# A review on mysterious poisonous mushrooms of Pakistan, unveiling their implications and threats

***Huma Gul[1], Shujaul Mulk Khan[1], Shakil Ahmad Zeb[1], Fazli Maula[1] and Nasira Bibi[2]**

*[1]Department of Plant Sciences, Quaid-i-Azam University, Islamabad, 45320, Pakistan*
*[2] Department of Botany, Islamia College University, Peshawar, Pakistan*
**Corresponding author's email: humabotanist@gmail.com*

## Abstract

Fungi have been fascinating humans for centuries due to their distinct properties and uses. Among them, the poisonous or toxic mushrooms are particularly intriguing and dangerous for human health. This review article provides an overview of poisonous mushrooms, including information on their toxins, risks, signs, and usage. A total of 81 poisonous mushrooms were reported which belongs to 30 families and 46 genera. The most dominant and toxic mushroom species were recorded from family Agaricaceae and Amanitaceae. Some macrofungi are highly toxic and are responsible for deaths such as *Galerina marginata*, *Amanita phalloides* and *Amanita cinis*. These deadly mushrooms have a wide range of unique chemicals like orellanine, muscimol, gyromitrin and ibotenic acid. Rhabidomyolisis, carcinogenicity, renal failure, increase heart rate and respiratory alterations effects are among the outcomes of the toxicity of these poisonous mushrooms. Based on this review, it is concluded that toxicological testing is required to confirm whether mushrooms are safe to eat or use medicinally along with accurate identification to avoid any mishaps. This comprehensive review will also enhance public knowledge about toxic mushrooms and how to prevent from mushroom poisoning.
**Keywords:** Ecology, Macrofungi, Mushroom poisoning, Wild mushroom.

## Introduction

Fungi are a diverse and large group of organisms with more than 5.1 million species (Blackwell, 2011). It can be divided into four phyla: Ascomycota, Basidiomycota, Zygomycota and Chytridiomycota (Webster and Weber, 2007). Macrofungi include puffballs, mushrooms, cup mushrooms and false truffles are distinguished by distinctive spore-like structures (Razaq *et al.*, 2014). Most macrofungi are Ascomycota or Basidiomycota, but some are Zygomycota. Most soil macrofungi are mycorrhizal symbionts, but some are plant pathogens and the abundance of sporocarps depends on climate (Müller *et al.*, 2001). Pakistan has a dry and hot climate near the coast and gradually cools towards the northeastern slopes. It is located in South Asia between 24-37° North Latitude and 61-75° East Longitude. Pakistan borders China to the northeast, Pakistan and India to the east, the Arabian Sea to the south, Iran to the southwest, and Afghanistan to the west and southwest. The area of Pakistan is 796,095 $km^2$. The climate changes from tropical to temperate and becomes drier on the south coast. Pakistan has four different seasons; Summer, winter, autumn and spring. The summer rainy season is from June-September, and the winter rainy season is from December-March. Summers are very hot with extreme temperatures ranging from 15 to 35 ºC. Then the minimum temperature is 0–20 ºC in cold and generally dry winters (Iqbal *et al.*, 2016). In general, the average annual rainfall in Pakistan is less than 500 mm (Salma *et al.*, 2012). Average annual precipitation generally decreases from northeast to southwest, and humidity can reach 57% (Champion *et al.*, 1968). Pakistan has a wide range of geographical diversity due to significant differences in climate and topography, including arid and tropical deserts in Baluchistan province, humid areas in the northwest, hills and humid areas and lush green valleys in the north (Arif *et al.*, 2012). The northern region of the country is bounded by the Hindu Kush, Himalayan, and Karakoram boundaries, which together constitute about 60% of the land. These are mountainous areas with abundant natural forest resources. Coniferous forests are found between 1000 and 4000 meters above sea level. These forests contain fungi that are important for ecosystem development and energy stability. Fungi are multicellular are eukaryotic organisms that are crucial components of ecosystems nutrients cycle. Many species of invertebrate and vertebrates including humans, eat the fruiting bodies of fungi, or sporocarps (Bajwa *et al.*, 1999 a, b; Arora, 2001). Poisonous mushrooms such as *Amanita subjunguilea, Amanita pallidorosea, Amanitin fuliginea, Amanita excialis* and *Amanitin rimosa* are known for their high toxicity (Zhao *et al.*, 2023). The genus Amanita includes approximately 600 species of mushrooms known worldwide. Most cases of mushroom poisoning result from consuming poisonous mushrooms of the genus *Amanita*. These mushrooms belong to the order Agaricales and the family Amanitaceae (Diaz, 2018). The objectives of the current review are: 1) To explore and identify the taxonomic classification of the species of poisonous mushrooms documented in Pakistan. 2) To analyze the biochemical consumption and toxicological effects of identified poisonous mushroom, focusing on symptoms, treatment options and mortality rates. 3) To analyze the ecological and economic threats posed by poisonous mushrooms to human health, agriculture, and biodiversity conservation in Pakistan.

