Diversity and Ethno-Mycological Importance of Mushrooms from Western Himalayas, Kashmir.

Tariq Saiff ULLAH (tariq.saiff@uokajk.edu.pk)
University of Kotli, Azad Jammu and Kashmir
Syeda Sadiqa Firdous
University of Azad Jammu and Kashmir
Hamayun Shaheen
University of Azad Jammu and Kashmir
Javeed Hussain
University of Kotli, Azad Jammu and Kashmir
Abdul Nasir Khalid
University of the Punjab

Research Article

Keywords: Ethnomycology, Diversity of mushrooms, Laetiporus sulphureus, morels, traditional uses of mushrooms

Posted Date: December 29th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1189562/v1

Version of Record: A version of this preprint was published at Journal of Ethnobiology and Ethnomedicine on April 13th, 2022.
See the published version at https://doi.org/10.1186/s13002-022-00527-7.

Abstract

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 ethno-medicinal uses of mushrooms from the State of Jammu and Kashmir.

Methods: Consecutive surveys were conducted to record ethno-mycological diversity and socio-economic importance of wild edible mushrooms value chain in rural areas of Azad Jammu and Kashmir during 2015-2020. 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 results identifying the gender, type of mushroom species, medicinal uses, and marketing of mushrooms. Principal component analysis (PCA) was also applied to the data set 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 2015-2020 from the study area. One hundred and one species of mushrooms were reported new to the State of Jammu and Kashmir. The dominant mushroom family was Russullaceae with 23 species followed by Agaricaceae, 16 species. Major mushroom species identified and grouped by the PCA were *Coprinus comatus, Lactarius sangufulus, Amanita fulva, Armillaria gallica, Lycoperdon perlatum, Lycoperdon pyriforme, and Russula creminicolor*. *Sparassis crispa, Pleurotus* sp and *Laetiporus sulphurous* were recorded most edible and medicinally significant fungi. Morels were the most expensive and medicinally important among all harvested macro-fungal species. These were reported to use against the common ailments and various health problems.

Conclusions: Collection and retailing of WEM contribute to improve the socioeconomic 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 a potential source of antibacterial and anticancer drugs in future.

Background

Mushrooms are fruiting bodies with distinctive carpophores of Basidiomycetes and some Ascomycetes [1]. They grow in the wild and cultivated for food and medicines worldwide [2] due to the presence of bioactive compounds and applications in the traditional medicines, health-promoting benefits, and antioxidant activity [3, 4, 5, 6]. These are rich in amino acids, protein, fibre elements, vitamins, and different minerals and play a significant role as anticholesterol, antitumor, antimicrobial, antioxidant, antilipidemic, antidiabetic antihyperglycemic, antihypertensives, anti-inflammatory hepatoprotective, immune-modulatory, anti-ageing properties and used against neuro-degenerative diseases [7,8, 9]. Due to diverse ecological, medicinal, nutritional, and health-promoting properties mushrooms are gaining prime importance among scientific and research communities throughout the world [10]. They possess remarkable dietetic and medicinal values and are rich in carbohydrate, protein, and bioactive metabolites effective against cardiovascular, and hepatic problems and contain anti-viral, antioxidant, and antimicrobial contents [11, 12, 13]. *Pleurotus* is used as protein-rich food with many health benefits worldwide [14]. Extracts of edible mushrooms are considered a rich source of carbohydrates, proteins and mineral elements [15, 16]. They have low contents of saturated fats and higher contents of proteins and fibres and might reduce the blood cholesterol level [17]. Different low molecular weight bioactive compounds, anthraquinones, sesquiterpenes, quinolines and oxalic acid with reported antimicrobial activity have been identified from mushrooms [18]. Edible mushrooms contain polysaccharides, terpenoids, vitamins, amino acids and minerals elements with maximum antibacterial activity and anti-ageing properties [19, 20, 21]. *Ganoderma lucidum* has been used for centuries by different tribes as an alternative traditional medicine to promote health and to treat specific disorders [22]. It was reported that *Hericium erinaceus*, *Sarcodon scabrosus*, *Ganoderma lucidum* and *Grifola frondosa* have neuro-protective health benefits [23].

Different common edible mushrooms like *Pleurotus* species, *Boletus edulis*, *Agaricus rubescens, Sparassis crispa, Cantharellus cibarius* and *Lactarius deliciosus* and *M. deliciosa* are good in natural antioxidants, phenolic compounds,

minerals, and other nutrients (24, 3). They have important antioxidant and biologically active compounds and used worldwide from ancient times in traditional medicines due to health-promoting and immune-stimulating properties [25, 26, 27). Different functional bioactive compounds Cardiac glycosides Anthraquinones, flavonoids, Tannins, Terpenoids and proteins were reported from mushrooms [28, 29, 30]. Water extract of Chaga mushrooms contains potent anti-cancer compounds [31]. Mushrooms are gaining importance by researchers worldwide due to their nutritional and pharmacological importance [32, 33]. Biomolecules of mushrooms have good biological and medicinal potential against different diseases [34].

Morels (*Morchella*) have been used as food with various health benefits [35] Different polysaccharides have been identified from *Morchella sextelata* with immune-modulating properties [36]. *Morchella esculenta* has a wide variety of antioxidant and antitumor compounds and is used as a source of food and traditional medicines [37]. It contains polyunsaturated fatty acids, carbohydrates, and bioactive compounds with antibacterial activity [38]. The whole region of AJK is blessed with diverse geographic and climatic conditions with a diversity of mushrooms but there are 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, ethno-mycological uses, production, harvesting and export of mushrooms. Present research work will contribute towards a detailed overview of the species diversity of mushrooms in AJK, their ethno-mycological uses and 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 sub-continent with an area of 13297 square Kilometres. The elevation from sea level ranges from three-sixty meters in the south to 6325 meters 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°C to 25°C and in winters, 10°C to 4°C. Annual rainfall (average) in the monsoon region is 900-1300 mm and in monsoon free region it remains 35-140 mm [39].

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 21 sites were selected from Neelum, Muzaffarabad, Hattian, Bagh, Heveli, Poonch and Kotli districts of Azad Jammu and Kashmir during 2015-19 to study mushroom diversity (Figure 1 & Table 1).

Collection and preservation of sporophores

Sporophores of fungi were collected from *Cedrus deodara* and *Pinus wallichiana* forest communities. Sporocarps were collected by using standard methods (Gateri et al., 2014). Ethno-mycological knowledge was obtained from different field visits and semi-structured questionnaires and interviews with rural people. 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. Morphological characters of the sporophores were recorded during collection in the field. 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. A sample of the selected type of mushroom was assigned a voucher number and carried to the laboratory of Botany, University of Punjab, Lahore, Pakistan for detailed morpho-anatomical examination. Specimens were finally cross-checked with the published

material, literature at the morpho-anatomical level. Appropriate taxonomic literature was used for the proper identification of mushrooms [40, 41, 42, 43, 44). Further citations were checked on mycobank and the index fungorum database. Final identification was made from fungal biology and systematic research laboratory Department of the Botany University of the Punjab Lahore after studying detailed morpho-anatomical study (identification keys and published material). Voucher specimens were deposited with the accession numbers at the Herbarium of Botany, University of Azad Jammu and Kashmir Muzaffarabad.

Table 1. Different study sites and coordinates

No	Site Name	District	N	E	Elevation (m)
1	Peer Chinasi	Muzaffarabad	34°23'2.41	73°33'33.67	2596
2	Shaheed Gali	Muzaffarabad	34°23'1.01	73°25'16.55	1346
3	Peer Hassimar	Muzaffarabad	34°92'4.58	73°37'00.42	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	Surgon	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	Havali	33°54'9.40"	74°12'21.59	2426
20	Nakyeal	Kotli	33°29'9.72"	74° 6'55.53"	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

Results

Demographic characteristics and community involvement

Wild mushroom value chain is seen to be gender oriented 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 [6] 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 [45, 46, 47). 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 [48] 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 [47]. 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 & entrepreneur, 12.6% employed, 6.7 % retired from 923 respondents (Table 2). Data on education in the present study revealed that almost 83 % informants had a middle school education in accordance with the findings of [49] who indicated that mushroom collection or cultivation were mostly managed by less educated people in the rural areas.

