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REVIEW

Assessment of Macro fungal diversity from Kashmir Himalayas

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The alpine region of Kashmir located in the northern part of Himalayan region amidst greater Himalayas and Pir Panjal range is home to a wide population of macro fungi. Temperate climatic conditions, varied terrain and distinct geography of the region sustains rich biodiversity of macro fungi. Prolific vegetation, extensive forest cover harbouring coniferous, broad leaf trees favour the growth of mushrooms. Abundant species of edible, medicinal as well as some poisonous species of mushrooms are present in the region which sustain the essentials of local community in form of food, medicine or ecological benefits. Spring to summer is generally the fruiting season of the mushrooms.The present review focuses on the rarely discussed species of macro fungi found in the Himalayan Kashmir province. Edible, medicinal mushrooms along with poisonous ones are mentioned in the review. The morphological features of the fruiting bodies, native names of the macro fungi, their nutritive, economical value and ethnomedicinal uses have also been discussed.

Keywords : Basidiomycota, diversity, medicinal value, mushroom, poisonous

INTRODUCTION

Kashmir valley located in the northern region of India at 33°202 to 34°542 N latitude, 73°352 E longitude forms a unique intermontane basin in the northwest Himalayan region (Pala *et al*.2011). Wani *et al*. (2020) documented 548 species of fungi comprising 268 species of micro and 280 species of macro-fungi from the state of Jammu and Kashmir. The valley of Kashmir harbours a significant status in the diversity of macro fungi due to its wide agro-climatic zones, diverse geomorphology and undulating topography (Dar *et al*. 2022).Varied terrain, favourable climatic conditions, widespread forest ecosystem and dense vegetation found in Kashmir Himalayas facilitate the growth of mycoflora in this region (Pala *et al*.2015).The high altitude Himalayan region of Kashmir constitute of rich myco-fungal population. Cultivation of edible mushrooms have a vital role in the socio-economic activities of local people (Kumar and Sharma, 2013).

Macro fungi are defined as larger fungi forming spore-bearing structures or fruiting bodies above or below the ground surface. Most of the macro fungi comprise of mushrooms belonging to Basidiomycota and Ascomycota (Mueller *et al*. 2007; Al- Thani, 2010; Zhao, 2023). Mushrooms belong to the kingdom “Fungi”and comprise of diverse number of species (Pala *et al*. 2011). According to Deshmukh (2006), 14,0000 species of mushroom are known globally. Macro fungi are widely recognized as potent source of nutrition and medicine as they serve curative for various health issues.Both wild and cultivated macro fungi act as healthy source of food .Macro fungi have played significant role in the evolution of different life forms on earth,aid in the balance and functioning of natural ecosystems of our planet (Perez *et al*. 2021). High macrofungal biodiversity represents healthy ecosystem of the region.Temperate conditions, feasible temperature and moderate rainfall are basic environmental factors sustaining environmental diversity of macrofungi in the Himalayan region (Sharma *et al*.2022). Pala and Wani (2015) found 109 species belonging to 61 genera in the coniferous forests of Kashmir region. Despite the

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huge diversity of macro fungi growing in the valley, information regarding the same is meagre. The present review provides an insight into the macro fungal diversity found in the North Himalayan region of Kashmir, their morphological characteristics, their use and their nutritional significance.

