Diversity and ethnomycological importance of mushrooms from Western Himalayas, Kashmir

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Abstract

Background: Wild edible mushrooms (WEM) are economically significant and used in traditional medicines worldwide. The region of Jammu and Kashmir (Western Himalayas) is enriched with the diversity of edible mushrooms, collected by the rural people for food and income generation. This is the first detailed study on diversity and ethnomedicinal uses of mushrooms from the State of Jammu and Kashmir.

Methods: Consecutive surveys were conducted to record ethnomycological diversity and socio-economic importance of wild edible mushrooms value chain in rural areas of Azad Jammu and Kashmir during 2015–2019. Ethnomycological data were collected with a semi-structured questionnaire having a set of questions on indigenous mycological knowledge and collection and retailing of wild edible mushrooms. A total of 923 informants from the study area provided the results identifying the gender, type of mushroom species, medicinal uses, and marketing of mushrooms. Diversity of mushrooms was studied by using quadrat and transect methods. Principal component analysis (PCA) and detrended correspondence analysis (DCA) were also applied to the dataset to analyse the relationship between species distribution, the underlying environmental factors, and habitat types. PCA identified the major species-specific to the sites and put them close to the sites of distribution.

Results: A total of 131 mushroom species were collected and identified during 2015–2019 from the study area. Ninety-seven species of mushrooms were reported new to the State of Azad Jammu and Kashmir. The dominant mushroom family was Russulaceae with 23 species followed by Agaricaceae, 16 species. Major mushroom species identified and grouped by the PCA were Coprinus comatus, Lactarius sanguifluus, Amanita fulva, Armillaria gallica, Lycoperdon perlatum, Lycoperdon pyriforme, and Russula crenicolaris. Sparassis crispa, Pleurotus sp, and Laetiporus sulphureus were recorded most edible and medicinally significant fungi. Morels were also expensive and medicinally important among all harvested macro-fungal species. These were reported to use against common ailments and various health problems.

Conclusions: Collection and retailing of WEM contribute to improving the socio-economic status, providing alternative employment and food security to rural people of the area. These mushrooms are used as a source of food and traditional medicines among the rural informants and could be used as a potential source of antibacterial and anticancer drugs in the future.

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**Background**

Mushrooms are fruiting bodies with distinctive carpophores of Basidiomycetes and some Ascomycetes [1]. They grow in the wild and are cultivated for food and medicines worldwide [2]. Diversity of ectomycorrhizal fungi studied from Pakistan revealed 23 species from eleven genera. Dominant mushrooms species were recorded from the genus *Hymenoscyphus* and *Inocybe* [3]. Fungal species have been identified using morphological and molecular techniques, used for food and culinary purpose [4]. Diversity studies of fungi have been carried out previously by [3–5] using standard methods. Targeted surveys for mushrooms species were found more efficient than random surveys [6]. Baseline fungal community data were obtained through plot-based diversity methods [7]. The quadrat method was also used to record fungal diversity and distribution [8]. The line transect method is also helpful to compare different fungal communities with each other and species conservation [9] and to gain prudence about the factors influencing the composition and association of fungal communities [10]. It also gives temporal variation in fungal growth and maturation [11].

Mushrooms have many health-promoting benefits and applications in traditional medicines [12–14]. Ethnomycology is a new area of research focused on the interaction of fungi with local communities. It includes cultural, recreational, and traditional uses of mushrooms [15, 16]. It is a naturally renewable and under-exploited resource contributing to improving rural livelihood [17]. Due to diverse ecological, medicinal, nutritional, and health-promoting properties, mushrooms are gaining prime importance among scientific and research communities throughout the world [18]. Wild mushrooms are non-timber forest products (NTFPs) collected as a source of food and income [19–21]. Collection and utilization of wild edible mushrooms (WEM) vary among the different communities [22]. These are collected and marketed for food and commercial values [23]. Folk taxonomic-based study of fungi is important because many species of fungi are going to extinct [24]. Traditional mycological knowledge is useful and transferred from one generation to other to safeguard the utilization and applications of edible mushrooms [25].

Morels are also a valuable source of food and income among the rural people of Pakistan [26]. These are used in traditional medicines against common ailments [27]. It is essential to transfer the folk knowledge of mushrooms among ethnic mountain communities to enhance the collection, utilization, and conservation of mushrooms [28].

The whole region of Azad Jammu and Kashmir (AJK) is blessed with diverse geographic and climatic conditions with a diversity of mushrooms. Despite a large number of ethnic groups in the state of Jammu and Kashmir, the ethnomycological data are poorly documented from the area and no comprehensive studies have been taken previously to explore such resources for human welfare. There is a lack of proper documentation on the diversity, specific habitat, ethnomycological uses, production, harvesting, and export of mushrooms. Present research work is designed to record species diversity of mushrooms in AJK, ethnomycological uses, and their commercial and economic importance.

**Methods**

**Study area**

The study area lies in the Western Himalayan regions of Azad Jammu and Kashmir between 32°-17’ and 36°-58’ North latitude and 73°-6’ and 80°-30’ longitude in the western part of the Indian subcontinent with an area of 13,297 square kilometres. The elevation from sea level ranges from three hundred and sixty meters in the south to 6325 m in the north. Average annual rainfall 1300 mm. The population is 4 million and the ratio between rural to urban populations is 88:12. Forestry, livestock, and agriculture are major economic activities for rural income. The climate of the study area is subtropical monsoon type in the lower range to moist temperate in the middle and subalpine to alpine in upper regions. The summer is hot at lower altitudinal zones and pleasant in upper zones with very cold winters. The area above 1200 m altitude receives heavy snowfall from November to April. The average temperature recorded in summer remains 34 to 25 °C and in winters, 10 to 4 °C. Annual rainfall (average) in the monsoon region is 900–1300 mm and in monsoon-free region it remains 35–140 mm [29].

**Data collection**

Consecutive field visits were carried out to selected villages, local markets, shops of the study area for gathering information about mushroom collection, and selling. A semi-structured questionnaire (Appendix 1) was used to collect the information on the wild edible mushrooms value chain, hunting, collection, preservation, and retailing [30]. Primary and secondary information was collected from all the available resources. Primary information was gathered by structured and
semi-structured interviews with collectors, consumers, and sellers. Secondary information was collected from different literature, thesis, maps, and websites. Both formal and informal discussions with forestry professionals, key informants, village elders, farmers, women, schoolteachers, social workers, and shopkeepers were carried out to identify and verify the facts. Information on edibility, medicinal uses, preservation methods, and any other uses was also recorded.

All the major terrestrial ecological sites and hotspots for mushroom species from the state of Azad Jammu and Kashmir were selected for this study. Sampling sites were finalized through consecutive field visits based on specific geographic and ecological significance from representative vegetation zones of Azad Jammu and Kashmir. A total of 22 sites were selected from Neelum, Muzaffarabad, Hattian, Bagh, Heveli, Poonch, and Kotli districts of Azad Jammu and Kashmir during 2015–2019 to study mushroom diversity (Fig. 1 & Table 1).

Diversity of wild mushrooms
Sporophores of fungi were collected from forest communities of Cedrus deodara and Pinus wallichiana. For the documentation of fungal diversity quadrat and transect methods were used following standard protocols [7, 31–33]. The collection of samples was mostly carried out by targeted surveys to record a maximum number of mushroom species as described by [34]. Density, frequency, and relative values were calculated for the application of diversity indices [35]. Shannon diversity index was also calculated [36].

