

Review Article

Review on bridging tradition and science: The role of mushrooms in Indian food systems, medicine, livelihood and ecology

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Abstract

Mushrooms are a vital yet underused biological resource in India, intersecting nutrition, medicine, livelihoods, and ecosystem health. Contemporary research spans medicinal, edible, toxic, taxonomic, phytochemical, and socio-economic fronts. Medicinal genera such as *Ganoderma* and *Pleurotus* display antioxidant, anticancer, antimicrobial, and immunomodulatory effects, yet translation into standardized clinical practice remains limited. Edible species including *Termitomyces*, *Agaricus*, and *Lentinus* provide high-quality proteins, minerals, vitamins, and dietary fibre, enhancing food diversity and micronutrient intake for rural and tribal households. Toxic species continue to pose a public-health challenge; amatoxins, orellanine, and muscarine can cause hepatic, renal, or neurotoxic syndromes, highlighting the need for early diagnosis and awareness. Taxonomic surveys across Indian hotspots keep revealing extensive macrofungal diversity, while molecular barcoding complements classical morphology for reliable identification. Phytochemical evaluations consistently report phenolics, flavonoids, terpenoids, polysaccharides, and saponins that underpin strong antioxidant and antimicrobial potential. Economic assessments show mushrooms are profitable, low-input enterprises that diversify income, create jobs, and support women's entrepreneurship. Ethnomycological evidence points to deep cultural and therapeutic relevance, even as intergenerational knowledge erodes under rapid socio-economic change. Cultivation and ecological studies provide region-specific guidance on temperature, humidity, substrates, casing soils, and composting, enabling climate-responsive production systems. Overall, mushrooms connect nutrition, culture, ecology, and rural economies. Priority actions include clinical validation of therapeutics, conservation of wild fungal resources, improved toxicovigilance, stronger taxonomy using genomics, and integration of indigenous knowledge with modern biotechnology to realise their full potential for health, livelihoods, and sustainable development. Coordinated policy support, value-chain strengthening, and market linkages will accelerate adoption.

Keywords: Mushrooms, Phytochemical screening, Medicinal properties, Rural livelihoods, Mushroom poisoning

Introduction

Mushrooms, members of the kingdom *Fungi*, represent one of the most diverse and ecologically significant groups of organisms. Globally, more than 14,000 species have been formally described, although estimates suggest the actual number may exceed 150,000 (Hawksworth & Lücking, 2017). These macrofungi play essential ecological roles as decomposers, symbionts, and nutrient recyclers, while also serving humanity as sources of food, medicine, and cultural heritage. Over the last few decades, mushrooms have gained considerable global attention for their nutritional quality, bioactive metabolites, and potential contributions to sustainable agriculture, health care, and rural livelihoods (Wasser, 2002; Miles & Chang, 2008).

For tribal and rural communities, mushrooms have long functioned as seasonal foods, ethno-medicines, and cultural resources, embedding them deeply into indigenous knowledge systems (Pala *et al.*, 2013; Debnath *et al.*, 2019). Ethnomycological investigations document species such as *Termitomyces*, *Morchella*, and *Auricularia* as highly valued for both dietary and ritual purposes, reflecting a sophisticated integration of ecological knowledge with cultural practices (Sharma *et al.*, 2022; Ullah *et al.*, 2022).

From a biomedical perspective, medicinal mushrooms have become the subject of intensive research in India and globally. Experimental and preclinical studies confirm the antioxidant, antitumor, antimicrobial, and immunomodulatory effects of genera such as *Ganoderma*, *Pleurotus*, *Lentinula*, and *Schizophyllum* (Ajith & Janardhanan, 2007; Bijalwan *et al.*, 2020; Bhambri *et al.*, 2022). Phytochemical analyses consistently identify bioactive metabolites, including phenolics, flavonoids, terpenoids, polysaccharides, and saponins, which contribute to these therapeutic properties (Sharma *et al.*, 2025). Despite this progress, significant challenges remain in terms of clinical trials, regulatory frameworks, and standardized dosage formulations (Panda & Luyten, 2022).

Table 1 and Figure 1 clearly shows that nutritionally, edible mushrooms offer high-quality proteins, essential amino acids, dietary fiber, and minerals such as potassium, iron, and zinc, while maintaining low fat content (Agrahar-Murugkar & Subbulakshmi, 2005; Singh *et al.*, 2025).