Table 2. Demographic characteristics of Mushroom collectors in 6 Districts of AJ&K, (N=923)

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

Collection and identification mushrooms

A total of 131 mushroom species were collected and identified during the study. Out of 131 mushroom species, 101 species of mushrooms were recorded new to the state of Azad Jammu and Kashmir (Figure 2), however few of these species have

been identified from different parts of Pakistan at molecular level previously. Already identified mushroom species were morphologically cross checked with published material. Many of these species were collected by the rural peoples based on folk taxonomy and only a few are considered edible. The dominant mushroom family was Russulaceae with 23 species followed by Agaricaceae, 16 species, Boletaceae, 10 species, Halvallaceae, 7 species and from Tricholomataceae and Physalaeriaceae 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 maximum number of sporophores decay 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. Maximum diversity of fungi was calculated in the Neelum valley followed by Las Dana, Chakar, Noon bangla and Leepa in Jhelum valley. The sites surveyed for collection of mushrooms had maximum forest cover that is responsible for the diversity variation including Tooli peer and forests of Peer Chinasi. The basidiomycetes constituted the major proportion i.e; 115 species while Ascomycetes constituted 16 species. Majority of mushrooms collected belong to gilled fungi. Species of *Coprinus, Flammulina, Peziza, Armillaria* and *Morchella* were found in clusters while as other species occur in scattered patches. In Previous studies six species of *Agaricus* were reported from Rawalakot, Azad Kashmir by [50] Similarly [51] collected and described edible mushrooms viz. *Armillaria mellea, Cantharellus cibarius, Craterellus cornucopiodes, Flammulina velutipes* and *Macrolepiota procera* from this state. Furthermore, more they added, *Amanita elliptica, A. muscaria var. alba, Ramaria aurea R. botrytis, Phallus impudicus, Morchella elata* and *M. semilibera*, *Amanita ceciliae, A. subglobosia, A. pantherina, A. pachycolea, A. virosa, Volvariella bombycina* and *V. speciosa* to Kashmir. [52, 53] also contributed to mushroom flora of AJK. They reported 25 edible mushrooms from different sites of the state.

Mushrooms edibility in the study area

The state of Azad Jammu &Kashmir (AJ&K) has a land of rich diversity of wild mushrooms which might have been contributed by the tropical and moist temperate forests, mostly Quercus and coniferous woodlands, and higher rainfall and annual precipitation. Among the identified wild mushrooms, 54 (48%) were identified as edible only, 24 (21%) as inedible, 14 (12%) as edible and medicinal (Figure 3). The detail of different categories of identified wild mushrooms with their percentage is given in figure (3).

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 which maximizes the species scores with respect of 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 together by the PCA based upon their species interrelationship are Pir 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 the similar species composition. Major mushroom species collected from these sites and grouped together by the PCA are *Coprinus comatus, Lactarius sangufulus, Amanita fulva, Armillaria gallica, Lycoperdon perlatum, Lycoperdon pyriforme, and Russula creminicolor*, these sites have shown a little correlation with a village Khawaja bandi kahuta Havali. The mushroom species grouped together by the PCA are the common fungi which 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 almost 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*, *Gyromitra esculenta*, *Armillaria sp*, *Agaricus campestris*, *Russula breviceps, Polyporus squamosus, Trametes versicolor* and *Laccaria* sp. Other mushroom species grouped at the centre of the PCA axis show that these species are almost equally distributed and present in all the sites of the study area. These species have no specific distribution pattern. These species are most common and grow almost equally in different geographic condition with slight changes in their growth period and maturation.

PCA identified five major keystone species from the data matrix and separated them along X-axis. *Lactarius piperatus, L. deliciosus, L. torminosus, Hygrocibe flavesence and Russula delica* were extracted as most significant vectors having maximum Eigen vale 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 (Fig. 4).

Discussion

Ethno-mycological and socio-economic 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. Consecutive field visits were carried out to different villages, local markets, shops of the study area for gathering of information about mushroom collection and selling. A semi-structured questionnaire (Appendix.1) was used to collect the information on wild edible mushrooms value chain, hunting, collection, preservation, and retailing [54]. Primary and secondary information was collected from all the available resources. Primary information gathered by structured and semi structured interviews with collectors, consumers, and sellers. Secondary information was collected from different literature, thesis, maps, and web sites. Both formal and informal discussions with forestry professionals, key informants, village elders, farmers, women, schoolteachers, social workers, shopkeepers were carried out to identify and verify the facts. Information on edibility, medicinal uses, preservation methods and any other uses was also collected. Mushrooms play a significant role in rural development. Many species of edible mushrooms and morels have been collected by the poor rural for socioeconomic purpose [55] and rural livelihood in terms of economic development [56].

Morels are collected by the people of rural areas of AJK for medicinal and commercial purposes. *Morchella conica, M. costata, Morchella 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 deodar* in association with Viburnum grandiflorum. Among morels, Morchella esculanta and M. tridentina were valuable morels and due to compact fruiting bodies, less moisture, and higher nutritional contents and considered good for export. *M. conica* has more water contents than the *M. esculanta* and turns dark black, which affects the preservation as well as its marketing. Edible fungi i.e., *Cantharellus cibarius*, *Lactarius deliciosus, Russula* sp were collected and sold in the market for food purposes [57]. *Morchella* species were collected mostly due to their commercial importance as one kilogram of dried morel was solid in the market up to 32 thousand PKR. One kilogram of dry morels can full fill the basic needs of a family of average size. Prices of dried morels vary from market to market. In a village (Neelum) average price of 1kg of dried morel was 30000 PKR. Other edible mushroom species Pleurotus ostreatus and Agaricus campestris were supplied to the famous hotels of the city. One Kg of dried mushroom was sold in 1500-2000PKR. These mushrooms are mostly used in dishes for foreign visitors. Mushrooms are collected worldwide as a source of income. More than 300 species of mushrooms were collected by different ethnic groups in Mexico for nutritional and medicinal purposes [58]. In China, local farmers earn up to 62% of their cash income through mushroom export [59].

Prices of dry mushrooms in this region were higher than fresh mushrooms. Similarly, those mushrooms which were exported showed higher prices. The most common species collected and used for trade-in neighbouring countries of Pakistan were e.g. *Boletus* spp. *Lactarius* spp., *Thelephora ganbajun, Suillus bovinus, Russula* sp. and *Termitomyces* spp. [59, 60]. 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 Rs. 100000-120000 in a season. Mushrooms are collected and exported from Pakistan to the neighbour countries for revenue generation. Fifty-six (56) species of mushrooms were reported as edible previously from Pakistan and unfortunately because of over-collection, urbanization, and deforestation some species are threatened [52]. 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 increasing due to the insufficiency of synthetic medicines and their disadvantages or side effects. Mushrooms have compounds that decrease oxidative stress and improve health [61, 62].

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. Previously we reported medicinally significant mushrooms from the Neelum Valley [78]. They are also collected in different advanced countries of the world like the United Kingdom, Sweden and France [64]. In the present study, Twenty-six (26) species of mushrooms were recorded as medicinally important which are used for the treatment of some common ailments. Among these mushrooms *Fistulina* sp, *Hericium* erinaceous, Laetiporus sulphurous, 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 Hattian in Jhelum Valley. *Morchella esculanta* is reported to contain antioxidant, anticancer and anti-inflammatory properties and is used as delicious food [62]. 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 [65]. Fruiting bodies of *Laetiporus sulphureus* were dried into a fine powder and used with milk as a portion of healthy food and anti-seminal 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 [66]. Use values of mushrooms 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 [67]. *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 and traditional medicines. People use *Morchella* species, *Hydnum repandum, Sparassis crispa* and *Polyporus squamosus* for stomach problems, *Lycoperdon perlatum* and *Auricularia auricula* in wound healing and as anti-hypertension. *Armillaria mellea*, *Boletus badius, Cantharellus cibarius, Pleurotus ostreatus* and *Lactarius deliciosus* contain bioactive organic contents, p-coumaric protocatechuic, ferulic, sinapic, p-hydroxybenzoic, vanillic and Cinnamic with reported uses in traditional medicines [68]. [69] 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 [70]. Extract of mushrooms can be used due to cosmeceutical and nutricosmetic ingredients to treat inflammatory skin disease and hyperpigmentation [71]. 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 chemical evaluation is very important before using an extract of mushroom species [72]. It is concluded that mushrooms, potentially can provide opportunities to rural communities to generate income for household's development in rural areas of Azad Jammu and Kashmir. Mushroom collection 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.