Identification and preservation of Sporophores
A specific collection number was assigned to each sample in triplicate. Specific characters of habitat and associated plant species were also recorded. Sporophores were cleaned gently, soil particles were removed, and photographs were taken with a digital camera Nikon D5600. Fruiting bodies were left into the air for drying before packing for preservation. For easy drying, the larger Sporophores were cut down into many smaller pieces. Dried samples were packed and labelled with separate tag numbers for further analysis and future references. Specimens were finally cross-checked with the published material. The appropriate taxonomic literature was used for the proper identification of mushrooms [37–41]. Further citations were checked on MycoBank [42] and the index Fungorum database (http://www.indexfungorum.org/names/names.asp [43]. Final identification was made from fungal biology and systematic research laboratory Department of the Botany University of the Punjab Lahore. Specimen's number

![Fig. 1 Map of the study area (right) and sampling sites (left)](image-url)
were assigned to each sample and freeze at a temperature of \(-80^\circ\) for further future analysis.

**Results and discussion**

**Diversity of mushrooms**

A total of 131 mushroom species were collected and identified up to species level during the study (Table 3) using standard methods [3–5]. Out of 131 mushroom species, 97 species of mushrooms were recorded new to the state of Azad Jammu and Kashmir (Fig. 2); however, few of these species have been identified from different parts of Pakistan at the molecular level previously [44]. Already identified mushroom species were morphologically cross-checked with published material. The dominant mushroom family was Russulaceae with 23 species followed by Agaricaceae, 16 species, Boletaceae, 10 species, Helvellaceae, 7 species, Tricholomataceae, and Physalacriaceae 6 species were recorded in present investigations. Amanitaceae, Hymenochaetaceae, and Pleurotaceae were identified with five species each. *Russula* and *Lactarius* were the dominant genera. Only a few species of these genera were edible, and the maximum number of sporocarps decays on substratum after maturity. Inedible species were often collected for wound healing and other medicinal purposes. Most of the mushroom species growing naturally were collected by the rural for food and medicinal purposes. The maximum diversity of fungi was calculated in the Neelum Valley followed by Las Dana, Chakar, Noon Bangla, and Leepa in Jhelum Valley. These sites have maximum forest cover and diverse ecological conditions. The Basidiomycetes constituted the major proportion, i.e. 115 species, while Ascomycetes constituted 16 species. The majority of mushrooms collected belong to gilled fungi. Species of *Coprinus*, *Flammulina*, *Peziza*, *Armillaria*, and *Morchella* were found in clusters while other species occur in scattered patches. In Previous studies, six species of *Agaricus* were reported from Rawalakot, Azad Kashmir by [45]. Similarly [45] collected and described edible mushrooms, viz. *Armillaria mellea*, *Cantharellus cibarius*, *Craterellus cornucopioides*, *Flammulina velutipes*, and *Morchella semilibera*, *M. elata*, *M. semilibera*, and *Amanita muscaria* var. alba, *Ramaria aurea*, *Phallus impudicus*, *Morchella elata*, and *M. semilibera*, *Amanita ceciliae*, *A. subglobosa*, *A. pantherina*, *A. pachycolea*, *A. virosa*, *Volvariella bombycina*, and *V. speciosa* to Kashmir [46, 47] also contributed to the mushroom flora of AJK. They reported 25 edible mushrooms from different sites of the Azad Jammu and Kashmir. Dominant species of fungi collected during this study were also common with

| No. | Site name          | District          | N       | E       | Elevation (m) |
|-----|-------------------|-------------------|---------|---------|---------------|
| 1   | Peer Chinasi      | Muzaffarabad      | 34°23'2.41 | 73°33'3.67 | 2596          |
| 2   | Shaheed Gali      | Muzaffarabad      | 34°23'1.01 | 73°25'16.55 | 1346          |
| 3   | Peer Hassimar     | Muzaffarabad      | 34°92'4.58 | 73°37'0.42  | 1901          |
| 4   | Haji Peer         | Bagh              | 33°58'2.61 | 74°04'40.43 | 2261          |
| 5   | Las Dana          | Bagh              | 33°55'2.54 | 73°57'06.81 | 2331          |
| 6   | Sudhan Gali       | Bagh              | 34°44'6.34 | 73°44'11.74 | 2307          |
| 7   | Banjosa           | Poonch            | 33°48'2.75 | 73°49'25.92 | 1910          |
| 8   | Toolipir          | Poonch            | 33°53'4.72 | 73°54'34.00 | 2334          |
| 9   | Noon Bangla       | Hattian           | 34°07'1.06 | 73°40'11.50 | 2023          |
| 10  | Chakar            | Hattian           | 34°15'5.96 | 73°37'01.85 | 1567          |
| 11  | Palandri          | Sudhnoti          | 33°43'3.37 | 73°38'10.43 | 1517          |
| 12  | Salkhala          | Neelum            | 34°33'0.56 | 73°53'14.53 | 1859          |
| 13  | Dawarian          | Neelum            | 34°44'0.53 | 74°02'26.60 | 2431          |
| 14  | Sargun            | Neelum            | 34°47'5.80 | 74°11'38.28 | 1921          |
| 15  | Changan           | Neelum            | 34°43'10.56 | 74°4'20.66  | 1920          |
| 16  | Sharda            | Neelum            | 34°46'5.36 | 74°11'52.35 | 2475          |
| 17  | Keil              | Neelum            | 34°48'3.44 | 74°21'25.70 | 2425          |
| 18  | Forward Kahota    | Haveli            | 33°54'1.58 | 74°04'13.97 | 1883          |
| 19  | Khursheed Abad    | Haveli            | 33°54'9.40 | 74°12'21.59 | 2426          |
| 20  | Nakyeal           | Kotli             | 33°29'9.72 | 74°65'53.83 | 1649          |
| 21  | Leepa Valley      | Hattian           | 34°18'5.25 | 73°54'50.69 | 2373          |
| 22  | Kerin (Nagdar Valley) | Neelum    | 34°44'0.76 | 74°02'26.00 | 2471          |
the previous studies [48–50]. These mushroom species grow during early spring in April to July in most of the studied areas. This pattern of diversity and distribution of fungal species associated with coniferous forest type was studied [51]. They reported *Russula* and *Lactarius* as a dominant genus associated with Himalayan cedar. Other studies on diversity of mushrooms in the literature revealed that most of the fungal communities were composed of Basidiomycetes [52]. Diversity and community stabilization of mushrooms depends upon different ecological factors including precipitation, soil organic matter and type of specific plant community. The sites which have some common geographic features also have similar species composition. This might be due to maximum annual rainfall and enough soil organic matter that promote the diversity of mushrooms because mushrooms grow maximum during the wet and rainy season in most parts of the world on different substrates [53]. Recently, fungal biology and systematics Laboratory University of
Punjab is working on establishing Mycoflora data base and added many species to Mycota of Pakistan [54, 55].