Economically, mushrooms serve as both cultivated and wild non-timber forest products (NTFPs). Cultivation of *Agaricus bisporus*, *Pleurotus* spp., and *Calocybe indica* has been widely adopted, particularly by smallholders and landless farmers. Research from Himachal Pradesh, Haryana,

Odisha, and Chhattisgarh demonstrates their contribution to household incomes, women's empowerment, and reduction of seasonal migration (Singh *et al.*, 2018). Wild mushrooms such as *Rugda* and *Termitomyces microcarpus* command high market prices, further underscoring their role in local economies (Kumar *et al.*, 2022b).

Ecological and cultivation research further demonstrates how environmental variables—temperature, humidity, substrate choice, casing soil, and composting techniques—directly affect mushroom yields and quality. Studies recommend region-specific strategies for optimizing production and ensuring sustainability (Suhana *et al.*, 2020). By integrating traditional farming practices with scientific recommendations, such work supports the development of climate-resilient mushroom production systems tailored to India's diverse agro-climatic conditions.

In summary, mushrooms in India embody a multidimensional resource that is simultaneously nutritional, medicinal, ecological, cultural, and economic. Nevertheless, challenges persist in taxonomy, conservation, toxicological safety, and the preservation of indigenous knowledge. The present review seeks to consolidate existing evidence, identify critical gaps, and chart directions for future research. By doing so, it frames mushrooms not only as biological resources but also as pivotal agents of sustainable development, healthcare innovation, and rural empowerment within the Indian context.

This review aims to 1) summarize the nutritional and medicinal potential of mushrooms, 2) highlight toxicological risks and the need for better diagnostics and awareness, 3) assess the socio-economic contributions of mushrooms to rural livelihoods, 4) document indigenous knowledge and cultural practices linked to mushrooms, 5) review ecological and cultivation factors influencing productivity and 6) Identify research gaps and future directions for sustainable utilization.

Medicinal mushrooms

Medicinal mushrooms represent one of the most promising groups of natural bioresources, valued for their nutritional richness and wide-ranging pharmacological properties. They are known to produce diverse bioactive metabolites—such as polysaccharides, terpenoids, phenolics, flavonoids, and lectins—that contribute to their antioxidant, immunomodulatory, antimicrobial, anti-inflammatory, and anticancer activities. These compounds play key roles in regulating oxidative stress, enhancing immunity, and preventing metabolic and degenerative diseases (Bhambri *et al.*, 2022). Laboratory-based investigations on *Ganoderma lucidum*, *Phellinus rimosus*, and *Pleurotus* spp. revealed significant free-radical scavenging and tumor-inhibitory properties, suggesting their potential application in cancer prevention and health promotion (Ajith & Janardhanan, 2007). Similarly, phytochemical assays on *Schizophyllum commune* from West Bengal showed high phenolic content and antioxidant capacity, validating its medicinal value (Table 2). A national review further highlighted that

although India possesses a vast diversity of medicinal mushrooms, a major gap persists between experimental research and clinical application (Bijalwan *et al.*, 2020). Ethnomycological studies from Jammu, Chhattisgarh, and Northeastern states have recorded the traditional use of over 100 wild mushroom species to treat ailments like digestive disorders, respiratory infections, and immune deficiencies, underscoring their therapeutic significance among tribal communities (Debnath *et al.*, 2019; Sharma *et al.*, 2022). Moreover, commercial reviews suggest that species such as *Ganoderma*, *Lentinula*, and *Pleurotus* could support both rural livelihoods and functional food industries in India (Veena & Pandey, 2012; Panda & Luyten, 2022). Collectively, medicinal mushrooms combine traditional wisdom with modern biomedical promise, making them key agents for sustainable health and nutrition.

Edible mushroom

Edible mushrooms form an integral part of India's nutritional and cultural heritage, particularly among rural and indigenous populations who have long relied on them as seasonal and sustainable food sources. Field surveys in Jharkhand documented more than seventy mushroom species familiar to local communities, of which around thirty-five are widely consumed. Nutritional evaluations revealed that these mushrooms are rich in protein and essential micronutrients, adding diversity and quality to the diets of tribal households (Singh *et al.*, 2025). In a complementary study from Mizoram, ten wild species showed protein contents ranging from 16 to 32 percent, carbohydrates up to 57 percent, and fat levels below 4 percent, confirming their role as affordable and nutrient-dense foods for marginalized populations (Thachunglura *et al.*, 2025).