Prominence of Mushrooms

Different species of edible and medicinal mushrooms occurring naturally are economically significant and used as traditional medicines from time immemorial (Ullah *et al*., 2022).The distinct environment of mountain areas contribute to the mushroom occurrence and their use as dietary sources from ancient times (Fongnzossie *et al*. 2020).Macro fungi act as low-calorie functional foods with excellent therapeutic properties (Lu *et al*. 2020). A large quantity of carbohydrates, proteins, enormous concentration of β-glucans, vitamin D and less fat content has been found in the dry matter of different mushrooms (Rathore *et al*.2017). Macro nutrients such as potassium (K), phosphorus (P), sodium (Na), calcium (Ca), magnesium (Mg) are present in abundance in macro fungi alongwith small quantities of micro nutrients including copper (Cu), zinc (Zn), iron (Fe), molybdenum (Mo), cadmium (Cd) etc. (Uzun *et al*. 2011).Mushrooms act as important dietary source of vitamin D_2, vitamin B complex, improve bone health and exhibit cholesterol, blood sugar-lowering properties (Singh *et al*. 2025). Medicinal mushrooms comprise of bioactive compounds that act as anticarcinogenic, hypoglycemic, antioxidantive agents (Lysakowska *et al*. 2023). Mushrooms offer a high protein,healthy and sustainable diet as vegetarian meal (Pashaei *et al*. 2024). A huge number of mushrooms growing in the alpine Himalayan region of Kashmir have therapeutic potential and can be consumed for healthy life style as functional foods (Panthari *et al*.2025).

Diverse mushrooms of Kashmir region

Temperate climate, Himalayan terrain, forest diversity present a viable environment for mushrooms to thrive in Kashmir valley due to which large number of wild mushrooms are found in the region. Different less reported species found in the natural habitat in Kashmir Himalayas are discussed.

Bovista plumbea Per.

Bovista plumbea, a Basidiomycete fungus commonly known as puffballs and “Sisdeoong” in native language belongs to the family *Agaricaceae* (Dar *et al*. 2023).The pileus of this mushroom is globuse shaped (Fig.1A), white in colour (Smith, 1951).Pileus size measures 2.5-3.0 cm, smooth with endoperidium inside it. Stipe is absent in it and rhizoids keep the fruiting body attached to substrate. Basidiospores of average length 4.0-6.0 µm and width 4.8 µm are found. They are smooth textured and spherical in shape (Dorjey *et al*. 2016).

Bovista plumbea is rich source of protein, higher amount of amino acids especially proline. An average antioxidant activity of about 90 per cent has been found in it (Badridze *et al*., 2024). Huge amount of flavonoids and antioxidants which are essential for healthy lifestyle are present (Mayirnao *et al*. 2025). It is consumed by people in the Himalayan region as nutritious food. It has also been used as treatment for blisters, ringworm, skin injuries in dried form with mustard oil from ancient times in the valley. Its use to cure frostbites has also been reported (Dar *et al*.2023).

Paxillusinvolutus(Batsch) Fr.

*Paxillusinvolutus*is commonly known as brown roll rim mushroom. It is non edible poisonous mushroom and belongs to the phylum Basidiomycota (Sayyed and Hussain, 2020), family *Paxillaceae* (Li *et al*. 2020). It is also known as “Poison pax” mushroom and called “Zaher haddur” in local kashmiri language. The pileus of this mushroom is thick textured, 5.0-11.0 cm wide, dark yellow- brown in colour, convex with a central indentation. Prominent, decurrent gills having yellowish brown colour are present(Fig. 1B). Stipe of the mushroom is 2.0-6.0 cm long, 1.0 -2.0 cm thick and narrows towards the base. Spore print is brown in colour with spores being smooth, oval in shape it grows during summer season in hardwood forests in association with coniferous trees (Pala *et al*. 2011).

Paxillusinvolutus acts as common ectomycorrhizal fungus and has been observed to develop ectomycorrhizal association with coniferous and deciduous trees (Hedh *et al*. 2008). It plays a significant role in nutrient mobilization (Akroume *et al*.2019), degrades organic matter to extract nutrients such as carbon and nitrogen (Rineau *et al*.2012).

Ganoderma lucidum (Fr.) Karst

G*anoderma lucidum* (Fr.) Karst also known as 'Reishi' mushroom is a Basidiomycete fungus belonging to the family *Ganodermaceae* (Yang *et al*. 2000). It is natively known as "Livith hedur" in Kashmir region. It is a medicinal mushroom having brown coloured, fan shaped pileus (Fig.1C) of thick texture (Dar *et al*. 2023). Pileus diameter of *Ganoderma lucidum* is recorded to be 6.0-7.0 cm with white zones towards the margin. Large stipe of length9.0-12.0 cm, thickness 0.5-1.0 cm (Sharma *et al*.2022) is found in this mushroom positioned lateral to the pileus. Double walled, oval shaped spores with smooth surface are produced. It grows on tree trunks, wood logs and forms fruiting bodies usually during spring (Dar *et al*.2022) or summer season. It is commonly found growing on willow tree trunks in Kashmir valley.

