_{cul}	CI_{med}	CI_{total}
Auricularia polytricha	0.86	0.08	0.94
Ophiocordyceps sinensis	-	1.00	1.00
Ganoderma lucidum	-	0.60	0.60
Termitomyces microcarpus	0.93	0.03	0.96
Pleurotus pulmonarius	0.90	0.03	0.93
Schizophyllum commune	0.80	0.18	0.98
Tricholoma imbricatum	0.83	0.06	0.89

CI_{cul} and CI_{med}, is cultural importance index of culinary and medicinal, respectively

Table 7. Factor informant consensus (F_{ic}) of various use categories for macro-fungi

Use category	n_{ur}	n_t	F_{ic}
Culinary	1300	5	1.00
Medicine	594	7	0.99

n_{ur} is number of use reports and n_t is the number of taxa

Table 8. Ethnopharmacological uses of *Ophiocordyceps sinensis* by Monpa folk practitioners

Illness	Impact	Illness	Impact
Erectile	++++	Infertility	++++
Female aphrodisiac	+++	General weakness	++++
Cough and cold	+++	Increase longevity	++++
Low BP	++	Tuberculosis	+++
Diabetics	++	Alcohol hepatitis	+
Kidney diseases	++	Liver diseases	++
Prostate enlargement	++	Coronary heart disease	++
Chronic pain	++	Malignant tumor	++
Jaundice	++	Rheumatism	+
Sciatica and backache	+	Arthritis	+

Whereas: + (low); ++ (moderate); +++ (high); ++++ (strong impact)

Discussion

Agriculture is the primary livelihood for the inhabitants of the Siang region of Arunachal Pradesh, supplemented by small-scale poultry farming, piggery and cattle farming. Women play a crucial role in agricultural activities, such as sowing, harvesting and livestock care, often accompanied by children who help gather firewood, non-wood forest products and WEM from nearby forests and grazing lands. This tradition not only supports daily needs but also passes down vital knowledge about these resources to the next generation. Similar practices involving females and children collecting forest products are observed across India (5). Seven WEM species were identified in the study, aligning with findings from Nagaland (1) and other north-eastern states (6, 7). *O. sinensis* emerged prominently for its recognized medicinal value, universally acknowledged among respondents for its therapeutic benefits. This mushroom holds significant medicinal importance, as corroborated by leading mycologists in India (8-10) and neighbouring countries such as China, Nepal and Bhutan (11). Female informants exhibited significantly higher knowledge of WEM in this study, consistent with findings from Jammu and Kashmir and other parts of India (4-7, 10) where women often possess greater knowledge about WEM than men. Elderly and illiterate informants also showed higher knowledge levels compared to younger and literate informants, respectively. Similar trends have been observed in studies from Jammu and Kashmir and other regions (4-6, 10), highlighting the pivotal roles of elderly and less educated individuals in the collection of non-wood forest products and WEM.

Informants identified several factors contributing to the underutilization of mushrooms, including a reduction in forest areas, expansion of shifting cultivation fields, lack of awareness about local mushroom diversity, insufficient availability of fungal species, poor identification skills and inadequate documentation of edible and medicinal fungi. Research indicates that low macro-fungal diversity is attributed to anthropogenic disturbances, forest area reduction and urbanisation. The study areas exhibited limited knowledge of folk nomenclature compared to mycophilic regions like Jammu and Kashmir, where rich ethnotaxonomic knowledge and extensive use of wild edible mushrooms are documented (5). *O. sinensis*, *S. commune* and *T. microcarpus* garnered the highest cultural importance index (CI), reflecting their global acceptance due to high concentrations of bioactive compounds, proteins, vitamins and minerals, alongside low fat and carbohydrate content and significant economic value (4, 10, 11). The highest consensus among informants was for the culinary use of fleshy fungi, echoing findings from Jammu district (4) and indicating strong agreement among informants regarding the culinary uses of WEM. High factor informant consensus values highlighted homogeneity among informants in sharing knowledge about WEM (4).

Conclusion

This is the first-ever study to document the traditional knowledge of wild edible mushrooms (WEM) in the Siang region of Arunachal Pradesh. Valuable insights into the culinary and medicinal uses of mushrooms were gathered from 300 informants, revealing seven WEM species across 7 families and 4 orders. However, there is a significant risk of losing this knowledge, as females, elders and illiterate individuals hold the most information, yet are vulnerable in terms of information retention and dissemination. The lack of written records and reduction in natural habitats further threaten the preservation of this valuable cultural heritage. Despite these challenges, the practice of accompanying children during mushroom gathering offers hope for the continuity of this knowledge. Urgent conservation efforts are needed to safeguard mushroom habitats and raise awareness about their importance. *O. sinensis*, *S. commune* and *T. microcarpus* emerged as the dominant WEM in the study, mirroring findings from other tropical regions worldwide. To benefit society, ensure food security and preserve cultural heritage, there is a pressing need to focus research on the domestication of these WEM species. Detailed investigations into their nutritional and medicinal properties are crucial steps towards sustainable utilization. The study emphasizes the profound narrative of diminishing traditional knowledge alongside the enduring medicinal and cultural significance of mushrooms in rural Arunachal Pradesh. The scientific community must recognise the biological and economic value of these resources. Collaborative efforts among the public, governmental agencies and researchers are essential for developing strategies to protect and promote the edible fungal diversity of the region, especially in Northeast India. Research and monitoring initiatives play a pivotal role in these conservation and development efforts.

Ethics and Intellectual Property Protection

Ethical clearance for the study was obtained and prior informed consent was secured from all informants in accordance with the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits. The study adhered to the International Society of Ethnobiology (ISE) Code of Ethics (2006) to ensure the protection of indigenous intellectual property rights.

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Authors' contributions

RS carried out data collection, photography and prepared the manuscript and draft paper of the study. AS helped in manuscript preparation and study map preparation.

Compliance with ethical standards

Conflict of interest: We hereby declare that we have no conflicts of interest.

Ethical issues: None

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