Broader reviews across the Indian subcontinent compiled approximately 283 edible species, though many remain underutilized and insufficiently documented. The authors stressed the urgency of updated taxonomic work, domestication research, and region-specific cultivation trials to expand mushroom-based livelihoods and ensure conservation of wild genetic resources. Similarly, studies in the Western Ghats of Karnataka revealed numerous protein- and carbohydrate-rich mushrooms with minimal fat content, identifying them as health-promoting, eco-friendly food alternatives. Earlier investigations into the biochemical and pharmacological potential of edible fungi confirmed that they can serve as both food and functional medicine. *Pleurotus* and *Ganoderma* species exhibited strong antioxidant and antitumor activities, demonstrating that edible and medicinal mushrooms are interconnected resources for nutrition and therapy alike (Ajith & Janardhanan, 2007). Nutritional profiling of Khasi Hills mushrooms reinforced similar conclusions, showing that wild edible fungi are excellent sources of protein and essential minerals while playing a vital role in local diets (Agrahar-Murugkar & Subbulakshmi, 2005).

Non edible/Poisonous mushroom

Toxic mushrooms represent a serious yet often underestimated public health concern in India and

Table 1: Nutrient content of some edible fungi (Yu *et al.*, 2020)

S. No.	Name	Moisture g/100 g	Ash g/100 g	Protein g/100 g	Fat g/100 g	Nutrients Dietary fibers g/100 g	Carbohydrates g/100 g	Polysaccharides g/100 g	Energy 100 g/kJ
1	<i>Tricholoma</i>	13.77	5.40	36.87	1.86	16.5	25.60	3.43	1263
2	<i>Shiitake</i>	15.38	3.81	17.95	0.94	32.1	29.82	6.35	1104
3	<i>Pleurotus</i>	9.16	6.40	19.15	0.56	27.5	37.23	6.85	1199
4	<i>Dictyophora indusiata</i>	14.50	6.65	18.25	0.86	33.5	26.24	5.87	1056
5	<i>Fisch Agrocybe</i>	10.62	5.82	24.79	1.18	31.1	26.49	3.74	1164
6	<i>Ganoderma lucidum</i> (Leyss. ex Fr.) Karst	15.51	3.85	9.31	0.59	70.2	0.54	2.11	751
7	<i>Yanshan</i>	10.79	8.10	11.03	0.48	63.2	6.40	6.83	820
8	<i>Pholiota nameko</i> Ito ex Imai.	10.48	5.42	17.55	1.22	33.8	31.53	7.07	1150
9	<i>Hericium</i>	10.68	5.27	9.55	0.78	47.0	26.72	5.81	1021
10	<i>Coprinopsis comatus</i>	10.81	5.31	30.90	1.26	14.4	37.32	5.38	1322
11	<i>Gray Tremella</i>	10.90	9.43	8.46	1.98	63.7	5.53	8.29	821
12	<i>Cordyceps</i>	10.60	5.32	25.41	1.70	20.8	36.26	6.39	1278
13	<i>Lentinus edodes</i> (Berk.) Sing	11.59	1.27	23.29	1.06	33.6	29.19	5.14	1200
14	<i>Agaric</i>	13.93	3.98	11.06	0.46	57.6	12.97	6.76	886
15	<i>Agaricus blazei</i>	9.15	7.10	26.60	1.98	22.9	32.27	4.26	1257
16	<i>Volvariella volvacea</i> (Bull.: Fr.) Sing.	10.24	10.08	28.10	1.19	20.7	29.69	5.83	1192
17	<i>Morchella</i>	12.72	7.25	25.85	3.89	22.4	27.89	5.14	1237
18	<i>Grifflola</i>	12.41	5.19	15.60	2.91	36.2	27.69	6.24	1133
19	<i>Arimillaria</i>	12.35	9.17	18.09	3.89	28.2	28.30	5.31	1158
20	<i>Boletus</i>	12.16	7.04	23.99	1.95	31.0	23.86	4.94	1134
21	<i>Russula vinosa</i>	8.20	8.16	27.26	1.57	31.9	22.91	3.39	1166
22	<i>Cordyceps</i>	12.78	4.84	25.52	1.73	21.1	34.03	5.40	1245
23	<i>Sparassis crispa</i>	6.90	1.65	10.10	0.91	55.3	25.14	5.99	1075