Table 3. List of Mushrooms species with their Ethno-mycological uses

No.	Name of Species	Family	Edibility Status	Ethno-mycological uses	Ecology	Region	Reference
1	*Agaricus amicosus* Kerrigan.	Agaricaceae	Edible	Not used	Saprobic, scattered in fir litter	Neelum AJK	Present study
2	*Agaricus campestris* L.	Agaricaceae	Edible	Consumed as food	Saprobic, growing in grassy area	AJK	[50, 51]
3	*Agaricus silvicolae-similis* Bohus & Locsmándi	Agaricaceae	Edible	Not consumed	Saprobic, growing in wood	AJK	[50, 51]
4	*A. subrutilescens* (Kauffman) Hotson & D. E. Stuntz	Agaricaceae	Edible	Consumed as food	Saprobe, growing in coniferous forest	AJK	Present study
5	*Amanita fulva* Fr.	Amanitaceae	Inedible	Not consumed	Mycorrhizal with conifers or hardwoods	AJK	Present study
6	*Amanita hemibapha* (Berk. &Broome) Sacc.	Amanitaceae	Poisonous	Poisonous	Saprobic, growing in hardwood leaf litter	AJK	Present study
7	*Amanita muscaria* (L.) Lam.	Amanitaceae	Poisonous	Poisonous	Mycorrhizeal with pine and oak	AJK	Present study
8	*Amanita phalloides* (Vaill. ex Fr.) Link.	Amanitaceae	Deadly poisonous	Poisonous	Mycorrhzeal with oaks	AJK	Present study
9	*Amanita vaginata* (Bull.) Lam.	Amanitaceae	Edible	Not consumed as food	Mycorrhizeal with pines and oaks	AJK	Present study
10	*Apioperdon pyriforme* (Schaeff.) Vizzini	Agaricaceae	Edible/medicinal	Consumed as food	Saprobic on deadwoods of hardwoods or conifers	Pak	[52]
11	*Armillaria gallica* Marxm. & Romagn	Physalacriaceae	Edible	Consumed as food	Saprophytic, on organic matter and soil	AJK	Present study
12	*Armillaria mellea* (Vahl) P. Kumm.	Physalacriaceae	Edible	Consumed as food	Parasitic on the hardwoods, on conifers produce white rot in the wood	Neelum AJK	Present study
13	*Auricularia auricula-judae* (Bull.) Quel.	Auriculriaceae	Edible/medicinal	Used in weakness after childbirth, anti-hypertension	Grows in groves of trees, on logs and dead branches.	AJK/KPK	[53]
14	*Aureoboletus gentilis* (Quél.) Pouzar	Boletaceae	Edible	Not consumed	Mycorrhizeal with conifers	AJK	Present study
15	*Boletus aureissimus* (Murrill) Singer	Boletaceae	Edible	Not consumed	Mycorrhizeal with oaks	AJK	Present study
16	*Boletus chrysenteroides* Snell	Boletaceae	Edible	Used as food	Mycorrhizeal with oaks and conifers	AJK	Present study
17	*Boletus edulis* Bull. Herb. Fr.	Boletaceae	Edible	Used as food	Mycorrhizeal with hardwoods	AJK/KPK	[52, 53]
18	*Bovista utriformis* (Bull.) Fr.	Agaricaceae	Edible	Consumed as food	Sandy ground	AJK	Present study
19	*Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson	Psathyrellaceae	Medicinal	Used in traditional medicines	Saprobic grow on decaying wood	AJK	Present study
20	*Calvatia cyathiformis* (Bosc) Morgan	Agaricaceae	Edible	Consumed as food	Saprobic, grow in grass	Kaghan valley	Ahmed, 1950
21	*Calvatia gigantea* (Batsch) Lloyd	Agaricaceae	Edible when young	Consumed as	Saprobic,	AJK	Present

				food	growing on grass, lawn, open places		study
22	*Cantharellus cibarius* Fr.	Cantharellaceae	Edible/medicinal	Consumed as food	Coniferous forest associated with moss	Pakistan	[75]
23	*Cantharellus ignicolor* (R.H. Petersen) Dahlman	Cantharellaceae	Edible/medicinal	Consumed as food	Mycorrhizal with oaks, found in cluster of mosses and grass	AJK	Present study
24	*Chlorophyllum rhacodes* (Vittad.) Vellinga	Agaricaceae	Edible	Consumed as food	Saprobic, found in roadside, lawns etc.	AJK	Present study
25	*Chlorophyllum olivieri* (Barla) Vellinga.	Agaricaceae	Potentially dangerous	Consumed as food	Found in open areas	AJK	Present study
26	*Clavaria fumosa* Pers.	Clavariaceae	Edible	Consumed as food	Saprobic, found in dense cluster in grass	AJK	Present study
27	*Clavariadelphus ligula* (Schaeff.) Donk	Clavariaceae	Edible	Consumed as food	Saprobic, associated with fir needles on ground	AJK	Present study
28	*Desarmillaria tabescens* (Scop.) R.A. Koch & Aime	Physalacriaceae	Edible	Consumed as food	Saprobic on oaks	AJK	Present study
29	*Clavulinopsis fusiformis* (Sowerby) Corner.	Clavariaceae	Edible	Consumed as food	Saprobic, under hardwoods or conifers	Neelum AJK	Present study
30	*Clavulina alta* Corner.	Clavulinaceae	Edible	Consumed as food	Mycorrhizal with conifers	Neelum AJK	Present study
31	*Clavulina cinerea* (Bull.) J. Schrot	Clavulinaceae	Edible	Consumed as food	Mycorrhizal association with conifers	Neelum AJK	Present study
32	*Clavulina coralloides* (L.) J. Schröt.	Clavulinaceae	Edible	Consumed as food	Mycorrhizal with conifers and hardwoods	Neelum AJK	Present study
33	*Clitocybe acicula Singer*.	Tricholomataceae	Edible	Not consumed	On debris of conifers	AJK	Present study
34	*Clitocybe nebularis* (Batsch) P. Kumm.	Tricholomataceae	Edible/uncommon/medicinal	Not consumed	Found under conifers	AJK	Present study
35	*Clitopilus prunulus* (Scop.) P. Kumm	Entolomataceae	Edible	Not consumed	Saprobic, under or conifers	AJK	Present study
36	*Coprinus coffeicola* Massee, Bull.	Hymenochaetaceae	Inedible	Inedible	Saprobic, under hardwoods	AKJK	Present study
37	*Coprinus commatus* (O. F. Mull.) Pers.	Coprinaceae	Edible when young	Not consumed	Widely in grassland	AJK	Present study
38	*Crepidotus applanatus* (Pres.) P. Kumm.	Cortinareaceae	Edible	Not consumed	Under forest	AJK	Present study
39	*Desarmillaria tabescens* (Scop.) R.A. Koch & Aime	Physalacriaceae	Edible	Consumed as food	Saprophyics on oaks	AJK	Present study
40	*Exidia recisa (*Ditmar) Fr.	Auriculareaceae	Inedible	Not consumed	Under wood and conifers	Neelum AJK	Present study
41	*Floccularia luteovirens* (Alb. & Schwein.) Pouzar	Russulaceae	Edible	Not consumed	Ecto-Mycorrhizael, grow on ground with pines	AJK	Present study
42	*Floccularia straminea* (P. Kumm.) Pouzar	Agaricaceae	Inedible	Not clear	Under confers	AJK	Present study
43	*Flammulina fennae* Bas.	Physalacriaceae	Edible	Not consumed	On older tree trunks and	AJK	Present study

					under conifers		
44	*Flammulina ononidis* Arnolds	Physalacriaceae	Edible	Not consumed	On ground and rotten trees	AJK	Present study
45	*Fistulina* sp	Agaricomycetes	Edible/medicinal	Consumed as food	At the tree trunk of *Prunus padis*	Neelum AJK	Present study
46	*Ganoderma adspersum* (Schulzer) Donk	Ganodermataceae	Inedible/med.	Not consumed	On ground and rotten trees	AJK	Present study
47	*Gyromitra intermedia* (Benedix) Harmaja	Discinaceae	Edible on choice	Not consumed	Under forest	AJK	Present study
48	*Gyromitra bubakii* (Velen.) J. Moravec	Discinaceae	Edible on choice	Not consumed	Under forest	AJK	Present study
49	*Ganoderma lucidum* (Curtis) P. Karst.	Ganodermataceae	Inedible/med.	Medicinal	On ground and rotten trees	AJK	Present study
50	*Ganoderma applanatum* (Pers.) Pat.	Ganodermataceae	Medicinal	Medicinal	Under Quercus trees	AJK	[73]
51	*Geastrum saccatum* Fr.	Geastraceae	Inedible	Not consumed	Under Quercus trees	Pakistan	[74]
52	*Geastrum pedicellatum* (Batsch) Dörfelt & Müll. Uri	Agaricaceae	Unknown	Not confirm	On grassy ground	AJK	[51]
53	*Geastrum triplex* Jungh.	Geastraceae	Inedible	Not consumed	Under Quercus trees	Pakistan	[51, 52]
54	*Gyromitra esculenta* (Pers.) Ex. Fr.	Discinaceae	Conditionally edible /medicinal	Conditionally edible	Under Quercus trees	AJK	Present study
55	*Helvella sulcata* Afzel.	Helvellaceae	Edible	Consumed s food	On decaying hardwoods stumps	AJK	Present study
56	*Helvella elastica* Bull.	Helvellaceae	Inedible	Inedible	On ground, on decaying wood	AJK	Present study
57	*Helvella crispa* (Scop.) Fr.	Helvellaceae	Edible	Consumed as food	Mycorrhizal. Growing under conifers or hardwoods.	Kaghan Valley	[74]
58	*Helvella lacunosa* Afzel.	Helvellaceae	Conditionally edible/medicinal	Consumed as food	Not consumed	Kaghan valley	[74]
59	*Helvella fibrosa* (Wallr.) Korf	Helvellaceae	Edible	Not consumed	On confers or wood of hardwoods	Pakiatan	[74]
60	*Hohenbuehelia* sp. T-62 (LAH, 1193)	Pleurotaceae	Edible/medicinal	Consumed as food	Saprobic, grows on decaying sticks and branches in damp spots on forest floor	Neelum AJK	Present study
61	*Hydnum repandum* L.	Hydaneceae	Edible/medicinal	Consumed s food	Under Quercus trees	AJK	Present study
62	*Hygrocybe acutoconica* (Clem.) Singer	Hygrophoraceae	Edible	Consumed s food	On confers or wood of hardwoods	AJK	Present study
63	*Hygrocybe flavescens* (Kauffman) Singer	Tricholomataceae	Inedible	Not consumed	On confers or wood of hardwoods	AJK	Present study
64	*Hygrophorus piceae* Kuhner.	Hygrophoraceae	Edible	Unknown	On confers or wood of hardwoods	AJK	Present study
65	*Hygrophorus persooni* Arnolds.	Hygrophoraceae	Edible /medicinal	Unknown	On confers or wood of	AJK	Present study