Principal component analysis
PCA is used to determine and analyse the relationship between species distribution and the underlying environmental factors and habitat types. It is an advanced technique that maximizes the species scores concerning sampling sites having linear and appropriate weights. PCA identified the major species-specific to the sites and put them close to the sites of distribution. The sites grouped by the PCA based upon their species interrelationship are Peer Chinasi, Haji Peer and Peer Hasimar, Toolipeer, and Leepa. All these sites have little variations in the biotic factors including species composition and topography. These sites have some common geographic features which are responsible for similar species composition. Major mushroom species collected from these sites and grouped by the PCA are Coprinus comatus, Lactarius sanguifluus, Amanita fulva, Armillaria gallica, Lycoperdon perlatum, Lycoperdon pyriforme, and Russula creninicolor, these sites have shown a little correlation with a village Khawaja bandi kahuta Havali. The mushroom species grouped by the PCA are the common fungi that are present in these sites. On the other hand, Nagdar (Upper Neelum), Dawarian, Sharda, Taobut, Chakar (Noonbangla), Sudhan Gali, and Banjosa are grouped near to each other. These sites are almost lying in the temperate forest of AJK and have same topography, Forest cover, and precipitation pattern so their mushroom composition is nearly like each other. Major fungal species of these sites were Amanita muscaria, Lactarius deliciosus, Gymnitra escultena, Armillaria sp, Agaricus campestris, Russula brevipes, Poly- porus squamosus, Trametes versicolor, and Laccaria sp. Other mushroom species grouped at the centre of the PCA axis showed equal distribution and association with all the sites of the study area. These species have no specific distribution pattern. PCA identified five major keystone species from the data matrix and separated them along X-axis. Lactarius piperatus, L. deliciosus, L. terminosus, Hygrocybe flavescens, and Russula delica were extracted as most significant vectors having maximum Eigenvalue scores represented by their distinct placement on PCA biplot. These five species were characterized by the higher IVI values in the species dataset and enjoyed abundance and broad distribution across the study area. The major bulk of the fungal elements were clustered in the centre of the PCA biplot showing their random distribution without specific site or habitat preference. These species are most common and grow almost equally in different geographic conditions with slight changes in their growth period and maturation (Fig. 3).

Detrended correspondence analysis
We subjected our species dataset to the DCA to extract the trends in species distribution and identify the specific habitat preference of the species represented by the sites. Our analysis results revealed uniform and continued species distribution patterns along specific environmental gradients with interpretable species-site assemblages. DCA separated the dataset into diffused but identifiable clusters. The Kotli site was separated at the top of X-axis with the characteristic species Coprinellus micaceus. This site lies in the subtropical zone with limited mushroom species growing during the monsoon. This specific microhabitat reflects the dominance of Pinus roxburghii and different grasses. Along the X-axis at the right side of the plot, different sites with similar species of mushrooms are grouped. These sites are Shaheed gali, Peer Chinasi, Sharda, Arangkeli, Noonbangla, Leepa Valley, Haji Peer, Dawarian, and Peer Hasimar. The Khurshidabad site in Havali was separated at the base of biplot and placed near to the Forward Kahuta with the characteristic mushroom species Ganoderma lucidum and Hygrocybe flavescens. Another identifiable cluster appeared at the left most of the biplot in the X-axis consisting of Chakar, Nagdar, and

### Table 2

Demographic characteristics of Mushroom collectors in 6 districts of AJK (N=923)

| S. no. | Characteristics     | Frequency | Percentage | Mean ± SEM   |
|--------|---------------------|-----------|------------|--------------|
| 1.     | Sex                 |           |            |              |
|        | Male                | 359       | 38.9       | 1.61 ± 0.01  |
|        | Female              | 564       | 61.1       |              |
| 2.     | Age group           |           |            |              |
|        | <18                 | 163       | 17.6       | 2.80 ± 0.41  |
|        | 19–30               | 238       | 25.8       |              |
|        | 31–40               | 259       | 28.1       |              |
|        | 41–50               | 140       | 15.2       |              |
|        | >50                 | 123       | 13.3       |              |
| 3.     | Education level     |           |            |              |
|        | Illiterate          | 157       | 17.0       | 2.88 ± 0.06  |
|        | Primary             | 238       | 25.8       |              |
|        | Middle              | 210       | 22.8       |              |
|        | Secondary           | 193       | 20.9       |              |
|        | HS above            | 125       | 13.5       |              |
| 4.     | Employment status   |           |            |              |
|        | Govt. servant       | 116       | 12.6       | 2.41 ± 0.26  |
|        | Farmer              | 366       | 39.7       |              |
|        | Housewife           | 379       | 41.0       |              |
|        | Retired             | 62        | 6.7        |              |
Fig. 3 Expression of principal component analysis

Fig. 4 Expression of detrended correspondence analysis
Upper Neelum placed with the Sharda site. While the left lowest groups are placed on the plot are the sites sharing the similar species composition these are Sudhan Gali, Banjosa, and Plandri (Figs. 4 and 5).

Demographic characteristics and community involvement
Wild mushroom value chain is seen to be gender orientated dominated by women in collection (61.1%, \( n = 564 \)) while men occupy only 38%, \( n = 359 \) out of the 923 respondents (Table 2). Women were found to participate in every mushroom activity such as collection to preservation while men contributed only to collection and selling. Similar findings were reported by [57] where female was found dominant in WEM collection. However, it was found that men dominated in selling of mushrooms (70%) to local shops, restaurant, markets, and local mushrooms entrepreneurs. The preponderance of female collectors in present study is supported by another research [58–60]. Every stage of mushroom activities from collection to processing and even marketing was led by women in this study. Poor involvement of men in mushroom activities might be due to the belief that mushroom collection is only art for remote areas of women. In remote areas of studied districts of AJK, women are mostly unemployed, dedicating themselves to household and subsistence activities. Mushroom collection and selling are one of their sources of food and income. The study revealed that collection activities are dominated by people of middle age (53.9%) especially those of 31–50 years old between the ages ranged 14–85, followed by 19–30 (25.8%), by 14 and over (17.6%), and by 50 and above (13.3%) (Table 2). Similar findings were also reported from the Finland [61] where it was shown that middle aged people by 30 (96.6%) or above involved in mushrooms collection activity. It revealed the participation of older, more experienced people in mushroom collection. Similar results on age distribution were also reported by [22]. Among 923 respondents, 25.8% had an education level of primary school, 22.8% middle school, 20.9% secondary or high school, 17% illiterate, and 13.5% higher secondary, university, or colleges (Table 2). There were 41% housewives 39.7% farmers and entrepreneur, 12.6% employed, 6.7% retired from 923 respondents (Table 2). Data on education in the present study revealed that almost 83% of informants had a middle school education per the findings of [15] who indicated that mushroom collection or cultivation was mostly managed by less educated people in the rural areas.

Socio-economic and ethnomycological importance of wild mushrooms
A total of 923 informants from 22 sites of selected districts were interviewed based on the harvesting, selling, and consumption of wild edible mushrooms. Mushrooms play a significant role in rural development. Many species of edible mushrooms and morels have been collected by the poor rural for a socio-economic purpose and rural livelihood in terms of economic development. Morels are