It has been used as traditional remedial component especially in China from time immemorial (Garuba *et al*. 2020).It comprises of bioactive polysaccharides, β-D glucans that have been found as a strong immune booster showing resistance against tumour, hepatic diseases along with showing anti bacterial, anti inflammatory action. It aids in the cure of dreadly diseases such as HIV (Bhat *et al*. 2021). Dar *et al*. (2023) reported use of *Ganoderma lucidum* in treatment of respiratory complications like asthma in Kashmir region also.

***Lactarius deliciosus* (L.) Gray**

Lactariusdeliciosus (L.) Gray commonly known as "saffron milk cap mushroom" is an edible mushroom found in the pine forests of Kashmir Himalayas. It is natively known as "Katrihhedur" (Dar *et al*. 2023). It is a basidiomycete fungi of family Russualaceae (Su and Xu, 2024).Pileus of diameter 4.0-9.0 cm, convex shaped with small depression in the centre is observed. Cylindrical stipe of size 2.0-4.0 cm length and breadth equal to 0.6-2.0 cm is attached to the cap and tapers towards the base. The pileus and stalk are bright orange or saffron coloured (Fig.1D). Ellipsoid spores having rigid surface are formed in four spored basidia (Nuytinck*et al*.2006). Bright orange gills are also present on underside of cap which reduce the hue on maturation.Orange exudation is observed in the fruiting body when it gets bruised or damaged (Yun *et al*. 2001).

Lactarius deliciosus (L.) Gray forms mycorrhizal association especially with pine trees and fruiting bodies are formed in late summer or autumn in Kashmir region (War *et al*. 2023).It is a nutritious macro fungus used as dietary supplement. Its anti inflammatory, anti bacterial , hypoglycemic activity has also been reported (Akgul *et al*. 2019). It is an effective antioxidant and immunostimulant along with exhibiting anti tumour properties. Its ethnomedicinal use in herbal medications to treat gastric irritation,heat burns has been reported from Kashmir region (Malik *et al*.,2017).

***Morchella esculanta* (L.) Pers.**

Morchella esculanta commonly known as common morel is an edible mushroom (Dar *et al*. 2022) of division Ascomycota (Donnell *et al*.2011) and family Morchellaceae (Ajmal *et al*.2015). It is known as "Guchhi" or "Khazerkannguech" in native language (Rani *et al*. 2024). It is a high worth mushroom found in the Himalayan terrain. The cap or pileus of morel mushroom is oval, round in shape having pale brown colour with yellow tinge in margins(Fig.1E). Pileus length is found to be 3.5-8.0 cm long and width equal to 2.0- 4.0 cm. Stipe is large, swollen, cylindrical shaped and usually white in colour. Stipe dimensions are found to be 2-7 cm long and 1-3 cm thick. Smooth, oval shaped ascospores of dimensions 12.5-21.0 × 8.0 -12.0 mm are formed in asci or spore sacs which are elongated, hyaline. Eight ascospores are present in single asci. It is saprotrophic in nature and forms fruiting bodies during spring season (Lone *et al*.,2024). It is one of the highly priced mushrooms of world (Li *et al*.2022).It is notable for its culinary uses, umami flavour and medicinal

Fig 1: (A-G) : Macrofungi from Kashmir**. A-***Bovista plumbea*Pers. ; **B**-*Paxillus involutus* (Batsch) Fr.; **C-** *Ganoderma lucidum* (Fr.) Karst; **D-** *Lactariusdeliciosus*(L.) Gray; **E-** *Morchella esculanta*(L.) Pers.; **F -** *Lentinus tigrinus*(Bull.) Fr ; **G-** *Helvella leucopus* Pers.

properties. It is a proteinaceous food with ample amount of proteins, vitamins and bioactive substances. Its anti tumour, anti microbial activity, immunity boosting ability qualifies it as dietary supplement, nutraceutical and functional food (Qiaodi *et al*.,2019).