					hardwoods		
66	*Imleria pallida* (Frost) A. Farid, A.R. Franck, & J. Bolin	Boletaceae	Unknown	Not consumed	Mycorrhizal with oaks	AJK	Present study
67	*Laccaria amethystina* Cooke	Hydnangiaceae	Edible on choice/medicinal	Not consumed	Mycorrhizal with oaks	AJK	Present study
68	*Laccaria bicolor* Maire	Hydnangiaceae	Conditionally edible	Not consumed	Mycorrhizal with conifers, found in mosses	AJK	Present study
69	*Lactarius deliciosus* (L.) Gray	Russulaceae	Edible/medicinal	Not consumed	Mycorrhizal with conifers	Pak	[52]
70	*Lactarius sp*	Russulaceae	Edible	Consumed as food	grows under conifers on acidic soils	AJK	Present study
71	*Lactarius helvus* (Fr.) Fr	Russulaceae	Poisonous	Poisonous	Mycorrhizal with conifers	AJK	Present study
72	*Lactarius quieticolor* Romagn	Russulaceae	Edible	Not consumed	Mycorrhizal	AJK	Present study
73	*Lepista ovispora* (J.E. Lange). Gulden	Tricholomataceae	Conditionally edible/med.	Not consumed	Open grassland	AJK	Present study
74	*Lactarius salmonicolor* R. Heim & Leclair A. H. Sm.	Russulaceae	Edible	Not consumed	Mycorrhizal with conifers, usually with cedar	AJK	Present study
75	*Lactifluus piperatus* (L.) Roussel	Russulaceae	Edible/medicinal	Inedible	On oak	AJK	[51]
76	*Lactarius torminosus* (Schaeff.) Pers	Russulaceae	Inedible	Inedible	Mycorrhizal, mixed forest	AJK	Present study
77	*Laetiporus sulphureus* Bull. Murrill	Fomitopsidaceae	Edible/medicinal	Consumed as food	On oak, prunus, Salix etc.	AJK	[52]
No.	**Name of Species**	**Family**	**Edibility Status**	**Ethno-mycological uses**	**Ecology**	**Region**	**Reference**
78	*Lepiota cristata*. (Bolton) P. kumm.	Agaricaceae	Edible	Consumed as food	Saprobic, on forest, lawns etc.	Sohawa shareef AJK	Present study
79	*Lepiota magnispora* Murill.	Agaricaceae	Inedible	Inedible	Saprobic, Found under hardwoods and conifers	Neelum AJK	Present study
80	*Lepista luscina* (Fr.) Singer	Tricholomataceae	Edible	Not consumed	In mixed forest	AJK	Present study
81	*Lepista irina* (Fr.) H.E. Bigelow	Tricholomataceae	Unknown	Not consumed	In mixed forest	AJK	Present study
82	*Lycoperdon perlatum* Pers.	Agaricaceae	Edible when young/medicinal	Consumed as food and wound healing	Open areas, grassy ground	Pak	[74]
83	*Leucopaxillus giganteus* Calonge & M	Stereaceae	Inedible	Inedible	Saprobic on deadwood of oaks	AJK	Present study
84	*Morchella tridentina* Bres.	Morchallaceae	Edible/medicinal	Used in cough and cold, highly medicinal	Saprobic on deadwoods or conifers	AJK	Present study
85	*Morchella deliciosa* Fr.	*Morchella*ceae	Edible/medicinal	Consumed as food and medicinal	On humus rich soil	AJK	Present study
86	*M. costata* Pers.	*Morchella*ceae	Edible/medicinal	Consumed as food and medicinal	On leaf litter	Pak	[77]
87	*Morchella conica* Pers.	Morchallaceae	Edible/medicinal	Consumed as food and medicine	On grasses	Pak	[77]
88	*Morchella esculenta* Pers	Morchallaceae	Edible/medicinal	Used in cough and cold, highly medicinal	Saprobic on deadwoods of hardwoods or conifer	AJK	[74]
89	*Morchella elata* Fr.	Morchallaceae	Edible/medicinal	Consumed as food and medicinal	On grasses	Pak	[77]

90	*Marasmius abrubtipes* Corner	Marasmiaceae	Inedible	Not used	On humus rich soil	AJK	Present study
91	*Marasmius abundans* Corner	Marasmiaceae	Inedible	Not used	On leaf litter	AJK	Present study
92	*Marasmius rotula* (Scop.) Fr.	Marasmiaceae	Inedible	Not used	Saprobic on deadwoods of hardwoods or conifer	AJK	Present study
93	*Marasmius strictipes (*Peck.) Singer	Marasmiaceae	Inedible	Not confirmed	Saprobic on deadwoods of hardwoods or conifer	AJK	Present study
94	*Marasmius acerinus* Peck	Marasmiaceae	Inedible	Not confirmed	On grasses	AJK	Present study
95	*Pleurotus dryinus* (Pers.) P. Kumm.	Pleurotaceae	Edible when young	Consumed as food and medicinal	Saprobic, growing on oaks	AJK	present study
96	*Pholiota brunnescens* A.H. Sm. & Hesler	Strophariaceae	Inedible	Not consumed	Saprobic on wood	AJK	Present study
97	*Pleurotus ostreatus* (Jacq.) P. Kumm	Pleurotaceae	Edible	Consumed as food	Saprobic on wood	AJK	Present study
98	*Polyporus septosporous* P.K. Buchanan & Ryvarden	Polyporaceae	Edible/medicinal	Consumed as food	Saprobic on decaying hardwood logs etc.	AJK	Present study
99	*Ramaria fennica* (P. karst.) Ricken	Gomphaceae	Edible	Consumed as food	Mycorrhizal with hardwoods	AJK	Present study
100	*Ramaria barenthalensis* Franchi & M.	Russulaceae	Edible	Not consumed	Mycorrhizal with trees and shrubs	AJK	Present study
101	*Ramaria stricta* (Pers.) Quel.	Gomphaceae	Edible	Consumed as food	Mycorrhizal and Saprobic	AJK	Present study
102	*Rhodocollybia butyracea* (Bull.) Lennox	Omphalotaceae	Inedible	Not consumed	Saprobic, decomposing the litter of conifers	AJK	Present study
103	*Russula amoenolens* Romagn	Russulaceae	Conditionally edible	Not consumed	Mycorrhizal with hardwoods and conifers	AJK	Present study
104	*Russula brevipes* Peck.	Russulaceae	Edible	Not consumed	Mycorrhizal with conifers	Pakistan	[76]
105	*Russula cinereovinosa* Fatto	Russulaceae	Inedible	Inedible	Mycorrhizal with conifers, fir	AJK	Present study
106	*Russula collina* Velen Frost.	Russulaceae	Inedible	Inedible	Mycorrhizal with hardwoods and conifers	AJK	Present study
107	*Russula cremoricolor* Earle	Russulaceae	Unknown	Not clear	Mycorrhizal, mixed forests	AJK	Present study
108	*Russula cystidiosa* Murrill	Russulaceae	Unknown	Not clear	Mycorrhizal with oaks	AJK	Present study
109	*Russula delica* Fr.	Russulaceae	Edible	Consumed as food	Found under broadleaved and coniferous wood	AJK	Present study
110	*Russula densifolia* Secr. ex Gillet	Russulaceae	Edible	Not consumed	Mycorrhizael with conifers	AJK	Present study
111	*Russula fragrantissima* Romagn	Russulaceae	Inedible	Inedible	Mycorrhizael with hardwoods and conifers	AJK	Present study
112	*Russula integra* (L). Fr	Russulaceae	Conditionally edible	Inedible	Mycorrhizael with hardwoods and conifers	AJK	Present study
113	*Russula acriuscula* Buyck	Russulaceae	Edible/med.	Not consumed	Mycorrhizal	AJK	Present