**Ecology and substrates of mushrooms**

Macrofungi are truffles, gill and cup mushrooms. According to their ecological relationships, macrofungi can be divided into parasitic, symbiotic (mycorrhizal) and saprophytic species. Macrofungi are common in nature and indicate the importance of rainfall patterns during the rainy season for mushroom phenology. According to Tibpromma *et al.* (2018), fungi can act as dispersants, live as endophytes in plant tissues and play an important role in nutrient cycling, attack on crops as pathogens or associated with roots as a mycorrhizal arbuscular fungus (Javaid and Khan, 2019). According to Cairney and Meharg (2002), ectomycorrhizal and saprotrophic fungi are important for nutrient cycling and degradation. Trees represent the typical flora of habitats, where soil fungi influence humidity, control soil temperature and feed on underground plants (Gomoryova *et al.*, 2013). Fungi are found in soil (terrestrial), dead leaves (folicolous), wood (lignicolous), decay (coprophilous), decay and organic matter. Fruiting of mushrooms is influenced by various environmental factors.

**Factors effecting the growth of mushroom**

Vegetation structure and plant species composition vary along with environmental gradients, and this variation affects the macrofungal community and the presence of species associated with woody plants. Macromycetes richness and distribution patterns have been related to the composition and structure of the trees community in temperate and tropical habitats (Ferrer and Gilbert, 2003), whereas, in the Mediterranean region, ecological studies have related fungal diversity and distribution to plant diversity (Richard *et al.*, 2004).

Precipitation and temperature have significant effects on the phenology, productivity and diversity of fungi. According to Becker (1956), fruiting was promoted by the alternating of dry and rainy periods. Studies have identified several variables that influence species diversity (Raatikainen *et al.*, 2007). Pykal *et al.* (2001) showed that long history of grazing, management, environmental conditions, habitat heterogeneity and soil pH influence species diversity. Today one of the biggest challenges is understanding how climate change affects the distribution and fruiting of fungi. A significant contemporary difficulty to find out how climatic variation affects the distribution and fruiting of fungi. According to Bujakewicz (1969), too much water prevents soil species (mycorrhizal fungi, humus, and litter saprotrophs) from fruiting. After examining the impact of rainfall and soil temperature on the presence of carpophores in conifer woods from June-December, Thoen (1976) reached to the same conclusion.

The production and diversity of mushrooms are significantly impacted by climate change, which is the most important variable, along with precipitation, temperature and their interactions (Taye *et al.*, 2016). Soil moisture is influenced by the interaction of these variables, and it can be said that this variable serves as an integral drivers of mushrooms fruit development, considering a variety of processes that lead to a particular level of mushroom productivity. Since warm, humid conditions are the most favorable for fungal fruiting, while production has decreased and been delayed in drier environments, current trends in temperature rise brought on by climate change are having been found to boost production and enhance the development of mushrooms in wet temperate regions (Boddy *et al.*, 2014). These modifications would probably make forested ecosystems more susceptible to extreme dryness and drought, which would eventually negatively impact on the growth of mushrooms (Büntgen *et al.*, 2015). Various threats that can also affect the growth, health and survival of fungi. Some mushrooms are poisonous and dangerous even in very small quantities.

**Poisonous mushrooms**

Mushroom poisoning refers to the serious and often fatal consequences of various toxins found in certain types of mushrooms. The severity of mushroom poisoning depends on the type of mushroom eaten, early diagnosis and appropriate treatment (Pajoumand *et al*., 2005). According to the Centers for Disease Control and Prevention, and World Health Organization more than 41,000 people died from mushrooms poisoning in 2008, and 0.346 million deaths since 2004, respectively (Warner *et al*., 2011). In 1998, 1675 cases of mycotoxin poisoning were reported in France, and it is estimated that 8,000 to 10,000 cases have been reported (Jo *et al*., 2014).

**Role of poisonous mushrooms in humans and animal causalities**

There are some poisonous mushrooms that threaten public health. Deaths from mushroom poisoning are increasing worldwide; more than 90% of deaths are attributed to the consumption of species containing amatoxin (Giannini *et al.*, 2007). Many toxins have been well described in the literature, including amatoxin, which causes kidney and liver damage, and orellanine, a nephrotoxic toxin (Qi *et al.*, 2000). Some species are used for food and medicine because of their pharmacologically active compounds. Moreover, mushrooms have been used for their medicinal substances since ancient times (Miyaji *et al.*, 2001). However, some pharmaceutical compounds have been found to be toxic. Of these each species of poisonous mushrooms, only 70-80 species are deadly. However, some types of poisonous mushrooms are morphologically similar like edible mushrooms (Nieminen *et al.*, 2006). Accidentally digesting poisonous mushrooms can cause injury or illness (Nordt *et al*., 2000). It has been reported in the literature that high doses of *Amanita phalloides* can cause suicidal behavior (Hruby *et al.*, 1983). According to Mao (2006), almost a thousand species of these diverse macrofungi are regarded as toxic mushrooms. Six categories belong to the symptoms resulting from poisonous mushrooms including harmful to nerves, cytotoxic, 3) metabolic, encompassing endocrine and associated toxicities. According to White *et al.* (2019), there are several adverse effects, including gastrointestinal irritation.