Table 2: List of some medicinal mushroom

S. No.	Mushroom species	Reported uses	Availability in India
1	<i>Schizophyllum commune</i>	Phytochemicals, antioxidant activity, free-radical inhibition (medicinal)	Wild, esp. West Bengal forests
2	<i>Ganoderma lucidum</i>	Immunomodulatory, anticancer, antioxidant; traditional therapy; commercial farming	Wild (on logs, stumps) and cultivated (commercial farming in India)
3	<i>Phellinus rimosus</i>	Antioxidant, tumor-inhibitory (cancer-preventive potential)	Primarily wild in South India, rare in cultivation
4	<i>Pleurotus</i> spp. (oyster)	Nutritional (protein-rich), antioxidant, antimicrobial, ethnomedicinal uses	Widely cultivated (commercial), also wild species collected
5	<i>Lentinula edodes</i> (shiitake)	Anticancer, immunological benefits, horticultural diversification	Cultivated in India (restricted scale, commercial trials)
6	<i>Morchella</i> spp. (morels)	High-value edible, ethnomedicinal (immunity, digestive health)	Wild, Himalayan and forest belts; seasonal availability
7	<i>Termitomyces</i> spp.	Edible delicacy, immunity boosting, tribal healthcare	Wild only; collected by tribal communities in central and NE India

Table 3: List of poisonous mushroom and their toxic molecule

S. No.	Mushroom (Genus/Species)	Main toxin(s)	Typical fruiting body colour
1	<i>Amanita phalloides</i>	Amatoxins (α -amanitin, etc.)	Pale green/yellow-green to olive cap
2	<i>Amanita muscaria</i>	Ibotenic acid, Muscimol	Bright red/orange with white warts
3	<i>Inocybe</i> spp.	Muscarine	Brown/tan/ochre, small fibrous caps
4	<i>Cortinarius orellanus/rubellus</i>	Orellanine	Orange-brown to rust-brown
5	<i>Gyromitra esculenta</i>	Gyromitrin (\rightarrow Monomethylhydrazine)	Reddish-brown, brain-like convoluted cap
6	<i>Psilocybe</i> spp.	Psilocybin, Psilocin	Brownish/yellow-brown, blue bruising
7	<i>Coprinopsis atramentaria</i>	Coprine (disulfiram-like with alcohol)	Grey to brown cap, dissolves into black ink
8	<i>Clitocybe dealbata/rivulosa</i>	Muscarine	White to pale cream funnel-shaped

worldwide. Globally, over 110 poisonous species have been catalogued, including numerous Indian taxa, whose biochemical mechanisms and clinical manifestations vary from mild gastrointestinal distress to fatal hepatic and renal failure (Sharma *et al.*, 2025). Ethnomycological research from Northeast India revealed that tribal communities

possess indigenous systems for distinguishing edible and toxic mushrooms; however, misidentifications continue to cause sporadic poisoning outbreaks, underscoring the need for better awareness and education. Retrospective analyses from Meghalaya indicated that early hospitalization significantly improves survival, although