![Fig. 5 Expression of correspondence analysis among the different site](image-url)
collected by the people of rural areas of AJK for medicinal and commercial purposes. *Morchella conica*, *M. costata*, *M. esculanta*, *M. elata*, and *M. tridentina* were considered highly prized morel species. These morel species widely grow under the dense forest cover of *Pinus wallichiana* and *Cedrus deodara* in association with *Viburnum grandiflorum*. Among morels, *Morchella esculanta* and *M. tridentina* were valuable morels and considered good for export due to compact fruiting bodies, less moisture, and higher nutritional contents. *M. conica* has more water contents than the *M. esculanta* and turns dark black, which affects the preservation as well as its marketing. One kilogram of dried morel is solid in the market up to 32 thousand (Pakistani rupees) PKR. One kilogram of dry morels can fulfil the basic needs of a family of an average size. Prices of dried morels vary from market to market. In a village (Neelum) average price of 1 kg of dried morel is between 30,000 and 32,000 PKR. Other edible mushroom species *Pleurotus ostreatus* and *Agaricus campestris* were supplied to the famous hotels of the city. One Kg of dried mushroom is sold in 1500-2000PKR. These mushrooms are mostly used in dishes for foreign visitors. Mushrooms are collected worldwide as a source of food and income. Edible fungi, i.e. *Cantharellus cibarius*, *Lactarius deliciosus*, and *Russula* sp., were collected and sold in the market for food purposes [62]. More than 300 species of mushrooms were collected by different ethnic groups in Mexico for nutritional and medicinal purposes [63]. In China, local farmers earn up to 62% of their cash income through mushroom export [30]. Mushrooms play a significant role in rural development. Many species of edible mushrooms and morels have been collected by the rural for a socio-economic purpose [56, 64] and rural livelihood in terms of economic development [63]. Prices of dry mushrooms are higher than fresh mushrooms. Similarly, those mushrooms which are exported showed higher prices. The most common species collected and used for trade in neighbouring countries of Pakistan are, for example, *Boletus* spp. *Lactarius* sp., *Suillus bovinus*, *Russula* sp., and *Termitomyces* sp. [46, 65]. In the present investigation, the socio-economic data showed that a family collects an average of 3–4 kg morels with an average income of about PKR 0.1-0.120 million in a season. Fifty-six species of mushrooms were reported as edible previously from Pakistan and unfortunately because of over-collection, urbanization, and deforestation some species are threatened [66].

Mushrooms are natural sources of bioactive compounds used in alternative traditional medicines. Today, in parallel with the increase in the number of diseases, alternative medicine, and their usage is also increasing. It might be due to the disadvantages or side effects of drugs. Mushrooms have compounds that decrease oxidative stress and improve health [67, 68]. Many unexplored species of medicinally and commercially important mushrooms were widely distributed in the forests of Azad Jammu and Kashmir. Mushroom species growing naturally were collected by the rural people for food and medicines. In previous studies, medicinally significant mushrooms from the Neelum Valley have been reported [27, 77]. They are also collected in different countries of the world like the UK, Sweden, France, and Mexico [62, 74]. In the present study, twenty-six species of mushrooms were recorded as medicinally important which are used for the treatment of some common ailments. Among these mushrooms *Fistulina* sp., *Hericium erinaceus*, *Laetiporus sulphureus*, *Polyporus squamosus*, *Ramaria fennica*, *Sparassis crispa*, *Morchella elata*, *M. conica*, *M. tridentina*, and *M. deliciosa* were the most delicious and widely used species as a nutritive food by the rural people of Neelum Valley and Jhelum Valley. *Morchella esculanta* is reported to contain antioxidant, anticancer, and anti-inflammatory properties and is used as delicious food [68]. Soup of dried fruiting bodies of *Ramaria fennica* is used by women during breastfeeding to improve lactation. *Ramaria fennica* and morel species were considered effective against common cough and cold. Many mushroom species are considered medicinally important and used against stomach problems, heart burning, and wound healing without considering any side effects or toxicity. Previously, it is reported that extract and powder of mushrooms are used in traditional medicines and have reported uses as a liver tonic, blood purifiers, fertility issue, and diabetes [69]. Fruiting bodies of *Laetiporus sulphureus* are dried into a fine powder and used with milk as a portion of healthy food and anti-semenial weakness. Previously, it is reported that *Laetiporus sulphureus* is used against speedy recovery of wounds and common cold [6]. In another study, it is found that dry powder of this mushroom is helpful to expel a retained placenta in women and against stomach pain [30]. Use values of mushrooms species recorded during the study are given in (Table 3). In the present study, we have found the use of morels in different traditional home remedies against common ailments, fever, cough, and cold. Soup of *Morchella* is considered nutritious and used to treat the common cold. Extract of many edible species of mushrooms is effective against different human diseases like coronary disorders, oxidative stress, and cancer and provides different physiological benefits to consumers [64]. *Sparassis crispa* and *Polyporus squamosus* were used to treat stomach issues and considered healthy food. Old villagers prefer to use these mushrooms as a source of food. People use *Morchella* species, *Hydnum repandum*, *Sparassis crispa*, and *Polyporus squamosus* against
| No. | Name of Species                        | Family               | Edibility Status | Ethno-mycological uses | Ecology                                                                 | Voucher specimen Number | Region     | Reference                  |
|-----|----------------------------------------|----------------------|------------------|------------------------|-------------------------------------------------------------------------|--------------------------|-----------|----------------------------|
| 1   | Agaricus amicosus Kerrigan.            | Agaricaceae          | Edible           | Not used               | Saprobic, scattered in fir litter                                      | TS-106                  | Neelum AJK | Present study              |
| 2   | A. campestris L.                       | Agaricaceae          | Edible           | Consumed as food       | Saprobic, growing in a grassy area                                     | TS-107                  | AJK       | [49, 50]                  |
| 3   | A. silvicolae-similis Bohus & Locsmándi| Agaricaceae          | Edible           | Not consumed           | Saprobic, growing on decomposed wood                                  | TS-110                  | AJK       | [49, 50]                  |
| 4   | A. subrutilescens (Kauffman) Hotson & D. E. Stuntz | Agaricaceae          | Edible           | Consumed as food       | Saprobe, growing under coniferous forest                               | TS-109                  | AJK       | Present study              |
| 5   | Amanita fulva Fr                       | Amanitaceae          | Inedible         | Not consumed           | Mycorrhizal with conifers or hardwoods                                 | TS-110                  | AJK       | Present study              |
| 6   | A. hemibapha (Berk. & Boeroome) Sacc   | Amanitaceae          | Poisonous        | Poisonous              | Saprobic                                                               | TS-111                  | AJK       | Present study              |
| 7   | A. phalloides (Vaill. ex Fr.) Link     | Amanitaceae          | Deadly poisonous | Poisonous              | Mycorrhizal with pines and oak                                        | TS-112                  | AJK       | Present study              |
| 8   | A. vaginata (Bull.) Lam                | Amanitaceae          | Edible           | Not consumed as food   | Mycorrhizal with pines and oaks                                       | TS-113                  | AJK       | Present study              |
| 9   | Apioperdon pyriforme (Schaeff.) Vizzini | Agaricaceae          | Edible           | Consumed as food       | Saprobic on deadwood of hardwoods or conifers                          | TS-114                  | AJK       | Present study              |
| 10  | Armillaria gallica Marxm. & Romagn     | Physalacriaceae      | Edible           | Consumed as food       | Saprophytic, on organic matter and soil                               | TS-120                  | AJK       | Present study              |
| 11  | A. mellea (Vahl) P. Kumm              | Physalacriaceae      | Edible           | Consumed as food       | Parasitic on the hardwoods, on conifers produce white rot in the wood  | TS-121                  | Neelum AJK | Present study              |
| 12  | Auricularia auricula-judae (Bull.) Quel | Auriculariaceae      | Edible           | Used in weakness after childbirth, anti-hypertension | Grows in groves of trees, on logs and dead branches                     | TS-122                  | AJK/KPK  | [52]                       |
| 13  | Boletus aurisinnus (Murrill) Singer    | Boletaceae           | Edible           | Not consumed           | Mycorrhizal with conifers                                             | TS-123                  | AJK       | Present study              |
| 14  | B. chrysenteroides Snell               | Boletaceae           | Edible           | Not consumed           | Mycorrhizal with oaks                                                  | TS-124                  | AJK       | Present study              |
| 15  | B. edulis Bull. Herb Fr               | Boletaceae           | Edible           | Used as food           | Mycorrhizal with oaks and conifers                                     | TS-125                  | AJK       | Present study              |
| 16  | Bovista utriformis (Bull.) Fr          | Agaricaceae          | Edible           | Consumed as food       | Mycorrhizal with hardwoods                                             | TS-126                  | AJK/KPK  | [51, 52]                  |
| 17  | Coprinellus micaceus (Bull.) Vilgalys, Hopple & Jacq Johnson | Psathyrellaceae   | Medicinal        | Used in traditional medicines | Saprobic grow on decaying wood                                        | TS-127                  | AJK       | Present study              |
| 18  | Coprinus micaceus (Bull.)              | Psathyrellaceae      | Medicinal        | Used in traditional medicines | Saprobic grow on decaying wood                                        | TS-10                   | AJK       | Present study              |