					with hardwoods and conifers		study
114	*Russula tenuiceps* Kauffman	Russulaceae	Inedible	Inedible	Mycorrhizal with oaks	AJK	Present study
115	*Russula violacea* Quel.	Russulaceae	Edible	Not consumed	Mycorrhizal with hardwoods and conifers	AJK	Present study
116	*Rhizopogon* roseolus (Corda)Th. Fr.	Rhizopogonaceae	Medicinal	Consumed as food	Ecto-mycorrhizeal fungus	Bagh AJK	Present study
117	*Suillus granulatus* (L.) Roussel,	Boletaceae	Edible	Not consumed	Mycorrhizal with pines	AJK	Present study
118	*Suillellus luridus* (Schaeff.) Murrill	Boletaceae	Conditionally Edible	Consumed as food	Mycorrhizal with pines and other hardwoods	AJK	Present study
119	*Scleroderma bovista, Fr.*	Sclerodermataceae	Inedible	Inedible	Saprobic on ground, mycorrhizeal with hardwoods	Kaghan valley	[77]
120	*Stromatinia rapulum* (Bull.) Boud.	Pezizaceae	Conditionally edible	Not consumed	Saprobic on well-decayed logs	AJK	Present study
121	*Scleroderma citrinum* Pers	Sclerodermataceae	medicinal/poisonous	Consumed as food	Attached to soil my mycelial cords	Bagh AJK	Present study
122	*Sparassis spathulata* (Schwein.) Fr.	Sparassidaceae	Edible when young	Used as stomach tonic and food	Pathogenic and Saprobic	AJK	Present study
123	*Sparassis crispa* (Wulfen) Fr.	Sparassidaceae	Edible/medicinal	Consumed as food/medicinal	Pathogenic and saprobic	Pakistan	[75]
124	*Suillus luteus* (L.) Roussel	Suillaceae	Edible	Not consumed	Mycorrhizal with pines	Pakistan	[73]
125	*Tricholoma portentosum* (Fr.) Quel.	Tricholomataceae	Edible and medicinal	Consumed as food	On Coniferous woods and oaks	AJK	Present study
126	*Volvopluteus gloiocephalus* (DC.) Vizzini, Contu & Justo	Pleurotaceae	Edible	Consumed as food	Saprobic, growing aggregates in gardens, lawns, woodchips tc,	AJK/KPK	[77]
127	*Volvariella volvaceae* (Bull.) Singer	Pleurotaceae	Edible	Consumed as food	Saprobic, growing in woodchips	AJK/KPK	[77]
128	*Volvariella bombycina* (Schaeff.) Singer	Pleurotaceae	Edible	Consumed as food	Saprobic, growing in woodchips	AJK/KPK	[77]
129	*Verpa bohemica* (Krombh.) J. Schroet	Helvellaceae	Conditionally edible	Consumed as food	Mycorrhizal. Found under hardwoods and conifers in early spring	Neelum AJK	Present study
130	*Verpa conica* (O.F. Müll.) Sw	Helvellaceae	Conditionally edible	Consumed as food	Mycorrhizal. Found under hardwoods and conifers in early spring	Neelum AJK	Present study
131	*Xerocomellus chrysenteron* (Bull.) Šutara	Boletaceae	Edible	Food	Mycorrhizal with oaks and conifers	AJK	Present study

Declarations

Authors' contributions

The first author carried the research including sampling of mushrooms. SSF and ANK designed the research, identified the mushroom samples and supervised at all the stages. HS and JH helped with data analysis.

Funding. The Research was supported by the Higher Education Commission of Pakistan and private funds of the author.

Availability of data and materials.

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Ethics approval and consent to participate. Not Applicable.

Consent for publication. Not applicable.

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

Acknowledgements. Not applicable

References

1. Das K. Diversity and conservation of wild mushrooms in Sikkim with special reference to Barsey Rhododendron Sanctuary. NeBIO. 2010;1(2):1-3.

2. Jung MY, Lee DE, Cheng HY, Chung IM, Kim SH, Han JG, Kong WS. Characterization of Volatile Profiles of Six Popular Edible Mushrooms Using Headspace-Solid-Phase Microextraction Coupled with Gas Chromatography Combined with Chemometric Analysis. J. Food Sci. 2019;84(3):421-9. https://doi.org/10.1111/1750-3841.14481.

3. Zhang T, Ye J, Xue C, Wang Y, Liao W, Mao L, Yuan M, Lian S. Structural characteristics, and bioactive properties of a novel polysaccharide from Flammulina velutipes. Carbohydr. Polym. 2018.1;197:147-56. https://doi.org/10.1016/j.carbpol.2018.05.069.

4. Valverde ME, Hernández-Pérez T, Paredes-López O. Edible mushrooms: improving human health and promoting quality life. Int. J. Microbiol. 2015; 20;2015. https://doi.org/10.1155/2015/376387.

5. Beelman RB, Kalaras MD, Richie Jr JP. Micronutrients and bioactive compounds in mushrooms: a recipe for healthy aging? Nutrition Today. 2019 Jan 1;54(1):16-22. doi: 10.1097/NT.0000000000000315

6. Sitotaw R, Lulekal E, Abate D. Ethnomycological study of edible and medicinal mushrooms in Menge District, Asossa Zone, Benshangul Gumuz Region, Ethiopia. J. Ethnobiol. Ethnomedicine. 2020;16(1):1-4. https://doi.org/10.1186/s13002-020-00361-9.

7.Phan CW, David P, Naidu M, Wong KH, Sabaratnam V. Therapeutic potential of culinary medicinal mushrooms for the management of neurodegenerative diseases: diversity, metabolite, and mechanism. J. Ethnobiol. Ethnomedicine,20153;35(3):355-68. https://doi.org/10.3109/07388551.2014.887649

8. Rathee S, Rathee D, Rathee D, Kumar V, Rathee P. Mushrooms as therapeutic agents. Rev Bras Farmacogn. 2012; 22:459-74. https://doi.org/10.1590/S0102-695X2011005000195

9. Cayan F, Deveci E, Tel-Cayan G, Duru ME. Phenolic acid profile of six wild mushroom species by HPLC-DAD. Chemistry of Natural Compounds. 2018; 54(5):985-6.

10. Odeyemi, O., Adeniyi, M. A., Odeyemi, Y. (2014). Introduction to Tropical Mycology China: Universal Academic Press. https://doi.org/10.1007/s10600-018-2529-2

11. Gonçalves JL, Roma EH, Gomes-Santos AC, Aguilar EC, Cisalpino D, Fernandes LR, Vieira AT, Oliveira DR, Cardoso VN, Teixeira MM, Alvarez-Leite JI. Pro-inflammatory effects of the mushroom Agaricus blazei and its consequences on atherosclerosis development. Eur. J. Nutr. 2012; 51(8):927-37. https://doi.org/10.1007/s00394-011-0270-8

12. Rahi DK, Malik D. Diversity of mushrooms and their metabolites of nutraceutical and therapeutic significance. J. Mycol. 2016; 10;2016.

13. Barros L, Baptista P, Ferreira IC. Effect of Lactarius piperatus fruiting body maturity stage on antioxidant activity measured by several biochemical assays.
Food Chem. Toxicol. 2007;45(9):1731-7. https://doi.org/10.1016/j.fct.2007.03.006

14. González A, Cruz M, Losoya C, Nobre C, Loredo A, Rodríguez R, Contreras J, Belmares R. Edible mushrooms as a novel protein source for functional foods. Food Funct. 2020;11(9):7400-14. https://doi.org/10.1039/D0FO01746A

15. Karadeniz Ö, Yaprak G. Soil-to-mushroom transfer of 137Cs, 40K, alkali–alkaline earth element and heavy metal in forest sites of Izmir, Turkey. J. Radioanal. Nucl. Chem. 2011 ;288(1):261-70. https://doi.org/10.1007/s10967-010-0908-7.

16. Sezgin S, Dalar A, Uzun Y. Determination of antioxidant activities and chemical composition of sequential fractions of five edible mushrooms from Turkey. J. Food Sci. Technol. 2020; 57(5):1866-76. https://doi.org/10.1007/s13197-019-04221-7.

17. Lee KJ, Yun IJ, Kim KH, Lim SH, Ham HJ, Eum WS, Joo JH. Amino acid and fatty acid compositions of Agrocybe chaxingu, an edible mushroom. J Food Compost Anal. 2011; 24(2):175-8. https://doi.org/10.1016/j.jfca.2010.09.011.

18. Alves MJ, Ferreira IC, Dias J, Teixeira V, Martins A, Pintado M. A review on antimicrobial activity of mushroom (Basidiomycetes) extracts and isolated compounds. Planta Med. 2012; 78(16):1707-18. DOI: 10.1055/s-0032-1315370.

19. Zhang H, Pu D, Sun B, Ren F, Zhang Y, Chen H. Characterization, and comparison of key aroma compounds in raw and dry porcini mushroom (Boletus edulis) by aroma extract dilution analysis, quantitation and aroma recombination experiments. Food Chem. 2018; 258:260-8. https://doi.org/10.1016/j.foodchem.2018.03.056

20. Villares A, García-Lafuente A, Guillamón E, Ramos Á. Identification and quantification of ergosterol and phenolic compounds occurring in Tuber spp. truffles. J Food Compost Anal; 2012 May 1;26(1-2):177-
82. https://doi.org/10.1016/j.jfca.2011.12.003

21. Loftus MG, Sánchez C, Moore D, Robson G, Trinci T. A 21st century miniguide to sporophore morphogenesis and development in Agaricomycetes and their biotechnological.
Mex. J. Biotechnol. 2020, 5(2):1-50. https://doi.org/10.29267/mxjb.2020.5.1.11

22. Zhong JJ, Xiao JH. Secondary metabolites from higher fungi: discovery, bioactivity, and bioproduction. Biotechnology in China I. 2009:79-150. https://doi.org/10.1007/10_2008_26

23. Sabaratnam V, Kah-Hui W, Naidu M, David PR. Neuronal health–can culinary and medicinal mushroomshelp? J. Tradit. Complement. Med. 2013 ;3(1):62-8. https://doi.org/10.4103/2225-4110.106549

24. Lalotra P, Bala P, Kumar S, Sharma YP. Biochemical characterization of some wild edible mushrooms from Jammu and Kashmir. Proceedings of the National Academy of Sciences, India Section B: Biol. Sci. 2018; 88(2):539-
45. https://doi.org/10.1007/s40011-016-0783-2

25. Poucheret P, Fons F, Rapior S. Biological and pharmacological activity of higher fungi: 20-year retrospective analysis. Cryptogam Mycol. 2006;27(4):311.