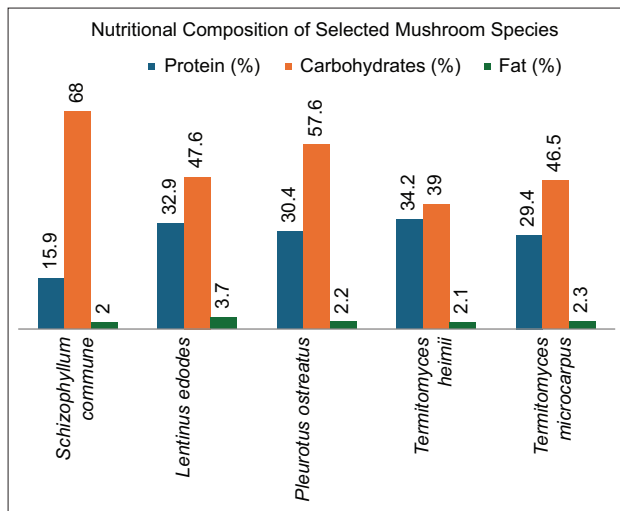


Figure 1: Nutritional composition of reported mushroom

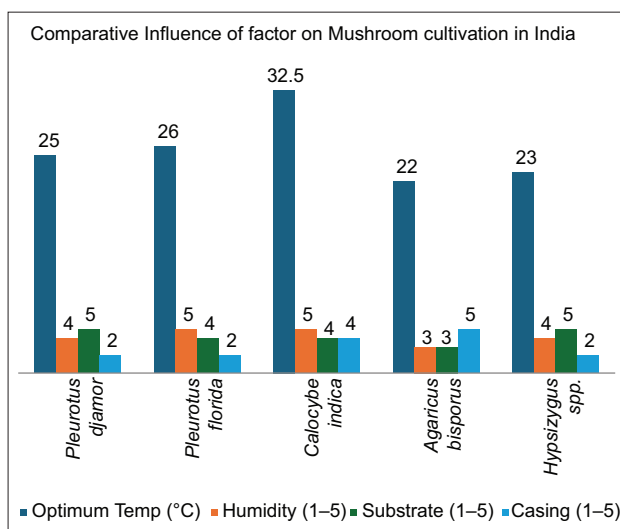


Figure 2: Factor affecting growth of mushroom

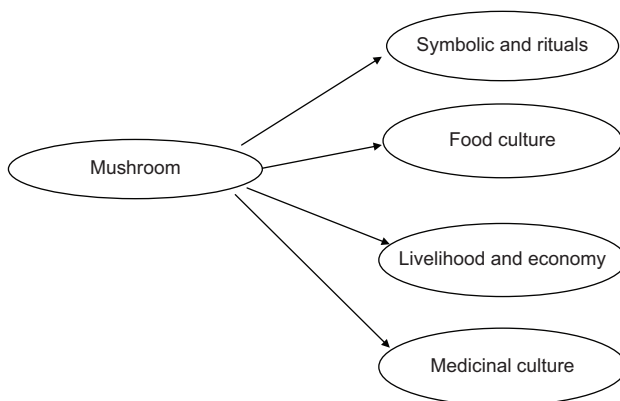


Figure 3: Multipurpose use of mushroom

amatoxin-related cases still show high fatality rates. Autopsy studies confirmed hepatic necrosis and renal tubular damage as pathological hallmarks of amatoxin toxicity.

Experimental investigations using rodent models have provided biochemical evidence of toxicity: mushrooms from the Western Ghats exhibited hepatotoxic and nephrotoxic effects, reinforcing the molecular basis of mushroom poisoning (Sai Latha *et al.*, 2018) (Table 3). Despite

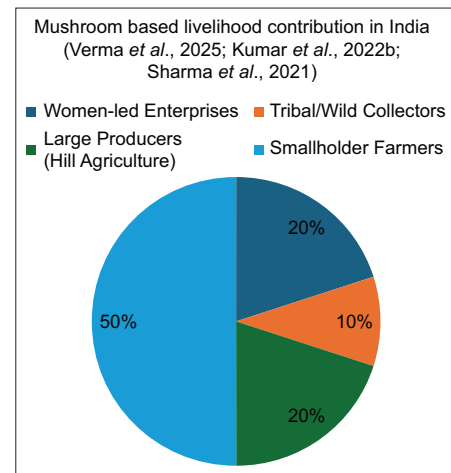


Figure 4: Mushroom contribute to Household income in different community

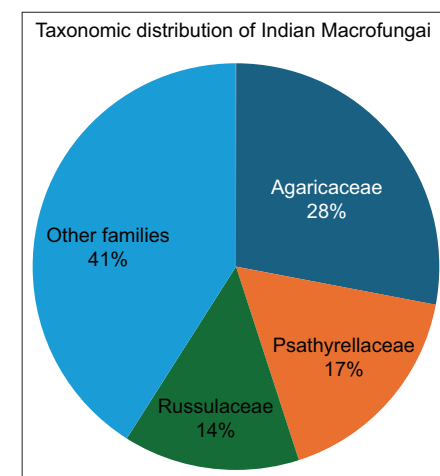


Figure 5: Taxonomic distribution of mushroom

recurring incidents, mushroom mycetism remains an underreported issue in India, particularly in the Himalayas and northeastern states, where traditional foraging continues without adequate toxicological awareness (Patra & Mukherjee, 2022). Forensic analyses have highlighted diagnostic challenges in species identification and toxin detection, calling for the development of rapid field assays to support medico-legal investigations (Sharma & Singh, 2016). Earlier taxonomic surveys identified numerous *Amanita*, *Inocybe*, and *Psilocybe* species responsible for toxic and hallucinogenic reactions, confirming the need for continuous field monitoring and public education to reduce accidental poisoning (Deshmukh *et al.*, 2006).

Factors affecting growth of mushroom

Mushroom cultivation research in India has advanced considerably over the past decade, generating valuable insights into species-specific growth parameters, substrate management, and environmental optimization. Recent findings have emphasized the potential of oyster and milky mushrooms as profitable and sustainable crops suitable for diverse agro-climatic zones. Studies on *Agaricus bisporus* have focused on improving casing and composting practices to enhance productivity. Research on tropical species, especially *Calocybe indica*, has expanded India’s warm-climate mushroom portfolio. A study found that growth