**Cytotoxic mushrooms**

The liver and kidneys are the primary organs targeted by cytotoxic mushrooms. Aminohexadienoic acid, orellanine, and amanitin are poisons that cause harm to the liver and kidneys. The majority of the species that produce these toxins belong to the *Amanita Pers.* and *Cortinarius (Pers.)* Gray genera (Karlson-Stiber and Persson, 2003).

**Neurotoxic mushrooms**

Macrofungi that produce neuroexcitatory effects are neurotoxic mushrooms. Isoxazoles, muscarines, and psilocybins are known poisons. Most of the mushrooms that produce these toxins are Agaricales, which includes *Gymnopilus*, *Amanita*, *Clitocybe*, *Inocybe*, and *Psilocybe*. Additionally, several Pezizales mushrooms, like *Morchella* spp., have been shown to cause neurotoxic syndrome; however, the specific toxins causing this condition are still unclear.

**Myotoxic mushroom**

Myotoxic mushrooms, which primarily come from Russula and Tricholoma, are strongly linked to rhabdomyolysis symptoms. *Tricholoma equestre* (L.) P. Kumm, *Russula subnigricans* Hongo and *T. terreum* (Schaeff.) P. Kumm are the common species that have been reported.

**Metabolic/endocrine and related toxicity mushroom**

Several deadly mushrooms were included in this large group of mushrooms that has been collected for convenience, even though they rarely share clinical characteristics. As an example, disulfiram-like mushrooms, which produce symptoms similar to disulfiram, are linked to alcohol intake later on (after consuming mushrooms). Most of the related species come from *Ampulloclitocybe, Coprinus* and *Coprinopsis.*

**Gastrointestinal irritant mushrooms**

Chlorophyllum, Agaricus, Gomphus, Hebeloma, Entoloma, Rubroboletus, Omphalotus, Sutorius, and other mushroom genera are among those that might result in gastrointestinal poisoning. According to Rumack and Spoerke (1994), the specific toxins responsible for these gastrointestinal side effects are unidentified. Since the Agaricus species in sections Hondenses and Xanthodermatei possess toxic phenolic chemicals that can result in typical gastrointestinal symptoms, they have been classified as poisonous. Some mushrooms in this genus might produce gastrointestinal symptoms such as cramps or soreness in the abdomen, nausea, vomiting, diarrhea, etc. A common fungus that produces gastrointestinal poisoning is *Chlorophyllum molybdites*. The majority of fatal poisonings are linked to myotoxic and cytotoxic poisonous mushrooms. The number of fatalities from mushroom poisoning each year is unknown, although it is estimated to be between 50 and 100 (Dadpour *et al*., 2017). According to the National Poison Data System (NPDS), 133700 cases (7248 per year) of fungal infections were reported between 1999 and 2016 (Brandenburg and Ward, 2018). Since many species in this order produce fleshy fruiting bodies, the fungus Boletales, Agaricales, Russulales (Basidiomycota) and Pezizales (Ascomycota) are the primary hosts of poisonous mushroom species (Wu *et al.*, 2019). The poisonous species are largely from the order Agaricales, such as the Amanita mushroom: *Amanita bisporigera* G.F. Atk. and the allied *Amanita phalloides* Vaill. Fr., *Lepiota brunneoincarnata* Chodat & Martin and *Galerina marginata* (Batsch) Kuhner. Amanita species, considered the most toxic mushroom, produces 90% of mushroom poisoning cases (Chen *et al*., 2014). One of the most toxic species is the deadly specie *Amanita phalloides*, which has killed thousands of people throughout history and is among the ten most poisonous fungi in the world (Hyde *et al.*, 2018). Some species are described as dangerous to health and poisonous, while some mushroom species with beneficial properties also contain toxic substances (Nieminen *et al.*, 2006). The ingestion of fungi containing toxins is unintentional and is often the result of misidentification of the species (Flesch *et al.*, 2004). This unintentional incident occurred due to a lack of information about poisonous mushrooms, including information about their potential toxicity. It is important to characterize the toxicological profile of mushroom species before utilizing for human consumption.