Reference [51, 52]
| No. | Name of Species                  | Family          | Edibility Status       | Ethno-mycological uses          | Ecology                                                                 | Voucher specimen Number | Region     | Reference       |
|-----|---------------------------------|-----------------|------------------------|---------------------------------|-------------------------------------------------------------------------|--------------------------|------------|-----------------|
| 20  | *Calvatia cyathiformis* (Bosc)  | Agaricaceae     | Edible                 | Consumed as food                | Saprobic, grow in grass                                                | SG-16                    | Kaghan Valley | Ahmed, 1950     |
| 21  | *C. gigantea* (Batsch) Lloyd    | Agaricaceae     | Edible when young      | Consumed as food                | Saprobic growing on grass, lawn, open places                           | SG-20                    | AJK         | Present study   |
| 22  | *Cantharellus cibarius* Fr     | Cantharellaceae | Edible/medicinal       | Consumed as food                | Coniferous forest associated with moss                                 | TS-003                   | Pakistan    |                |
| 23  | *C. signicolar* (R.H. Petersen) | Cantharellaceae | Edible/medicinal       | Consumed as food                | Mycorrhizal with oaks, found in the cluster on mosses and grass        | PC-132                   | AJK         | Present study   |
| 24  | *Chlorophyllum rhacodes* (Vittad.) Vellinga | Agaricaceae | Edible                 | Consumed as food                | Saprobic, found in roadside, lawns, etc.                               | PC-133                   | AJK         |                |
| 25  | *C. olivieri* (Barla) Vellinga  | Agaricaceae     | Potentially dangerous  | Consumed as food                | Found in open areas                                                    | SG-134                   | AJK         | Present study   |
| 26  | *Clavaria fumosa* Pers          | Clavariaceae    | Edible                 | Consumed as food                | Saprobic, found in a dense cluster in grass                            | TS-135                   | AJK         | Present study   |
| 27  | *Clavariadelphus ligula* (Schaeff.) Donk | Clavariaceae | Edible                 | Consumed as food                | Saprobic, associated with fir needles on the ground                    | TS-138                   | AJK         | Present study   |
| 28  | *Desarmillaria tubescens* (Scop.) R.A. Koch & Aime | Physalaciaceae | Edible                 | Consumed as food                | Saprobic on oaks                                                       | TS-139                   | AJK         | Present study   |
| 29  | *Clavulinopsis fusiformis* (Sowerby) Corner | Clavariaceae | Edible                 | Consumed as food                | Saprobic, under hardwoods or conifers                                 | TS-140                   | Neelum AJK | Present study   |
| 30  | *Clavulina alta* Corner         | Clavulinaceae   | Edible                 | Consumed as food                | Mycorrhizal with conifers                                             | TS-141                   | Neelum AJK | Present study   |
| 31  | *C. cinerea* (Bull) J. Schrot   | Clavulinaceae   | Edible                 | Consumed as food                | Mycorrhizal association with conifers                                  | TS-142                   | Neelum AJK | Present study   |
| 32  | *C. coralloides* (L.) J. Schröt | Clavulinaceae   | Edible                 | Consumed as food                | Mycorrhizal with conifers and hardwoods                                | SG-027                   | Neelum AJK | Present study   |
| 33  | *Clitocybe acicula* Singer     | Tricholomataceae| Edible                 | Not consumed                    | On debris of conifers                                                  | TS-143                   | AJK         | Present study   |
| 34  | *C. nebularis* (Batsch) P. Kumm | Tricholomataceae| Edible/uncommon/medicinal | Not consumed                    | Found under conifers                                                  | TS-76                    | AJK         | Present study   |
| 35  | *Citopilus prunulus* (Scop.) P. Kumm | Entolomataceae | Edible                 | Not consumed                    | Saprobic, under, or conifers                                          | PC-88                    | AJK         | Present study   |
| 36  | *Coprinus coffeicola* Massee, Bull | Hymenochaetaceae | Inedible              | Inedible                        | Saprobic, under hardwoods                                              | TS-144                   | AJK, AKJ   | Present study   |
| 37  | *C. connatus* (O. F. Mull) Pers | Coprinaceae     | Edible when young      | Not consumed                    | Widely in grassland                                                   | TS-145                   | AJK         | Present study   |
| 38  | *Crepidotus appplanatus* (Pres) P. Kumm | Cortinariaceae | Edible                 | Not consumed                    | Under forest                                                          | TS-146                   | AJK         | Present study   |
| No. | Name of Species                    | Family            | Edibility Status | Ethno-mycological uses | Ecology                                                                 | Voucher specimen Number | Region     | Reference |
|-----|-----------------------------------|-------------------|------------------|------------------------|-------------------------------------------------------------------------|--------------------------|------------|-----------|
| 39  | *Desarmillaria tabescens* (Scop.) R.A. Koch & Aime | Physalacriaceae  | Edible           | Consumed as food       | Saprophytic on oaks                                                    | TS-150                  | AJK        | Present study |
| 40  | *Exidia recisa* (Ditm.) Fr | Auriculariaceae   | Inedible         | Not consumed           | Underwood and conifers                                                | PC-89                   | Neelum AJK | Present study |
| 41  | *Plocarcus luteovirens* (Alb. & Schwein.) Pouzar | Russulaceae       | Edible           | Not consumed           | Ecto-Mycorrhizal, grow on the ground with pines                       | SG-19                   | AJK        | Present study |
| 42  | *F. straminea* (F. Kumm.) Pouzar | Agaricaceae       | Inedible         | Not clear              | Under conifers                                                        | TS-151                  | AJK        | Present study |
| 43  | *Rammulina fennae Bas*             | Physalacriaceae   | Edible           | Not consumed           | On older tree trunks and under conifers                               | TS-152                  | AJK        | Present study |
| 44  | *F. ononidis* Dobson             | Physalacriaceae   | Edible           | Not consumed           | On the ground and rotten trees                                        | TS-153                  | AJK        | Present study |
| 45  | *Fistulina* sp                    | Agaricomycetes    | Edible/medicinal | Consumed as food       | At the tree trunk of *Prunus padis*                                    | TS-154                  | Neelum AJK | Present study |
| 46  | *Gyromitra bubakii* (Velen.) J. Moravec | Discinaceae   | Edible on choice | Not consumed           | Under forest                                                          | TS-155                  | AJK        | Present study |
| 47  | *G. intermedia* (Benedix) Harmaja | Discinaceae       | Edible on choice | Not consumed           | Under forest                                                          | TS-156                  | AJK        | Present study |
| 48  | *G. esculenta* (Pers.) Ex. Fr     | Discinaceae       | Conditionally edible | Conditionally edible | Under Quercus trees                                                   | TS-157                  | AJK        | [27]      |
| 49  | *Ganoderma adspersum* (Schulzer) Donk | Ganodermataceae | Inedible/medicinal | Not consumed           | On the ground and rotten trees                                        | TS-158                  | AJK        | Present study |
| 50  | *G. lucidum* (Curtis) P. Kanst    | Ganodermataceae   | Inedible/medicinal | Medicinal              | Medicinal                                                             | TS-159                  | AJK        | [45]      |
| 51  | *G. applanatum* (Pers.) Pat | Ganodermataceae   | Medicinal         | Medicinal              | Under Quercus trees                                                   | TS-160                  | AJK        | [68]      |
| 52  | *Geastrum sacratum* Fr            | Geastraceae       | Inedible          | Not consumed           | Under Quercus trees                                                   | TS-161                  | Pakistan   | [69]      |
| 53  | *G. pedicellatum* (Batsch) Dörfelt & Müll. Uri | Agaricaceae       | Unknown           | Not confirm            | On grassy ground                                                       | TS-162                  | AJK        | [50]      |
| 54  | *G. trigona* Jungh                | Geastraceae       | Inedible          | Not consumed           | Under Quercus trees                                                   | SG-173                  | Pakistan   | [30, 51] |
| 55  | *Helvella sulcata* Alzey          | Helvellaceae      | Edible            | Consumed as food       | On decaying hardwoods stumps                                           | SG-174                  | AJK        | Present study |
| 56  | *H. elatica* Bull                | Helvellaceae      | Inedible          | Inedible               | On the ground, on decaying wood                                        | SG-175                  | AJK        | Present study |
| 57  | *H. crispa* (Scop.) Fr            | Helvellaceae      | Edible            | Consumed as food       | Mycorrhizal. Growing under conifers or hardwoods                      | SG-176                  | Kaghan Valley | [69]      |
| 58  | *H. lacunos* Alzey               | Helvellaceae      | Conditionally edible/medicinal | Consumed as food       | Not consumed                                                          | SG-177                  | Kaghan Valley | [69]      |
| No. | Name of Species | Family               | Edibility Status | Ethno-mycological uses   | Ecology                                    | Voucher specimen Number | Region         | Reference |
|-----|----------------|----------------------|------------------|--------------------------|--------------------------------------------|--------------------------|---------------|-----------|
| 59  | *H. fibrosa* (Wallr.) Korf | Helvellaceae         | Edible           | Not consumed             | On conifers or wood of hardwoods           | SG-178                  | Pakistan      | [69]      |
| 60  | *Hohenbuehelia* sp. T-62 (LAH, 1193) | Pleurotaceae        | Edible/medicinal | Consumed as food         | Saprobic grows on decaying sticks and branches in damp spots on the forest floor | SG-179                  | Neelum AJK    | Present study |
| 61  | *Hydnum repandum* L. | Hydaneceae           | Edible/medicinal | Consumed s food          | Under Quercus trees                        | SG-180                  | AJK           | Present study |
| 62  | *Hygrocybe acutoconica* (Clem.) Singer | Hygrophoraceae      | Edible           | Consumed s food          | On conifers or wood of hardwoods           | SG-181                  | AJK           | Present study |
| 63  | *H. flavescens* (Kauffman) Singer | Tricholomataceae    | Inedible         | Not consumed             | On conifers or wood of hardwoods           | SG-182                  | AJK           | Present study |
| 64  | *Hygrophorus piceae* Kuhner | Hygrophoraceae      | Edible           | Unknown                  | On conifers or wood of hardwoods           | SG-183                  | AJK           | Present study |
| 65  | *H. persooni* Arnolds | Hygrophoraceae       | Edible/medicinal | Unknown                  | On conifers or wood of hardwoods           | SG-184                  | AJK           | Present study |
| 66  | *Imenia pallida* (Frost) A. Farid, A.R. Franck, & J. Bolin | Boletaceae          | Unknown          | Not consumed             | Mycorrhizal with oaks                      | TS-185                  | AJK           | Present study |
| 67  | *Laccaria amethystina* Cooke | Hydnangiaceae       | Edible on choice/medicinal | Not consumed             | Mycorrhizal with oaks                      | TS-186                  | AJK           | Present study |