Lentinus tigrinus (Bull.) Fr.

Lentinus tigrinus (Bull.) Fr. is a wood rotting Basidiomycetous fungi (Dulay *et al*.2012) that belongs to the family Polyporaceae. It is commonly called Tiger sawgill mushroom (Kalaw *et al*.2023)and locally known as “Vire hedur” as it usually grows on *Salix* (Willow) stumps (Pala *et al*.2013).It is an edible fungi (Dulay *et al*.2011). Basidiocarps measure 3.0 - 4.5 cm in height. Convex pileus of width 2.0-3.0 cm is found in it with slight depression in the centre of pileus (Fig. 1F).Brownish scales are found on the fruiting body. Cylindrical stipe tapering towards the base is reported in *Lentinus tigrinus* (Bull.) Fr. mushroom. Length and thickness of the stipe is reported to be 3.2-5.4 × 0.8-1.5 cm respectively. Ellipsoid basidiospores having smooth surface are formed (Lone *et al*. 2024).

Tiger sawgill mushroom is a nutritious edible mushroom containing enormous concentration of carbohydrates, proteins, fiber with small lipid composition (Pourianfar*etal*.2020). Sevindik (2018) suggested its use as an effective antioxidant and antimicrobial agent. Ethnomycological study of *Lentinus tigrinus* (Bull.) Fr confirmed its use as food source and effective medicine against respiratory diseases, digestive disorders and diabeties in Kashmir valley (Pala *et al*.2013).

Helvellaleucopus Pers.

*Helvellaleucopus*Pers. commonly known as “Bachu mushroom”is an edible, medicinal wild mushroom (Zhang *et al*. 2026). It is an Ascomycete fungi belonging to the family . Helvellaceae. It is locally known as “Kanpapri”. Pileus is brown to black in colour (Fig.1G), curved with 3-4 asymmetrical lobes. Average pileus diameter of this mushroom is 2.5-3.5 cm and length is 1.5- 4.0 cm. Small cream coloured stipe having smooth texture is observed in these macro fungi. Stipe widens and shows furrow towards the base. Elliptical, translucent, thin walled ascospores with large central lipid droplet are present in cylindrical asci that bears eight ascospores per asci.Fruiting bodies are usually formed in late spring to early summer season (Talie *et al*. 2021). It is a nutritional food source. It is rich in protein, amino acids and essential vitamins such as Vit. B, Vit. C (Song *et al*. 2024). It is a powerful immune modulator and possess significant medicinal properties due to its anti tumour, hypolipidemic properties (Hou and Chen, 2008). Its antioxidant, enzyme inhibitory activity and abundance of phenolic compounds in it qualifies its use in pharmaceutical and food

industry (Acar *et al*., 2020).Apart from qualifying as nutritious, healthy food, it forms mycorrhizal association with popular trees and aid in their nutrition (Talie *et al*. 2021, 2024)

CONCLUSION

Kashmir valley residing in the Himalayan region is inhabitant of rich diversity of macro fungi due to its diverse climatic conditions and unique topography which supports growth of diverse mushrooms in the region. Enormous edible and medicinal mushrooms are present in the valley which are consumed by locals as food and for various medicinal purposes.Some poisonous mushrooms are also reported in the region. They act as beneficial fungi for higher plants by forming mycorrhizal association with them. The distinct geography of the region offers apposite conditions for the cultivation of mushrooms.Commercial cultivation and economic use of these mushrooms at large scale will aid in the upliftment of rural and urban communities by providing agrobusiness opportunities to local people.

DECLARATION

Conflict of Interest. Authors declare no conflict of interest

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