**Incidents cases of poisonous mushroom species from Pakistan**

Even though they are a tasty frequent food source, deadly mushrooms can cause serious disease and even death if accidentally consumed, especially in rural areas. Incorrect identification of harmful species is the main cause of incidental consumption of toxic mushrooms. There have been reports of 18 cases from Pakistan, of which 15 were older than five years old, and the number of female patients was twice more than male patients. Three individuals suffered kidney damage and fifteen patients suffered liver failure. 13 patients passed away (Jan *et al*., 2008). Vomiting (100%), diarrhea (100%), with signs of moderate to severe dehydration, and indigestion (83.3%) were the most reported symptoms. Hepatic involvement was observed in 15 (83.3%) cases, and hepatic encephalopathy developed in 50% of these cases. After 48 hours, symptoms of liver damage started to appear in most of these cases. In 4 patients (22.3%), renal failure was noted. In Puran tehsil Shangla's Mir Kanai Chawga district, two brothers died after consuming toxic mushrooms. The dead children have been named Wajiha Ishaq, two years old, and Fajar Ishaq, four years old, who were the daughters of Mohammad Ishaq. Locals people says that both children passed away during treatment.

**Reported case study from other countries**

Euripides was the first to report mushroom poisoning in 430 BC. when he told the story of the deaths of his wife and three children after eating mushrooms. There is almost universal agreement that it is difficult to definitively distinguish between poisonous and non-toxic mushrooms. Mushroom poisoning constitutes an important part of plant toxicity in Turkey, in which only 20-25% of mushrooms have been named and 3% of them are poisonous (Gonmori *et al.*, 2003). Previous experiences and observations allow us to distinguish between poisonous and non-poisonous mushrooms (Lancet *et al.*, 1980). In addition to rural areas, mushroom picking is also a habit in Istanbul among villagers who have moved to cities and settled in nearby forests (Oztekin-Mat *et al.*, 1998). From four years, 19948–1998, in Sivas, Turkey, mushroom poisoning accounted for 10.9% of the different types of poisoning analyzed (Alagözlü *et al.*, 2002). However, these cases have not been analyzed toxicologically. The story of a family living in a village in the Kullu district of Himachal Pradesh, India, consisting of a young couple with a one-year-old child, middle-aged parents and a brother. Except for the deceased's husband and child, all family members ate mushrooms collected from the nearby Mäkinen area. Most of the reported cases are accidental, as its use in homicide should not be considered, due to its high toxicity and easy availability. After 10–12 hours, abdominal pain, vomiting and diarrhea appeared. When the entire family experienced stomach wounds after eating wild mushrooms, they all went to primary care and were referred to a regional hospital where they received symptomatic treatment for food poisoning.

**Medicinal benefits of poisonous mushroom**

While many fungi, including *M. giganteus* species, have been found to be effective against yeasts and bacteria (Kalvoncu *et al.*, 2010), other fungi, including *Amanita smithiana*, *Gymnopilus marginatus*, *Gymnopilus venenate*, *Lepiota josserandii*, *Lepiota helveola,* and *Lepiota castanea,* appear to be toxic and contain harmful toxins (West *et al.*, 2009). The toxicity of *Cortinarius speciocissimus* has been attributed to the toxic chemical mineral, which caused irreversible damage to the kidneys (Munstermann *et al.*, 2002). *Amanita phalloides* is considered a life-threatening poison causing acute organ failure, while phallolysin isolated from *Amanita phalloides* has been shown to be a hemolytic toxin (Erguven *et al.*, 2007). In a previous study conducted in Swat (Pakistan), amatoxin was the major toxic compound in mushrooms from the Swat region (Pakistan) and caused gastrointestinal disorders, liver and kidney failure (Chandra and Perkaysth, 1977). Mushrooms contain polysaccharides. Polysaccharides can be used as immunomodulatory, anticancer, anti-inflammatory, antimicrobial, antidiabetic and antioxidant agents (Elsayed *et al.*, 2014). Many species of mushrooms can have medicinal properties, with *Ganoderma*, the king of medicinal mushrooms, and *Lentinula* being the most important genera. *Lentinula edodes* (shiitake) and *Grifola frondosa* (maitake) have a history of medicinal use in different regions of Asia. Studies with mushrooms have shown potential cardiovascular, antitumor, antiviral, antibacterial, antiparasitic, anti-inflammatory, hepatoprotective and antidiabetic effects (Lentinan, 2009).