26. Ersel FY, Cavas L. Enzyme-Based Scavengers and Lipid Peroxidation in Some Wild Edible Agaricales sl Mushrooms from Mug la (Turkey). Int. J. Med. Mushr. 2008;10(3).doi: 10.1615/Int. J. Med. Mushr.v10.i3.80

27. Witkowska AM, Zujko ME, Mironczuk-Chodakowska I. Comparative study of wild edible mushrooms as sources of antioxidants. Int. J. Med. Mushr. 2011;13(4).doi: 10.1615/IntJMedMushr.v13.i4.30.

28. Bellettini MB, Fiorda FA, Maieves HA, Teixeira GL, Ávila S, Hornung PS, Júnior AM, Ribani RH. Factors affecting mushroom *Pleurotus* spp. Saudi J. Biol. Sci. 2019 May 1;26(4):633-46. https://doi.org/10.1016/j.sjbs.2016.12.005

29. Prasad MP & Sethi R. Studies on the detection of genetic variation of commercially cultivated Mushroom species using RAPD markers. Int. J. Res. Pharm (2013). *4*(2), 165-170. http://scopeindex.org/handle/sc/405

30. Ribeiro B, Valentão P, Baptista P, Seabra RM, Andrade PB. Phenolic compounds, organic acids profiles and antioxidative properties of beefsteak fungus (*Fistulina hepatica*). Food Chem. Toxicol. 2007 Oct 1;45(10):1805-13. https://doi.org/10.1016/j.fct.2007.03.015

31. Arata S, Watanabe J, Maeda M, Yamamoto M, Matsuhashi H, Mochizuki M, Kagami N, Honda K, Inagaki M. Continuous intake of the Chaga mushroom (Inonotus obliquus) aqueous extract suppresses cancer progression and maintains body temperature in mice. Heliyon. 2016; 2(5):e00111. https://doi.org/10.1016/j.heliyon.2016.e00111

32. Rathore H, Prasad S, Sharma S. Mushroom nutraceuticals for improved nutrition and better human health: A review. Pharma Nutrition. 2017 Jun 1;5(2):35-46. https://doi.org/10.1016/j.phanu.2017.02.001

33. Roncero-Ramos I, Delgado-Andrade C. The beneficial role of edible mushrooms in human health. Curr. Opin. Food Sci. 2017 Apr 1;14:122-8. https://doi.org/10.1016/j.cofs.2017.04.002

34. Rai SN, Mishra D, Singh P, Vamanu E, Singh MP. Therapeutic applications of mushrooms and their biomolecules along with a glimpse of in silico approach in neurodegenerative diseases. Biomed. Pharmacother. 2021;137:111377.https://doi.org/10.1016/j.biopha.2021.111377.

35. Wang J, Xiao J, Geng F, Li X, Yu J, Zhang Y, Chen Y, Liu D. Metabolic and proteomic analysis of morel fruiting body (Morchella importuna). J Food Compost Anal. 2019; 76:51-7. https://doi.org/10.1016/j.jfca.2018.12.006

36. Meng X, Che C, Zhang J, Gong Z, Si M, Yang G, Cao L, Liu J. Structural characterization and immunomodulating activities of polysaccharides from a newly collected wild Morchella sextelata. Int. J. Biol. Macromol. 2019; 129:608-14.

37. Ajmal M, Akram A, Ara A, Akhund S, Nayyar BG. *Morchella esculenta*: An edible and health beneficial mushroom. Pak J Food Sci. 2015;25(2):71-8.

38. Heleno SA, Stojković D, Barros L, Glamočlija J, Soković M, Martins A, Queiroz MJ, Ferreira IC. Chemical composition and bioactivity of wild samples of *Morchella esculenta* from Portugal and Serbia. InThe 7th International Workshop on Edible Mycorrhizal Mushrooms, 2013 2013.

39. Pak. Met. https://www.pmd.gov.pk/meteorogram/kashmir

40. Gateri MW, Ndung UB, Muriuki AW, Rauwl V, Kabacia S. Collection, identification and morphological characterization of indigenous mushrooms in coastal Kenya. InProceedings of 8th International Conference on Mushroom Biology and Mushroom Products (ICMBMP8), New Delhi, India, 19-22 November 2014. Volume I & II 2014 (pp. 17-23). ICAR-Directorate of Mushroom Research.

41. Tisserant E, Malbreil M, Kuo A, Kohler A, Symeonidi A, Balestrini R, Charron P, Duensing N, dit Frey NF, Gianinazzi-Pearson V, Gilbert LB. Genome of an arbuscular mycorrhizal fungus provides insight into the oldest plant symbiosis. Proceedings of the National Academy of Sciences. 2013 Dec 10;110(50):20117-22.

42. Kuo MM. University of Michigan Press. Ann Arbor. 2005;923.

43. Kuo M. Coprinoid mushrooms: The inky caps.

44. Lo HC & Wasser SP. Medicinal mushrooms for glycemic control in diabetes mellitus: history, status, future perspectives, and unsolved problems. Int. J. med. mushr. 2011;13(5).

45. Hood IA. An illustrated guide to fungi on wood in New Zealand. Auckland University Press; 1992.

46. Garibay-Orijel R, Caballero J, Estrada-Torres A, Cifuentes J. Understanding cultural significance, the edible mushrooms case. J. Ethnobiol. Ethnomedicine. 2007. 3(1):1-8.

47. Oseni JO. Economic analysis of mushroom marketing as a copping strategy for poverty reduction in Ondo State, Nigeria. In8th African Crop Science Society Conference, El-Minia, Egypt, 2007 (pp. 1255-1260). African Crop Science Society.

48. Tibuhwa DD. Wild mushroom-an underutilized healthy food resource and income generator: experience from Tanzania rural areas. J. Ethnobiol. Ethnomedicine. 2013 (1):1-4.

49. Sievänen T, Pouta E, Neuvonen M. Participation in mushroom picking in Finland.

50. Celik Y, Peker K. Benefit/cost analysis of mushroom production for diversification of income in developing countries. Bulg. J. Agric. Sci. 2009.15(3):228-37.

51. Gardezi SR. New and unreported species of mushrooms of Azad Jammu and Kashmir, Pakistan. Arch. Phytopathol. 2005; 38(1):41-51.

52. Gardezi SR, Ayub N. Mushrooms of Kashmir VII. Asian J. Plant Sci. 2003.

53. Sultana KI, Rauf CA, Riaz AB, Naz FA, Irshad G, Haque MI. Checklist of Agarics of Kaghan valley 1. Pak. J. bot. 2011; 43(3):1777-87.

54. Sultana K, Shinwari ZK, Iftikhar F. Diversity of edible mushrooms in Pakistan. Pak. J. Agric. Sci. 2007; 20(1-2):88-91.

55. Yilmaz H, Zencirci N. Ethnomycology of macrofungi in the Western Black Sea region of Turkey: identification to marketing. Econ. bot. 2016 Oct;70(3):270-84.

56. Christensen M, Larsen HO. How can collection of wild edible fungi contribute to livelihoods in rural areas of Nepal. For. Trees Livelihoods. 2005;4(2):50-5.

57. Ponce JM, Calderón MH, Comandini O, Rinaldi AC, Arzú RF. Ethnomycological knowledge among Kaqchikel, indigenous Maya people of Guatemalan Highlands. J. Ethnobiol. Ethnomedicine. 2019 Dec;15(1):1-24.

58. Garibay-Orijel R, Cifuentes J, Estrada-Torres A, Caballero J. People using macro-fungal diversity in Oaxaca, Mexico. Fungal divers. 2006. 28;21:41-67.

59. Chen YL. Song rong (Tricholoma matsutake), a valuable forest mushroom from China: consumption, development and sustainability. Forest products, livelihoods and conservation: case studies of non-timber forest products systems. 2004;1:78-93.

60. Halling RE. Wild Edible Fungi: A global overview of their use and importance to people. Non-wood Forest Products 17. Econ. Bot. 2006. 60(1):99-100.

61. Akgul H, Sevindik M, Coban C, Alli H, Selamoglu Z. New approaches in traditional and complementary alternative medicine practices: Auricularia auricula and Trametes versicolor. J Tradit Med Clin Natur. 2017;6(2): 239.

62. Wu H, Chen J, Li J, Liu Y, Park HJ, Yang L. Recent Advances on Bioactive Ingredients of Morchella esculenta. Appl. Biochem. Biotechnol. 2021;193(12):4197-213.

63. de Román M, Boa E, Woodward S. Wild-gathered fungi for health and rural livelihoods. Proceedings of the Nutrition Society. 2006. 65(2):190-7.

64. Panda AK, Swain KC. Traditional uses, and medicinal potential of Cordyceps sinensis of Sikkim. J Ayurveda Integr Med. 2011. 2(1):9.