| 68  | *L. bicolor* Maire | Hydnangiaceae       | Conditionally edible | Not consumed             | Mycorrhizal with conifers, found in mosses | TS-187                  | AJK           | Present study |
| 69  | *Lactarius deliciosus* (L.) Gray | Russulaceae         | Edible/medicinal | Not consumed             | Mycorrhizal with conifers grows under conifers on acidic soils | TS-188                  | Pak           | [51]      |
| 70  | *Lactarius sp* | Russulaceae          | Edible           | Consumed as food         | Mycorrhizal with conifers                  | TS-189                  | AJK           | Present study |
| 71  | *L. helvus* (Fr) Fr | Russulaceae          | Poisonous        | Poisonous                | Mycorrhizal with conifers                  | TS-190                  | AJK           | Present study |
| 72  | *L. quieticolor* Romagn | Russulaceae         | Edible           | Not consumed             | Mycorrhizal                                | TS-200                  | AJK           | Present study |
| 73  | *L. toriminosus* (Schaeff.) Pers | Russulaceae         | Inedible         | Inedible                 | Mycorrhizal, mixed forest                  | HP-007                  | AJK           | Present study |
| 74  | *Lactifluus piperatus* (L.) Roussel | Russulaceae         | Edible/medicinal | Inedible                 | On oak                                    | SG-192                  | AJK           | [50]      |
| 75  | *Lepista ovispora* (J.E. Lange) Guilden | Tricholomataceae    | Conditionally edible/med | Not consumed             | Open grassland                            | SG-193                  | AJK           | Present study |
| 76  | *Laetiporus sulphureus* Bull. Murrill | Fomitopsidaceae    | Edible/medicinal | Consumed as food         | On oak, prunus, Salix, etc.                | TS-201                  | AJK           | [51]      |
| 77  | *Lepiota cristata* (Bolton) P kumm | Agaricaeae         | Edible           | Consumed as food         | Saprobioc, on forest, lawns, etc.          | TS-202                  | Sohawa Shareef AJK | Present study |
| 78  | *L. magnispora* Murill | Agaricaeae          | Inedible         | Inedible                 | Saprobioc, Found under hardwoods and conifers | TS-203                  | Neelum AJK    | Present study |
| 79  | *Lactis luscina* (Fr) Singer | Tricholomataceae    | Edible           | Not consumed             | In mixed forest                           | TS-204                  | AJK           | Present study |
| 80  | *Lepista violacea* (Fr) Singer | Tricholomataceae    | Edible           | Not consumed             | In mixed forest                           | TS-204                  | AJK           | Present study |
| No. | Name of Species                | Family               | Edibility Status       | Ethno-mycological uses                          | Ecology                              | Voucher specimen Number | Region | Reference |
|-----|--------------------------------|----------------------|------------------------|------------------------------------------------|--------------------------------------|-------------------------|--------|-----------|
| 81  | L. irina (Fr.) H.E. Bigelow    | Tricholomataceae     | Unknown                | Not consumed                                    | In mixed forest                     | TS-205                  | AJK    | Present study |
| 82  | Lycoperdon perlatum Pers.      | Agaricaceae          | Edible when young/medicinal | Consumed as food and wound healing          | Open areas, grassy ground           | TS-210                  | Pak    | [69]       |
| 83  | Leucopaxillus giganteus        | Stereaceae           | Inedible               | Inedible                                        | Saprobic on deadwood of oaks        | TS-002                  | AJK    | Present study |
| 84  | Morchella tridentina Bres.      | Morchallaceae        | Edible/medicinal       | Used in cough and cold, highly medicinal       | Saprobic on deadwood or conifers   | T-05 & T-06             | AJK    | Present study |
| 85  | M. deliciosa Fr.               | Morchallaceae        | Edible/medicinal       | Consumed as food and medicinal                | On humus-rich soil                  | T-02                    | AJK    | Present study |
| 86  | M. costata Fr.                 | Morchellaceae        | Edible/medicinal       | Consumed as food and medicinal                | On leaf litter                      | T-04                    | Pak    | [72]       |
| 87  | M. conica Pers.                | Morchallaceae        | Edible/medicinal       | Consumed as food and medicinal                | under grass and conifers            | T-07                    | Pak    | [72]       |
| 88  | M. esculenta Pers.             | Morchallaceae        | Edible/medicinal       | Used in cough and cold, highly medicinal       | Saprobic on deadwood of hardwoods or conifer | T-08                    | AJK    | [69]       |
| 89  | M. elata Fr.                   | Morchallaceae        | Edible/medicinal       | Consumed as food and medicinal                | On grasses                          | T-09                    | Pak    | [72]       |
| 90  | Marasmius abrubtipes Corner.   | Marasmiaceae         | Inedible               | Not used                                        | On humus-rich soil                  | TS-65                   | AJK    | Present study |
| 91  | M. abundans Corner             | Marasmiaceae         | Inedible               | Not used                                        | On leaf litter                      | TS-66                   | AJK    | Present study |
| 92  | M. rotula (Scop.) Fr.          | Marasmiaceae         | Inedible               | Not used                                        | Saprobic on deadwood, hardwoods of conifer | TS-68                   | AJK    | Present study |
| 93  | M. strictipes (Peck.) Singer.  | Marasmiaceae         | Inedible               | Not confirmed                                   | Saprobic on deadwood of hardwoods or conifer | TS-69                   | AJK    | Present study |
| 94  | M. acerinus Peck               | Marasmiaceae         | Inedible               | Not confirmed                                   | Saprobic on grasses                 | TS-70                   | AJK    | Present study |
| 95  | Pleurotus dryinus (Pers.) P. K. | Pleurotaceae         | Edible when young      | Consumed as food and medicinal                | Saprobic, growing on oaks           | TS-72                   | AJK    | Present study |
| 96  | P. ostreatus (Jacq.) P. Kumm.   | Pleurotaceae         | Edible                 | Consumed as food                                | Saprobic on wood                    | TS-65                   | AJK    | [75]       |
| 97  | Pholiota brunescens A.H. Sm. & Hesler | Strophariaceae | Inedible               | Not consumed                                    | Saprobic on wood                    | TS-212                  | AJK    | Present study |
| 98  | Polyporus septosporous P.K. Buchan & Ryvarden | Polyporaceae | Edible/medicinal       | Consumed as food                                | Saprobic on decaying hardwood logs, etc. | TS-213                  | AJK    | Present study |
| 99  | Ramaria fennica (P. Karst.) Riken | Gomphaceae | Edible                 | Consumed as food                                | Mycorrhizal with hardwoods          | TS-214                  | AJK    | Present study |
| 100 | R. barenthensis Franchi & M.   | Russulaceae          | Edible                 | Not consumed                                    | Mycorrhizal with trees and shrubs   | TS-215                  | AJK    | Present study |
| 101 | R. stricta (Pers.) Quel         | Gomphaceae           | Edible                 | Consumed as food                                | Mycorrhizal and Saprobic            | TS-216                  | AJK    | Present study |
| No. | Name of Species                        | Family             | Edibility Status | Ethno-myecological uses | Ecology                                      | Voucher specimen Number | Region | Reference |
|-----|---------------------------------------|--------------------|------------------|-------------------------|----------------------------------------------|--------------------------|--------|-----------|
| 102 | Rhodocollybia butyracea (Bull.) Lennox | Omphalotaceae      | Inedible         | Not consumed            | Saprobic, decomposing the litter of conifers | TS-217                   | AJK    | Present study |
| 103 | Russula amoenaens Romagn              | Russulaceae        | Conditionally edible | Not consumed            | Mycorrhizal with hardwoods and conifers      | TS-218                   | AJK    | Present study |
| 104 | R. brevipes Peck                      | Russulaceae        | Edible           | Not consumed            | Mycorrhizal with conifers                    | TS-219                   | Pakistan | [71]      |
| 105 | R. cinereovinoso Fatto                | Russulaceae        | Inedible         | Inedible                | Mycorrhizal with conifers, fir               | TS-220                   | AJK    | Present study |
| 106 | R. collina Velen Frost                | Russulaceae        | Inedible         | Inedible                | Mycorrhizal with hardwoods and conifers      | T-46                     | AJK    | Present study |
| 107 | R. cemonicolor Earle                  | Russulaceae        | Unknown          | Not clear               | Mycorrhizal, mixed forests                   | T-47                     | AJK    | Present study |
| 108 | R. cystidiosa Murrill                | Russulaceae        | Unknown          | Not clear               | Mycorrhizal with oaks                        | T-48                     | AJK    | Present study |
| 109 | R. delica Fr                         | Russulaceae        | Edible           | Consumed as food        | Found under broadleaved and coniferous wood  | T-49                     | AJK    | Present study |
| 110 | R. densifolia Secr. ex Gillet         | Russulaceae        | Edible           | Not consumed            | Mycorrhizal with conifers                    | PS-34                    | AJK    | Present study |
| 111 | R. fragrantissima Romagn             | Russulaceae        | Inedible         | Inedible                | Mycorrhizal with hardwoods and conifers      | PS-35                    | AJK    | Present study |
| 112 | R. integra (L.) Fr                   | Russulaceae        | Conditionally edible | Inedible                | Mycorrhizal with hardwoods and conifers      | ND-09                    | AJK    | Present study |
| 113 | R. acriscula Buyck                   | Russulaceae        | Edible/med       | Not consumed            | Mycorrhizal with hardwoods and conifers      | ND-10                    | AJK    | Present study |
| 114 | R. tenuiceps Kauffman                | Russulaceae        | Inedible         | Inedible                | Mycorrhizal with oaks                        | ND-11                    | AJK    | Present study |
| 115 | R. violacea Quel                     | Russulaceae        | Edible           | Not consumed            | Mycorrhizal with hardwoods and conifers      | ND-12                    | AJK    | Present study |
| 116 | Rhizopogon roseolus (Corda)Th. Fr    | Rhizopogonaceae    | Medicinal        | Consumed as food        | Ectomycorrhizal fungus                      | ND-16                    | Bagh   | AJK       |
| 117 | Suillus granulatus (L.) Roussel,     | Boletaceae         | Edible           | Not consumed            | Mycorrhizal with pines                       | ND-17                    | AJK    | Present study |
| 118 | S. luteus (L.) Roussel               | Suillaceae         | Edible           | Not consumed            | Mycorrhizal with pines                       | ND-19                    | Pakistan | [68]      |
| 119 | Suillus luridus (Schaeff.) Murrill    | Boletaceae         | Conditionally Edible | Consumed as food        | Mycorrhizal with pines and other hardwoods   | ND-20                    | AJK    | Present study |
| 120 | Scleroderma bovista, Fr              | Sclerodermataceae  | Inedible         | Inedible                | Saprobic on the ground, mycorrhizal with hardwoods | PHM-07                   | Kaghan Valley | [72] |
| 121 | S. citrinum Pers                     | Sclerodermataceae  | medicinal/poisonous | Consumed as food        | Attached to soil mycelial cords              | PHM-08                   | Bagh   | AJK       |
| 122 | Stromatinia rapulum (Bull.) Boud      | Pezzaceae          | Conditionally edible | Not consumed            | Saprobic on well-decayed logs                | PHM-12                   | AJK    | Present study |
Table 3 (continued)