**Understanding the toxicity of poisonous mushrooms**

According to Wu *et al.* (2019), most species in the orders Agaricales, Boletales, Russulales (Basidiomycota), and Pezizales (Ascomycota) are responsible for most poisonous mushroom species. *Lepiota brunneoincarnata* Chodat & Martın, *Amanita bisporigera* G.F. Atk. and *Amanita phalloides* Vaill. Fr., and *Galerina Marginata* (Batsch) Kuhner are the main providers of lethal species, including those that produce amanitin. Ninety percent of fatal mushroom poisonings are caused by Amanita species, which are thought to be the most poisonous mushrooms (Chen *et al.*, 2014). Depending on the target organ and the period of appearance, 14 symptoms were found in (Diaz, 2005). Recent research has classified mushroom poisoning into six primary classes based on the main clinical features: Neurotoxic, cytotoxic, myotoxic (rhabdomyolysis), metabolic (including endocrine toxicity and associated toxicities), gastrointestinal irritant, and miscellaneous mushroom side effects. Among the six primary groupings, 14 recognized and 6 unknown symptoms connected to toxins were discovered (White *et al.*, 2019). The signs of mushroom poisoning include twenty-one. According to Bas (1969), amanita mushrooms belong to the family Amanitaceae, order Agaricales, order Agaricomycetes. Species of the genus Amanita are widespread throughout the world and easy to identify. This plant is endemic to deciduous and deciduous forests of the central and northern Arctic regions, including the Indian Hemisphere, the Mediterranean, and Central America. There are approximately 1000 species of Agaricales worldwide. About 100 species in this genus are considered poisonous and about 50 species are edible. *Amanita muscaria* forms ectomycorrhizal symbiotic associations with various hosts of the Betulaceae, Pinaceae, Rosaceae families, although it is most often associated with representative trees of the Betula and Pinus genera (Dunk *et al.*, 2011). The main toxins found in *Amanita muscaria* are muscarinic acid, ibotenic acid, muscimol and muscazone (Eugster and Takemoto, 1967). Toxins found in the genus Amanita belong to the Phallotoxin family, which includes phalloin, phalloidin, phallacin, phallacidin, phallacin and phallacin. Virotoxin is also present in this genus and is closely related to phallotoxins (Wong *et al.*, 2006). Only a minority of patients require an emergency liver transplant (Escudié *et al.*, 2007). Species of the genus Clitocybe also cause muscarinic syndrome. The species *Clitocybe dealbata, Clitocybe rivulosa, Clitocybe candicans, Clitocybe cerussata* and *Clitocybe phyllophilaare* are described in the literature as poisonous mushrooms due to the presence of muscarine in their chemical composition (Mas *et al.*, 2005).

**Impacts of poisonous mushrooms**

In addition, many fungi can produce toxins that can contaminate our food and the environment. Many mycotoxin-producing fungi produce aflatoxins and trichothecenes, which cause various adverse health effects. About 4% of the world's population and 70% of young adults in geographic areas are allergic to mushrooms (Denning, 2014). Furthermore, more than 100 mushrooms are highly poisonous to humans, and these deadly mushrooms kill hundreds of people every year due to accidental consumption (Li *et al.*, 2021). In total, the number of mushroom species that directly or indirectly threaten humans is approximately 10% of the currently known mushroom species. A three-year (1999–2002) global survey commissioned by the Food and Agriculture Organization of the United Nations (FAO) found that people in more than 80 countries routinely collect wild mushrooms as a source of food, medicine and income for rural residents. According to the US National Poison Data System (NPDS), 133,700 cases of mushroom poisoning (7,428 per year) were reported between 1999 and 2016, of which 47,220 (2,623 per year) and 52 (2,628 per year) required hospital treatment 2.5/years of deaths (Brandenburg *et al.*, 2018). The Basidiomycota outline served as the basis for the taxonomic data for each species (He *et al.*, 2019). Index Fungorum were used to verify the common synonymy names. Each species' symptoms were categorized using the most recent clinical categorization for mushroom poisoning (White *et al.*, 2019). We provide a list of dangerous mushrooms with details on taxonomy and symptoms, based on reports of deadly mushrooms from Pakistan (Table 1 & 2). We examined the information provided for each species individually with relevant references to better understand the toxicity of each species.

**Methodological approaches**

The published literature data has been collected from online databases such as Google Scholar, Web Sciences, PubMed, Science Hub, Reseachgate and Science direct, as well as local newspapers and Pakistan-specific databases such as PubMedNet. A comprehensive literature study was conducted until August 2023. This database was chosen to cover all national and international literature. We used various terms and keywords such as wild poisonous mushrooms of Pakistan, ecology, medicinal benefits, uses, and ethno mycology. Meeting minutes and data in languages other than English were excluded. Those articles and studies were selected that were published in English or have an English abstract. Also highlighted were resources focusing on wild poisonous mushrooms found in the Pakistani regions.

**Data collection and analysis**

Data was collected from selected publications and articles using a standard methodological approach. The collected data includes scientific names, family name, disorders and disease duration time. Data obtained from selected sources were analyzed descriptively.

**Ethical consideration and quality assessment**

Ethical issues play an important role at every stage of the evaluation process. Communities that use these mushrooms possess indigenous knowledge and intellectual property rights are recognized and respected. The formal quality of the studies was not assessed as the review focused on ethnobotanical and ethnomycological aspects rather than clinical studies or research. However, in mycological and ethnobotanical research, preference is given to strong and reliable sources of verification.

**Non-edible mushrooms of Pakistan**

Almost 81 mushrooms belonging to 30 families and 46 genera were reported from Pakistan.