Table 4: Some mushroom and their phytochemical

S. No.	Mushroom species	Reported phytochemicals	Key outcomes/bioactivity
1	<i>Lentinus</i> spp.	Phenols, flavonoids, carotenoids, saponins, alkaloids, terpenoids, vitamin C	High antioxidant activity
2	<i>Pleurotus</i> spp.	Phenols, flavonoids, carotenoids, saponins, alkaloids, terpenoids, vitamin C	Strong antioxidant potential
3	<i>Scleroderma polyrhizum</i>	Phenolics, flavonoids, terpenoids, alkaloids, saponins	Highest antioxidant potential among tested spp.
4	Wild mushrooms (Garhwal Himalaya)	Alkaloids, flavonoids, glycosides, saponins, tannins	Strong antimicrobial effects (some extracts)
5	<i>Pleurotus ostreatus</i>	Phenolics, flavonoids, elemental nutrients	Potent antioxidant, antibacterial, anticancer
6	<i>Lentinus leptomerus</i>	Phenolics, flavonoids	Moderate antioxidant activity
7	<i>Macrocybe gigantea</i>	Phenolics, flavonoids	Good antioxidant activity
8	<i>Russula thindii</i>	Phenolics, flavonoids (highest)	Maximum DPPH radical scavenging activity
9	Wild edible mushrooms (Nagaland)	Phenolics, flavonoids (TPC/TFC values high)	Strong antioxidant activity
10	<i>Pleurotus ostreatus</i>	Alkaloids, saponins, steroids, phenols, glycosides, terpenoids, flavonoids	Ethanol extracts showed widest metabolite range
11	<i>Ganoderma</i> spp.	Baseline macrofungal diversity; multiple bioactive classes	Ethnomedicinal value, potential for screening
12	<i>Ganoderma lucidum</i>	Phenolic compounds, other metabolites (methanolic extract)	Antibacterial activity confirmed

on PDA and MEA media was most vigorous around 30°C, confirming its thermophilic nature and aiding spawn optimization. Earlier reviews consolidated the ecological and cultural parameters for *C. indica*, emphasizing that successful cultivation requires temperatures of 30-35°C, relative humidity above 80%, and neutral pH, with precise control of air exchange and light during cropping. Bokaria *et al.* (2014) further contributed to practical knowledge by documenting environmental set points—temperatures in the low thirties, humidity >85%, and light intensity between 1,600 and 3,200 lux—highlighting casing soil management as a critical determinant of crop success (Figure 2).

Cultural and indigenous knowledge on mushrooms

Ethnomycological research across India has revealed the deep cultural, nutritional, and economic significance of wild mushrooms among tribal and rural communities (Figure 3). In Jharkhand, surveys of indigenous populations combined with nutritional analyses confirmed that *Termitomyces* species serve as nutrient-rich seasonal foods, enhancing dietary diversity and food security (Singh *et al.*, 2025). In Northeast India, detailed ethnographic and biochemical studies showed that wild mushrooms—particularly *Termitomyces* and *Auricularia*—are not only rich in protein and antioxidants but also central to local cuisines and cultural identity.

Large-scale surveys have quantified this cultural dependency. In the Western Himalayas, Ullah *et al.* (2022) interviewed 923 informants and identified species such as *Morchella* and *Termitomyces* as dual-purpose fungi used for both nutrition and supplemental income through informal rural markets. Similar work in Jammu district documented 14 edible and medicinal mushroom species, using ethnobotanical indices like Cultural Importance (CI) and Informant Consensus Factor (F_{ic}) to show that *Termitomyces* and *Auricularia* are most valued for their taste and therapeutic effects (Sharma *et al.*, 2022). A synthesis of

ethnomedicinal practices from 14 Indian states catalogued nearly 100 macrofungal species and 24 preparation methods—ranging from soups and stews to medicinal pastes and decoctions—demonstrating the complexity and regional variation of traditional fungal usage (Debnath *et al.*, 2019). Studies among Central Indian tribes reported consistent foraging of 15-20 species, classified according to morphology, substrate, and taste, reflecting indigenous taxonomies parallel to scientific classification systems. Field research in the Jaunsar region of Uttarakhand revealed that locals still rely on morphological and ecological cues to identify edible fungi, though traditional expertise is declining as younger generations disengage from forest-based livelihoods (Kumar *et al.*, 2017). In the Kashmir Himalayas, Shauket Ahmed Pala *et al.* (2013) recorded 35 species used in folk medicine—especially against respiratory and digestive ailments—illustrating the detailed ecological knowledge and risk awareness that underpins traditional mycological practices.