65. Anderson MK, Lake FK. California Indian ethnomycology and associated forest management. J Ethnobiol. 2013. 33(1):33-85.

66. Ferreira IC, Baptista P, Vilas-Boas M, Barros L. Free-radical scavenging capacity and reducing power of wild edible mushrooms from northeast Portugal: Individual cap and stipe activity. Food chem. 2007;100(4):1511-6.

67. Isildak Ö, Turkekul I, Elmastas M, Tuzen M. Analysis of heavy metals in some wild-grown edible mushrooms from the middle black sea region, Turkey. Food Chem. 2004 ;86(4):547-52.

68. Sher H, Shah AH. Traditional role of Morels (Morchella Spp.) as food, medicine and income in Palas valley, Pakistan. Biol Med. 2015;7(2):1.

69. Guissou KM, Lykke AM, Sankara P, Guinko S. Declining wild mushroom recognition and usage in Burkina Faso. Econ Bot. 2008;62(3):530-9.

70. Taofiq O, Barreiro MF, Ferreira IC. The Role of Bioactive Compounds and other Metabolites from Mushrooms against Skin Disorders-A Systematic Review Assessing their Cosmeceutical and Nutricosmetic Outcomes. Curr. Med. Chem. 2020 ;27(41):6926-65.

71. Krakowska A, Zięba P, Włodarczyk A, Kała K, Sułkowska-Ziaja K, Bernaś E, Sękara A, Ostachowicz B, Muszyńska B. Selected edible medicinal mushrooms from Pleurotus genus as an answer for human civilization diseases. Food chem. 2020. 15;327:127084.

72. Razaq A, Shahzad SA. Additions to the diversity of mushrooms in Gilgit-Baltistan, Pakistan. Pak J Bot. 2017; 1(49) :305-9.

73. Ahmed S. Ascomycetes of Pakistan Biological Soc. of Pakistan. Mon. 1978; 7:1-46.

74. Nasim G, Bajwa R, Ali M. *Sparassis crispa* (Wulf.) Fr., the cauliflower Mushroom. Mycopathol. 5(2): 119-120.

75. Niazi AR, Iqbal SH, Khalid AN. Biodiversity of Mushrooms and ectomycorrhizas. 1. Russula brevipes Peck., and its ectomycorrhiza-A new record from Himalayan moist temperate forests of Pakistan. Pak. J. Bot. 2006; 38(4):1271.

76. Sultana K, Riaz N, Irshad G, Khan AN. Research Note: Contribution to Mushroom Flora of Rawalpindi-Islamabad, Pakistan. J. bioresour. manag. 2014; 1(1):2.

77. Ullah TS, Firdous SS, Mehmood A, Shaheen H, Dar ME. Ethnomycological and nutritional analyses of some wild edible mushrooms from Western Himalayas, Azad Jammu and Kashmir (Pakistan). Int J med mushr. 2017; 19(10).

Figures

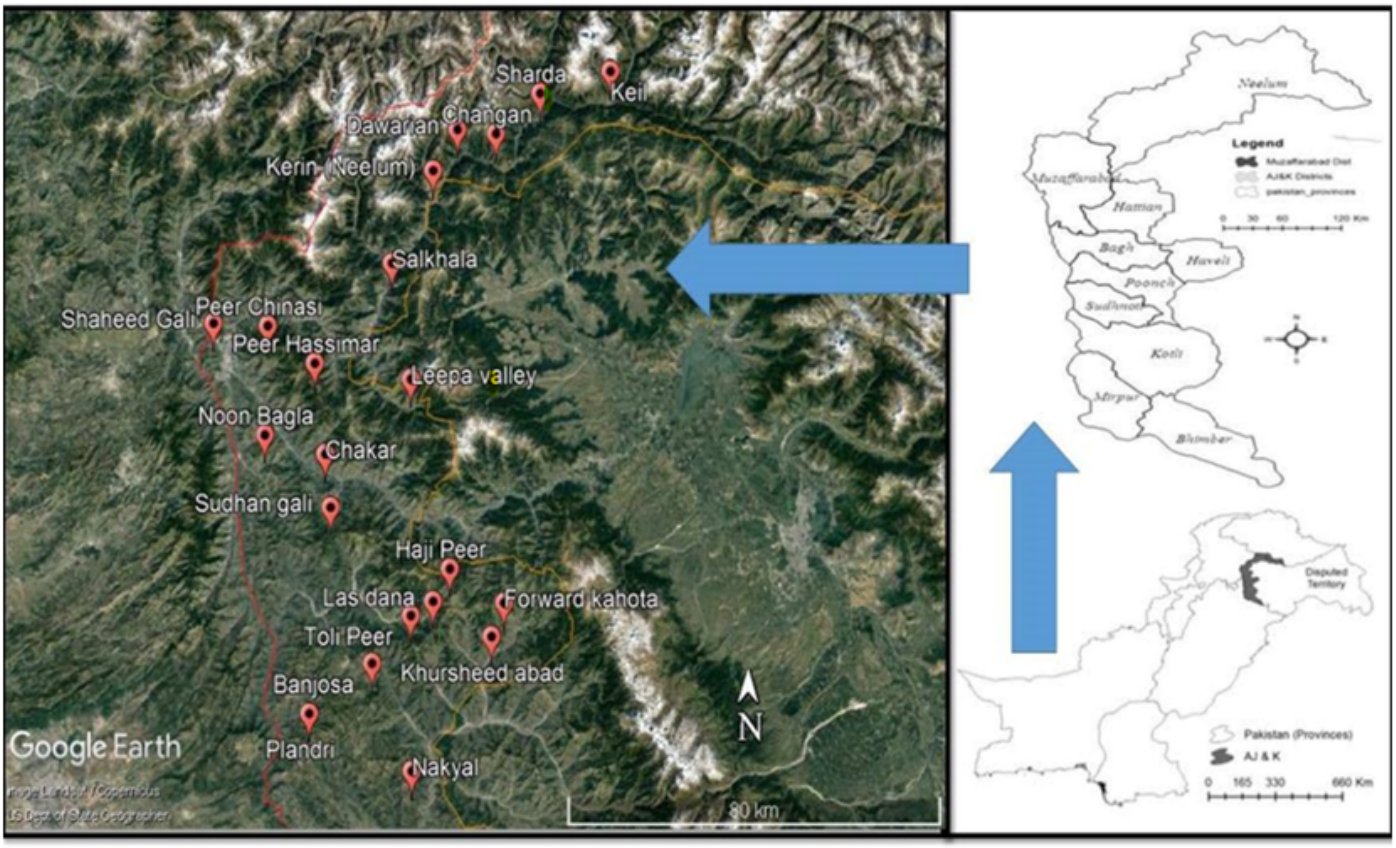

Figure 1

Map of the study area (Right) and sampling sites (Left)