| No. | Name of Species                       | Family              | Edibility Status | Ethno-mycolological uses                        | Ecology            | Voucher specimen Number | Region | Reference |
|-----|---------------------------------------|---------------------|------------------|------------------------------------------------|--------------------|-------------------------|--------|-----------|
| 123 | *Sparassis spathulata* (Schwein.) Fr | Sparassidaceae      | Edible when young | Used as stomach tonic and food                  | Pathogenic and Saprobic | PHM-13                | AJK    | Present study |
| 124 | *S. crispa* (Wulfen) Fr               | Sparassidaceae      | Edible/medicinal | Consumed as food/medicinal                      | Pathogenic and saprobic | PHM-14                | Pakistan | [70]       |
| 125 | *Tricholoma portentosum* (Fr) Quel    | Tricholomataceae    | Edible and medicinal | Consumed as food                              | On Coniferous woods and oaks | ND22                | AJK    | Present study |
| 126 | *Volvopluteus gloiocephalus* (DC.) Vizzini, Contu & Justo | Pleurotaceae | Edible | Consumed as food                              | Saprobic, growing aggregates in gardens, lawns, woodchips, etc. | ND-27           | AJK/KPK | [72]       |
| 127 | *Volvariella volvacea* (Bull.) Singer | Pleurotaceae        | Edible           | Consumed as food                              | Saprobic, growing in woodchips | SG-07           | AJK/KPK | [72]       |
| 128 | *V. bombycina* (Schaeff.) Singer       | Pleurotaceae        | Edible           | Consumed as food                              | Saprobic, growing in woodchips | CHK-02          | AJK/KPK | [72]       |
| 129 | *Verpa bohemica* (Krombh.) J. Schroet | Helvellaceae        | Conditionally edible | Consumed as food                              | Mycorrhizal. Found under hardwoods and conifers in early spring | PC-01           | Neelum AJK | Present study |
| 130 | *V. conica* (O.F. Müll.) Sw           | Helvellaceae        | Conditionally edible | Consumed as food                              | Mycorrhizal. Found under hardwoods and conifers in early spring | CHK-02           | Neelum AJK | Present study |
| 131 | *Xerocomellus chrysenteron* (Bull.) Šutara | Boletaceae        | Edible           | Food                                         | Mycorrhizal with oaks and conifers | CHK-03           | AJK    | Present study |
stomach problems, *Lycoperdon perlatum*, and *Auricularia auricula* in wound healing and as anti-hypertension agents. *Armillaria mellea*, *Boletus badius*, *Cantharellus cibarius*, *Pleurotus ostreatus*, and *Lactarius deliciosus* contain bioactive organic contents with reported uses in traditional medicines [70]. Sher and Shah [26] reported that morels were utilized both for food as well as medicines to cure different diseases.