Economic contribution of mushrooms to local villagers

Mushroom-based livelihoods have emerged as a significant driver of rural income generation, nutritional security, and social empowerment across India. Recent studies demonstrate that both wild and cultivated mushrooms contribute meaningfully to household economies, particularly among smallholders and tribal communities (Figure 4). Verma *et al.* (2025) evaluated training programs for farmers in Haryana and found that participation in mushroom cultivation led to measurable improvements in household income and economic stability, highlighting the role of skill development in rural entrepreneurship. Complementary research from Odisha identified *Rugda* and *Termitomyces* species as key sources of seasonal income; surveys in the Bonai Forest Division recorded fifteen commercially valuable taxa, with *Rugda* commanding premium market prices (Kumar *et al.*,

2022b). Parallel work in Mayurbhanj district confirmed that *Termitomyces microcarpus* and *Rugda* serve as crucial livelihood buffers by providing regular cash flow during lean agricultural seasons (Kumar *et al.*, 2022b).

In the Bastar Plateau of Chhattisgarh, ethnographic and nutritional assessments revealed that mushroom collection and sales augment household diets while providing consistent income through weekly markets (Kumar & Netam, 2022). Structured interviews with growers in Himachal Pradesh demonstrated that mushroom farming contributes up to half of smallholder earnings and as much as 72% among larger producers, underscoring its economic viability in hill agriculture (Sharma *et al.*, 2021). In Haryana and adjoining regions, women-led enterprises in mushroom cultivation have proven effective in promoting financial independence, income diversification, and empowerment within rural households (Aditya & Bhatia, 2020). Similar trends were documented in Patna district of Bihar, where women participants gained control over household finances and improved decision-making capacities through mushroom-based microenterprises (Singh *et al.*, 2018). Earlier ethnographic evidence from Santal communities in eastern India revealed that wild edible mushrooms account for nearly 10% of household income, ranking among the most valuable non-timber forest products (Manna & Roy, 2013). Foundational work in Ambala, Haryana, showed how technology transfer through agricultural extension programs enabled marginal and landless farmers to adopt low-cost mushroom farming, reducing dependence on seasonal migration and promoting self-employment (Bhatia *et al.*, 2012).

Mushroom diversity and taxonomy in India

Taxonomic and biodiversity research on Indian macrofungi has expanded remarkably in the last decade, offering foundational insights into species richness, ecological associations, and the integration of molecular identification tools. Molecular characterization has further refined species identification: Kumar *et al.* (2022a) analyzed five commercially cultivated mushrooms—*Agaricus bisporus*, *Calocybe indica*, *Flammulina velutipes*, *Pleurotus florida*, and *Volvariella volvacea*—using ITS-based DNA sequencing at ICAR-DMR, Solan, confirming accurate species identity and emphasizing the role of molecular markers in complementing classical taxonomy.

Large-scale field surveys in the Western Himalayas recorded exceptional fungal richness. Ullah *et al.* (2022) reported 131 species, including 97 new regional records, with *Russulaceae* as the dominant family. Their use of transects, quadrats, and multivariate analyses (PCA/DCA) linked diversity patterns to both ecological gradients and ethnomycological relevance. In Rajasthan, Chouhan and Panwar (2021) described eight Gasteromycete species, including new Indian records such as *Montagnea haussknechtii*, demonstrating that even arid and semi-arid landscapes harbor unique fungal assemblages. National syntheses have also consolidated regional findings. Earlier compilations by Choudhary *et al.* (2015) integrated edible

mushroom records from across India and neighboring countries, emphasizing the need for molecular confirmation of species traded in local markets to ensure accurate identification and food safety. Additional contributions include Borkar *et al.* (2015), whose foundational work on Agaricales provided one of the earliest overviews of Indian mushroom biodiversity (Figure 5).

Phytochemical screening of mushrooms

Phytochemical investigations of Indian mushrooms have revealed a remarkable diversity of bioactive compounds with strong antioxidant, antimicrobial, and therapeutic potential. Recent studies across multiple regions of India demonstrate that both wild and cultivated species contain abundant secondary metabolites contributing to their medicinal and nutritional importance (Table 4). In Tripura, *Lentinus* and *Pleurotus* species exhibited notably high concentrations of phenolics, flavonoids, carotenoids, and vitamin C, confirming strong antioxidant properties when analyzed through quantitative colorimetric assays (Sharma *et al.*, 2025). Similarly, studies from Meghalaya reported rich phytochemical diversity among mushrooms traditionally consumed by ethnic groups, with *Scleroderma polyrhizum* showing the highest phenolic content and antioxidant capacity (Borthakur *et al.*, 2023). Research from the Garhwal Himalayas revealed that wild mushrooms contain multiple bioactive classes, including alkaloids, glycosides, flavonoids, saponins, and tannins, with several extracts displaying pronounced antibacterial activity (Kothiyal & Singh, 2022). Complementary work on *Pleurotus ostreatus* in India identified high levels of phenolic and flavonoid compounds, potent radical-scavenging effects, and *in vitro* anticancer potential, underscoring its combined nutritional and pharmacological significance (Abd El-Razek *et al.*, 2022).