All these mushroom species were toxic and non-edible (Table 3). The dominant families of mushroom species were Agaricaceae (12) followed by Amanitaceae (10), Marasmiaceae (7), Polyporaceae (7), Pleurotaceae (4), Strophariaceae (3), Inocybaceae (1), Hygrophoraceae (1), Geastraceae (2), Loranthaceae (1), Pasthyrellaceae (4), Mycenaceae (1), Phallaceae (1), Crepidotaceae (1), Gomphaceae (1), Pluteaceae (1), Ganodermataceae (3), Bolbitiaceae (2), Calostomataceae (1), Xylariaceae (1), Russulaceae (7), Xanthomonadaceae (1), Schizophyllaceae (1), Tremellaceae (1), Discinaceae (1), Tricholomataceae (2), Rhinesuchidae (1), Sclerodermataceae (1), and Fomitopsidaceae (1) (Table 4).

In many developing mushroom consuming countries such as Pakistan, many poisoning cases are reported annually, mainly due to lack of knowledge and misidentification of species. These species contain dangerous toxins that can cause death depending on the symptoms and amount consumed. It is difficult to avoid accidental consumption of mushrooms, especially in countries where consumption of wild species is common. The most reported symptoms are vomiting, diarrhea and diarrhoea. Gastrointestinal disorders with moderate to severe dehydration and abdominal pain. In most of these cases, symptoms of diabetes and liver-related symptoms were noted. In rare cases, skin problems, allergies, swelling, nausea and heart disease have also been reported.

## Conclusion

A review of the literature indicates that more efforts are needed to reduce mortality from highly toxic poisonings. All patients who appear with acute food poisoning should be tested for the possibility of having mushroom poisoning, especially if they are a family group. Gastric washing should be performed as soon as there is any type of indication. Injectable Silymarin, which should be accessible for improved results. In patients with moderate to severe amanitin poisoning, intensive combined therapy is quite effective in improving their condition; hence, hemodialysis is recommended in these extreme cases of mushroom poisoning. Establishing a central poison control center could enable faster identification of poisonous mushrooms. The media should warn the public about eating unknown mushrooms.

## Contribution of authors

HG collected data, SZ, FM, SM and NB analyzed data, wrote and reviewed the initial manuscript. All the authors approved the final submission of this manuscript.

## Conflict of interest

The author of this work declare that they have no conflict of interest.

**Table 1:** Disorders caused by poisonous mushrooms of Pakistan.

| S. No | Botanical Name | Disorders | References |
|---|---|---|---|
| 1 | *Agaricus* sp. | Heart disease and diabetes | Diamandis *et al.* (2008) |
| 2 | *Agaricus subrutilescens* | Unpleasant gastric disorders | Diamandis *et al.* (2008) |
| 3 | *Agrocybe retigera* | Neuroinflammation | Yaseen *et al.* (2021) |
| 4 | *Amanita cinis* | Cancer, obesity and hypertension | Keskin *et al.* (2022) |
| 5 | *Amanita fulva* | Gastrointestinal | Kotowski (2016) |
| 6 | *Amanita hemibapha* | Liver failure | Taylor *et al.* (2019) |
| 7 | *Amanita muscaria* | Gastrointestinal distress, liver failure/dizziness and diarrhoea | Taylor *et al.* (2019) |
| 8 | *Amanita nigra* | Chronic pain, and gastroesophageal reflux | Khalid (2022) |
| 9 | *Amanita ovoidea* | Organ damage in the human body | Biagi *et al.* (2014) |
| 10 | *Amanita pallidorosea* | Typical photosensitive dermatitis | Li *et al.* (2023) |
| 11 | *Amanita phalloides* | Gastrointestinal disorders | Garcia *et al.* (2015) |
| 12 | *Amanita virosa* | Violent with vomiting and intense, watery diarrhea | Tavassoli *et al.* (2019) |
| 13 | *Bolbitius titubans* | Inflammation of the internal wall of the heart | Cagli *et al.* (2019) |
| 14 | *Calostoma insignis* | Cancer and gastroduodenal diseases | Fui *et al.* (2018) |
| 15 | *Chlorophyllum hortense* | Stomach irritation and vomiting | Berger *et al.* (2005) |
| 16 | *Chlorophyllum molybdites* | Diarrhea | Benjamin *et al.* (1995) |
| 17 | *Clitocybe fragrans* | Abdominal pains | Ojanperä *et al.* (2008) |
| 18 | *Coprinellus micaceus* | Causing serious diseases such as heart and blood pressure | Ojanperä *et al.* (2008) |