Ethno-mycological uses of mushrooms vary from region to region and even among the communities of the same area [71]. In Poland, edible mushroom species are used as food and medicines. Folk taxonomy is very important to share the knowledge and use of these mushroom species. Extract of mushrooms can be used due to cosmeceutical and nutricosmetic ingredients to treat inflammatory skin disease and hyperpigmentation [72]. Aqueous Extracts of *Polyporus squamosus*, *Morchella* spp., and *Sparassis crispa* are considered more effective against common diseases of the stomach by the rural informants of Kashmir. As it is reported that mushrooms are effective against different diseases, but the chemical evaluation is very important before using an extract of mushroom species [73]. Mushrooms are used in culinary traditional medicines and sometimes cooked in oil [74]. It is concluded that mushrooms potentially can provide opportunities to the low-income areas to improve their living standards in terms of income generation and socio-economic development. It is very important to raise awareness among the local communities/mushroom collectors, about the importance of mushrooms as food and medicines. Mushrooms, if well addressed in society, are a potential source of traditional medicines, anti-cancer compounds, food, and nutrition security specifically in developing countries.

**Mushrooms edibility in the study area**

The state of Azad Jammu and Kashmir (AJK) is blessed with a fertile land, rich with diversity of mushrooms. Among the identified wild mushrooms, 54 (48%) were identified as edible, 24 (21%) inedible, 14 (12%) edible and medicinal (Fig. 6). *Lactarius deliciosus*, *Morchella* sp., *Pleurotus ostreatus*, *Polyporus squamosus* *Sparassis crispa*, and *Laetiporus sulphureus* were collected by the rural people of the area as a source of food. Edible mushrooms have been collected and consumed as food worldwide [4, 14, 27, 74]. Edible mushrooms like *Lactarius deliciosus* and *Ramaria* sp. have been collected and consumed in the neighbouring countries of Pakistan [78].

**Appendix 1**

See Table 4
Table 4: The questionnaire used for data collection from rural informants

| S. no. | Information on mushroom | Respondent |
|-------|-------------------------|------------|
| i.    | Who sells mushrooms, women or men? | –          |
| ii.   | Age of the vendors (five age groups): < 18, 19–30, 31–40, 41–50, > 50 | –          |
| iii.  | The level of education (illiterate, primary, middle, secondary, higher secondary and above)? | –          |
| iv.   | Employment status (Govt. servant farmer and entrepreneur, housewife, and retired)? | –          |
| v.    | Types of socio-economic data | –          |
| vi.   | Wild or cultivated edible mushroom species local people know? | –          |
| vii.  | Which edible mushrooms have you collected? | –          |
| viii. | Which mushroom species have you sold? | –          |
| ix.   | Which mushroom species have you used but not sold? | –          |
| x.    | The folk name of each mushroom species being sold? | –          |
| xi.   | Mushroom collected per season (kg)? | –          |
| xii.  | Usage of gathered mushrooms (food, medicine, or income)? | –          |
| xiii. | Learning ways of traditional knowledge about macro-fungi? | –          |
| xiv.  | Basic marketing channels of wild and cultivated edible mushrooms? | –          |
| xv.   | Economic aspects of wild and cultivated edible mushrooms in the studied area? | –          |
| xvi.  | Methods of processing and preservation of mushrooms (freezing, sun drying, or salting)? | –          |
| xvi.  | Therapeutic uses of mushrooms in the traditional pharmacopeia of the region? | –          |

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Author contributions
The first author carried out the research including the sampling of mushrooms. SSF, WTS and ANK designed the research, identified the mushroom samples, and supervised at all the stages. HS, MU and JH helped with data analysis. MA helped in revision of article. All authors read and approved the final manuscript.

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Availability of data and materials
Data sharing does not apply to this article as no datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
No written consent was obtained. Sharing of knowledge and other related information was obtained after taking a verbal consent from a family or individual. No ethical committee permits were required for this study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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