Earlier work on wild mushrooms of Nagaland established a direct correlation between total phenolic and flavonoid contents and overall antioxidant strength, reinforcing the nutritional value of traditionally gathered fungi (Ao & Deb, 2019). Additional contributions have broadened the taxonomic and biochemical scope of Indian mushroom research. Surveys in the Konkan region of Maharashtra catalogued *Ganoderma* and other macrofungal species, providing crucial baseline data for western India's fungal flora (Borkar *et al.*, 2015).

Research gaps and future directions

Mushrooms occupy a vital intersection of India's nutrition, medicine, and rural livelihood systems, yet scientific understanding remains incomplete. Indigenous and ethnomycological knowledge is still dispersed, with only limited quantitative validation of the traditional applications of species such as *Termitomyces*, *Ganoderma*, and *Pleurotus*. Most existing pharmacological investigations are confined to laboratory analyses. Socio-economic research on household income, gender roles, and local marketing networks is also sparse. Unregulated wild collection and insufficient policy frameworks further endanger native fungal biodiversity and equitable community benefits.

Future work should focus on integrating traditional wisdom with modern research tools and conservation strategies. Establishing open digital databases, advancing clinical and metabolomic research on Indian strains, and promoting low-cost, eco-friendly cultivation techniques are essential steps. Strengthening cooperative value chains, empowering women's groups in processing and marketing, and embedding mushrooms into climate-smart agroforestry and bio-circular models will enhance sustainability. Merging traditional insights with scientific innovation can transform mushrooms into enduring resources for nutrition, health care, and livelihood resilience in India.

Conclusion

Mushrooms are versatile and valuable biological resources that hold immense significance in India's nutritional, medicinal, ecological, cultural, and economic spheres. Extensive scientific investigations highlight their dual utility as both food and therapeutic agents. Notable species such as *Ganoderma lucidum*, *Pleurotus* spp., *Lentinus* spp., and *Termitomyces* spp. demonstrate remarkable antioxidant, antimicrobial, anticancer, and immunomodulatory activities. Phytochemical studies consistently reveal high concentrations of phenolics, flavonoids, alkaloids, terpenoids, and saponins, which collectively contribute to their protective roles against oxidative damage, metabolic dysfunction, and degenerative illnesses.

As a food source, edible mushrooms provide a high-quality nutritional profile, rich in proteins, essential minerals, and low in fats, thus enhancing dietary diversity—particularly within tribal and rural communities. At the same time, the existence of toxic species such as *Amanita phalloides* and *Inocybe* spp. underscores the importance of community awareness, correct identification, and rapid diagnostic tools to prevent poisoning incidents.

Ethnomycological research illustrates that mushrooms are deeply embedded in traditional systems of healthcare, nutrition, spiritual practices, and local economies. Wild foraging and commercial cultivation both serve as significant contributors to income generation, women's empowerment, livelihood diversification, and small-scale entrepreneurship in rural areas.

Biodiversity and taxonomic assessments reveal India's rich yet insufficiently documented macrofungal diversity, with molecular tools now playing a crucial role in improving species identification and ensuring food safety. Additionally, technological progress in cultivation and environmental control is paving the way for large-scale, climate-resilient mushroom production.

In summary, mushrooms are poised to become essential bioresources for sustainable nutrition, innovative healthcare, ecological restoration, and socio-economic advancement. Strengthening the connections between traditional knowledge, scientific research, and industrial innovation will be vital to realizing their full potential within India's bioeconomy.

Author contributions

Dolamani Sahu: Conceptualization, Methodology, Writing – Original Draft, Supervision, Editing. Mohammad Arshad: Literature Review, Data Curation, Investigation. Umashankar Chandra: Literature Review, Data Collection, Investigation. Yogesh Chandra: Data Analysis, Writing. Sandeep Shukla: Review & Editing, Validation. Sushil Kumar Agrawal: Data Analysis, Writing – Original Draft Preparation. Ishwar Prasad Sahu: Editing, Visualization, Manuscript Refinement. Nalin Kumar Singh: Review & Editing, Validation, Supervision.

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