| | | | |
|---|---|---|---|
| 19 | *Coprinopsis picacea* | Severe nausea, vomiting and heart palpitations | Zeb *et al.* (2023) |
| 20 | *Coprinopsis variegata* | Cause allergy | Zeb *et al.* (2023) |
| 21 | *Coprinus cofeicola* | Vomiting and nausea | Nowakowski *et al.* (2020) |
| 22 | *Cyclocybe parasitica* | Like nausea and vomiting | Badshah *et al.* (2021) |
| 23 | *Fomes fomentarius* | Liver-related problems, inflammations and various cancers | Kalitukha *et al.* (2023). |
| 24 | *Fomitopsis pinicola* | Headaches, nausea and liver disease | Grienke *et al.* (2014) |
| 25 | *Ganoderma lucidum* | Liver disease/hepatitis and neuropathies | Li *et al.* (2021) |
| 26 | *Geastrum triplex* | Defective cardiac function and cardio-toxicity/ liver disorders | De Leon *et al.* (2020) |
| 27 | *Ganoderma adspersum* | Liver disease | Sułkowska *et al.* (2023) |
| 28 | *Ganoderma applanatum* | Liver damage | Ghareeb *et al.* (2021) |
| 29 | *Geastrum saccatum* | Human cervical cancer | Yasin *et al.* (2019) |
| 30 | *Gyromitra esculenta* | Abdominal pain, muscle cramps and faintness | Arłukowicz *et al.* (2019) |
| 31 | *Helvella elastica* | Hydrologic alterations and livestock activity | Britting *et al.* (2016) |
| 32 | *Hygrocybe miniata* | Anaemia | Perkins *et al.* (1994) |
| 33 | *Inocybe pallida* | Liver necrosis | Dwivedi *et al.* (1992) |
| 34 | *Lactarius helvus* | Nausea and vomiting | Schmidt *et al.* (1982) |
| 35 | *Lepiota magnispora* | Nausea, vomiting, stomach cramps, diarrhoea, liver failure and death | Wennig *et al.* (2020) |
| 36 | *Lactarius torminosus* | Fatal gastroenteritis | Widén *et al.* (1979) |
| 37 | *Lactarius pubescens* | Vomiting, nausea, diarrhea, antioxidant and anti-diabetes | Im *et al.* (2016) |
| 38 | *Lactifuus piperatus* | Cause skin disease | Barron (2003) |
| 39 | *Lentinula edodes* | Sarcomas, myelomas, leukemias and lymphomas | Orywal *et al.* (2021) |
| 40 | *Lepiota brunneoincarnata* | Gastrointestinal, nausea and vomiting | Varvenne *et al.* (2015) |
| 41 | *Lepiota cristata* | Gastrointestinal symptoms | Fuller *et al.* (1986) |
| 42 | *Lepiota flavoaurantiaca* | Liver failure | Ullah *et al.* (2022) |
| 43 | *Lepiota oreadiformis* | Nausea and vomiting | Bresinsky *et al.* (2004) |
| 44 | *Leucoagaricus nivalis* | Liver, gastrointestinal tract, kidneys, nervous system and immune system | Altunay *et al.* (2019) |
| 45 | *Leucopaxillus giganteus* | Cause a redox imbalance and toxicity in cancer cells | Dai *et al.* (2021) |
| 46 | *Marasmius acerinus* | Chronic diarrhea and respiratory failure | Fuhrman *et al.* (2004) |
| 47 | *Marasmius rotula* | Cardiological problems and obesity | Ullah *et al.* (2022) |
| 48 | *Marasmius strictipes* | Oxidative stress and cancer | Ullah *et al.* (2022) |
| 49 | *Marasmiellus* sp. | Cancers | Daker *et al.* (2008) |
| 50 | *Marasmius abrubtipes* | Deficiency in calories and energy | Suryavanshi (2010) |
| 51 | *Panaeolus foenisecii* | Digestive disturbances | Schenk-Jaeger *et al.* (2017) |
| 52 | *Phallus sp* | Gastrointestinal disorders | Overbo *et al.* (2004) |
| 53 | *Volvariella volvacea* | Cancer and hyperlipidaemia diseases | Salit *et al.* (2010) |
| 54 | *Coprinus comatus* | Caused protein and fat metabolism | Cao *et al.* (2019) |
| 55 | *Coprinus xerophilus* | Cause skin reactions | Nowakowski *et al.* (2020) |
| 56 | *Panaeolus subbalteatus* | Cause severe illness and even death | Fay (2024) |
| 57 | *Panellus mitis* | Cause the deterioration of the human body | Najmanova *et al.* (2022) |
| 58 | *Pleurotus djamor* var. *djamor* | Human breast cancer | Khalid (2022) |
| 59 | *Pleurotus giganteus* | Neurodegenerative | Phan *et al.* (2015) |
| 60 | *Pleurotus ostreatus* | Cardio metabolic parameters | Dicks & Ellinger (2020) |
| 61 | *Pleurotus tuber-regium* | Diabetes is a cluster metabolic disorder | Huang *et al.* (2012) |