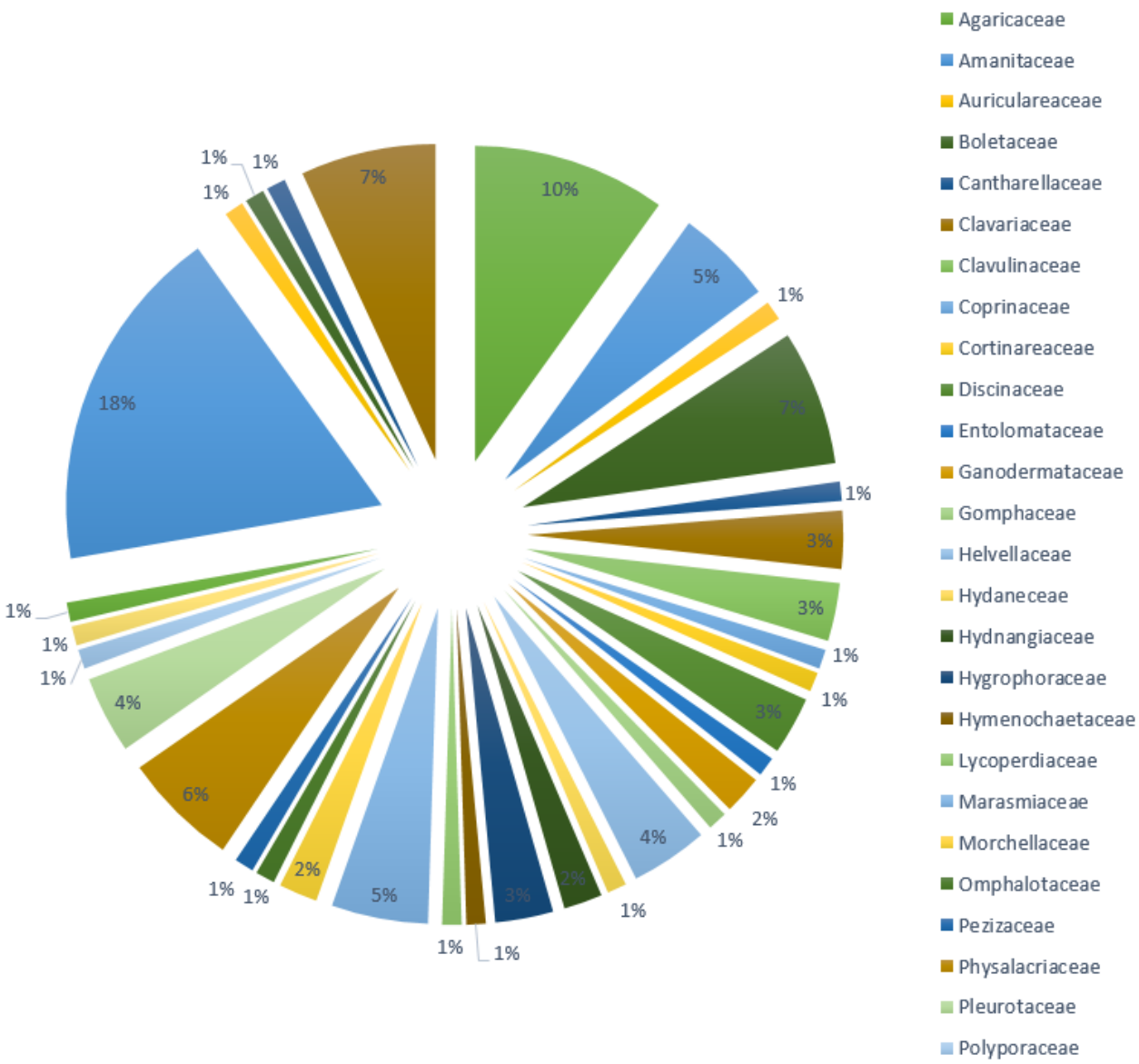

Figure 2

Mushroom species recordrd new to the state of AJK

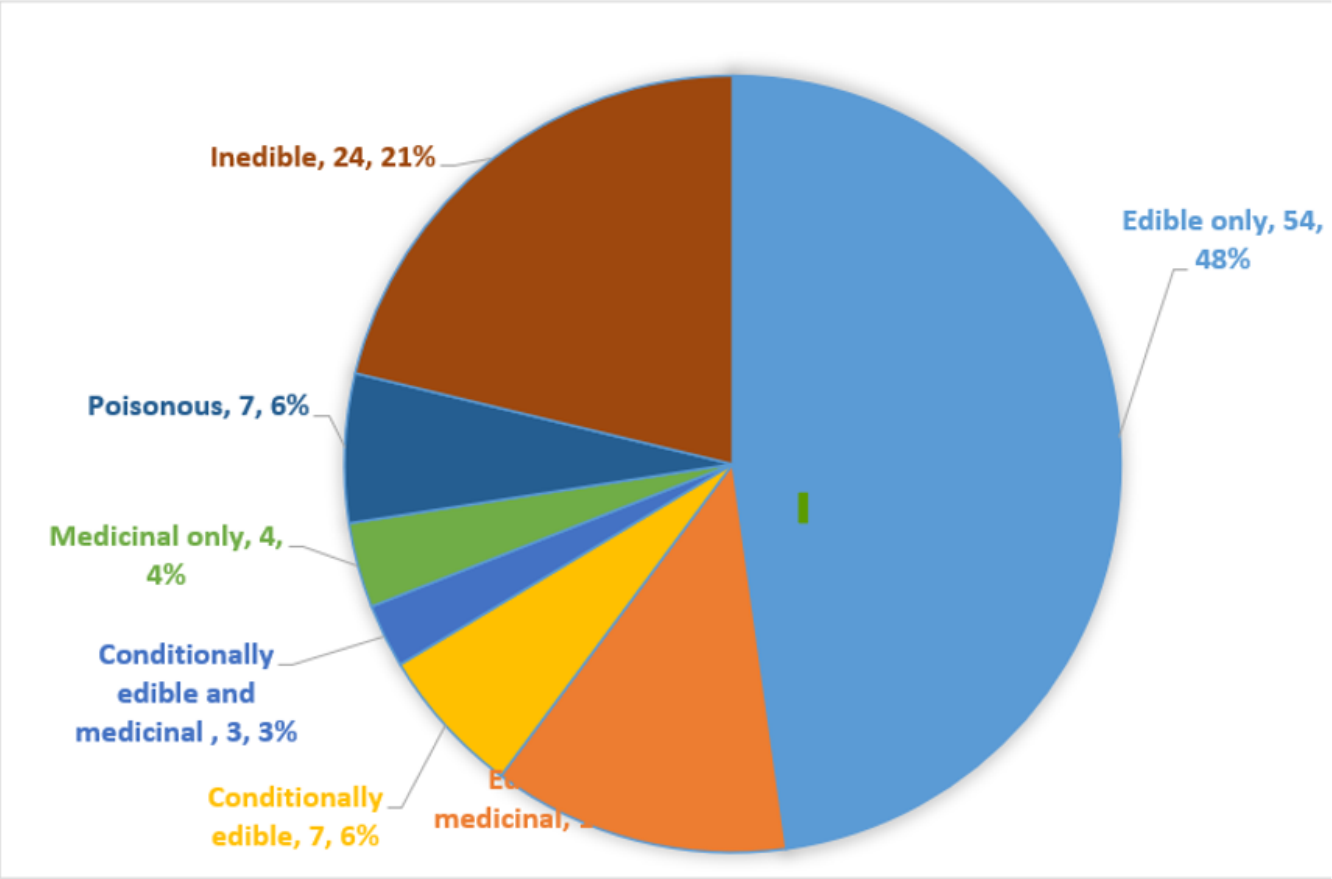

Figure 3

Category, number with percentage and use value of identified Wild Mushrooms from the study area.

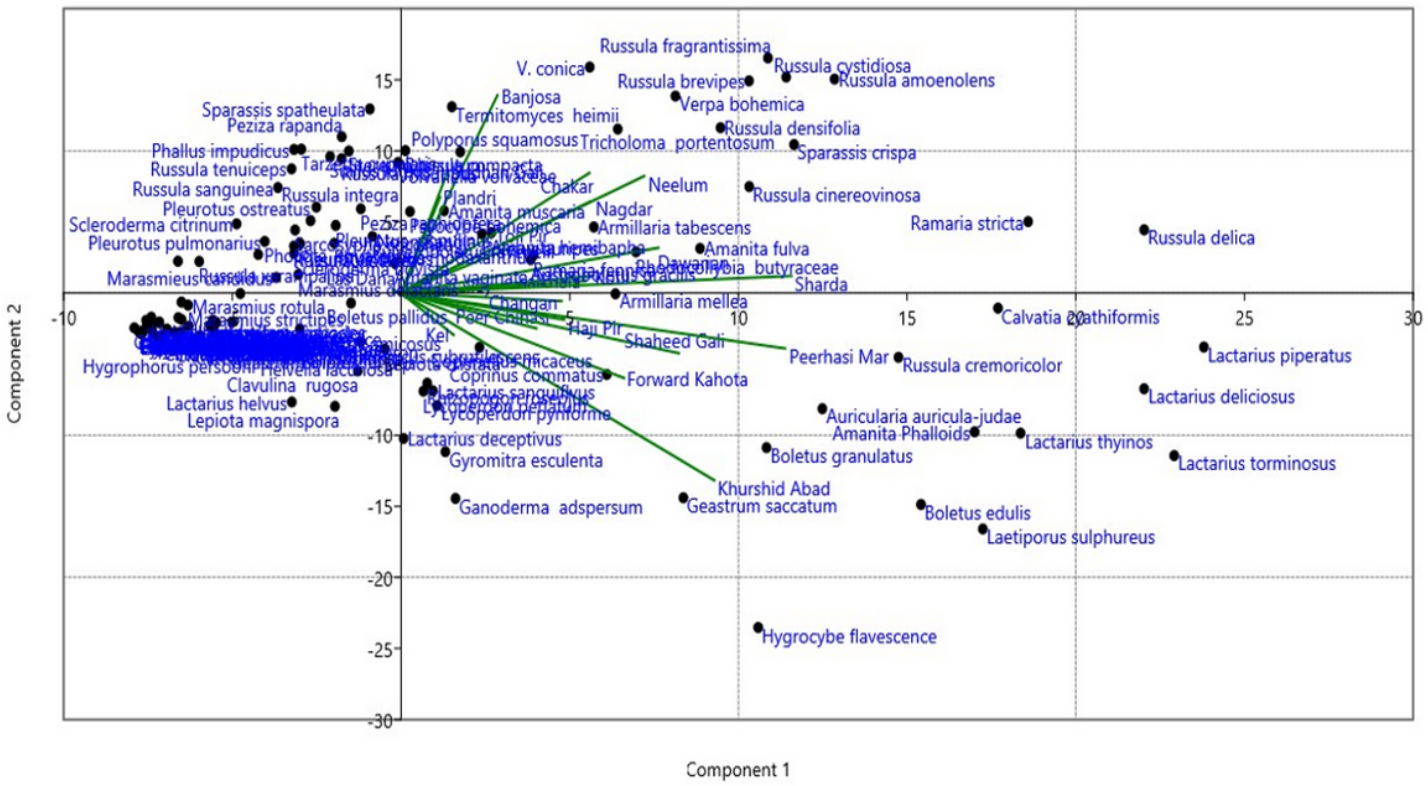

Figure 4

Expression of Principle componenent analysis

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix1.docx