| | | | |
|---|---|---|---|
| 62 | *Polyporus alveolaris* | Cancer | Kadirvelraj *et al.* (2011) |
| 63 | *Russula fragrantissima* | Acute liver failure | Li *et al.* (2021) |
| 64 | *Russula cinereovinosa* | Oxidative stress and cancer | Ullah *et al.* (2022) |
| 65 | *Rhodocollybia butyracea* | Gastroenteric disorders | Větrovský *et al.* (2013) |
| 66 | *Russula sanguinaria* | Gastrointestinal disorders | Gilardoni *et al.* (2014) |
| 67 | *Schizophyllum commune* | HIV disease | Rosenthal *et al.* (1992) |
| 68 | *Scleroderma bovista* | Cause acute liver failure | Li *et al.* (2021) |
| 69 | *Spongipellis pachyodon* | Diabetes and cardiovascular disorders | Chaudhary *et al.* (2023). |
| 70 | *Trametes gibbosa* | High blood pressure and urinary tract infection | Sivaprakasam (2011) |
| 71 | *Trametes versicolor* | Neurodegenerative | Cordaro *et al.* (2022) |
| 72 | *Tremella fuciformis* | Skin inflammation and carcinogenesis | Ullah *et al.* (2022) |
| 73 | *Xylaria polymorpha* | Cancer and cardiological disorders | Saridogan *et al.* (2021 |
| 74 | *Cantharellus floccsus* | Anti-inflammation | Ullah *et al.* (2022) |
| 75 | *Crepidotus iqbalii* | Cough, influenza, asthma and cancer | Izhar *et al.* (2021) |
| 76 | *Pholiota brunnescens* | Cause leaf spot diseases | Fukasawa *et al.* (2021) |
| 77 | *Russula collina* | Hyperlipidaemia and gastroduodenal diseases | Ullah *et al.* (2022) |
| 78 | *Russula tenuiceps* | Acute kidney injury | Ullah *et al.* (2022) |
| 79 | *Russula umbra* | Acute kidney injury | Ullah *et al.* (2022) |
| 80 | *Tyromyces chioneus* | White rot disease in wood plant | Ullah *et al.* (2022) |
| 81 | *Astraeus hygrometricus* | Liver/ anti-inflammatory | Moradali *et al.* (2007) |

**Table 2:** List of mushrooms with disease symptoms, duration time and toxicity.

| Toxicity | Genus/species | Symptoms | Time | Reference |
|---|---|---|---|---|
| Gastroenteritis | *Chlorophyllum Molybdites* | Nausea, vomiting | 1-3 hours | Lehmann *et al.* (1992) |
| Disulfiram-like reactions | *Coprinus atramentarius* | Headache, Nausea, Vomiting, Flushing, Hypotension. | Several hours | Michelot *et al.* (1992) |
| Psilocybin and hallucinations | *Psilocybe*, *Conocybe*, *Gymnopilus* and *Panaeolus* | Anxiety, visual and auditory hallucinations | 30 min or 4-12 hours | Dinis-Oliveira *et al.* (2017) |
| Liver toxicity | *Galerina*, *Lepiota* and *Amanita* | Gastrointestinal effects | 6-12 hours | Diaz *et al.* (2018) |
| Nephrotoxicity | *Cortinarius*, *Amanita smithiana* | Kidney disorders | 1-2 weeks | Dinis-Oliveira *et al.* (2016) |

**Table 3:** Diversity and distribution of poisonous mushrooms from Pakistan.

| Botanical Name | Family | Collection area | Seasonality | Ecology | References |
|---|---|---|---|---|---|
| *Agaricus* sp. | Agaricaceae | Haripur | May-Apr | Shady area | Bibi *et al.* (2019) |
| *Agaricus subrutilescens* | Agaricaceae | Haripur | Jun-Jul | Shady area | Bibi *et al.* (2019) |
| *Agrocybe retigera* | Strophariaceae | Swabi | Feb-Oct | Soil | Yaseen *et al.* (2021) |
| *Amanita cinis* | Amanitaceae | Swabi | Jun-Oct | Dead Wood | Yaseen *et al.* (2021) |
| *Amanita fulva* | Amanitaceae | AJK | Jul–Aug | On Conifers | Ullah *et al.* (2022) |
| *Amanita hemibapha* | Amanitaceae | AJK | Jun-Jul | Saprobic | Ullah *et al.* (2022) |
| *Amanita muscaria* | Amanitaceae | AJK | Jul-Aug | Grow with Pine | Yaseen *et al.* (2021) |
| *Amanita nigra* | Amanitaceae | Swabi | Jun-Jul | Tree | Yaseen *et al.* (2021) |
| *Amanita ovoidea* | Amanitaceae | Swabi | Aug-Oct | Soil | Yaseen *et al.* (2021) |
| *Amanita pallidorosea* | Amanitaceae | Salarzai | Jul-Aug | On tree | Khalid (2022) |

| | | | | | |
|---|---|---|---|---|---|
| *Amanita phalloides* | Amanitaceae | AJK | Jun-Jul | On Oaks tree | Yaseen *et al.* (2021) |
| *Amanita virosa* | Amanitaceae | Punjab | Aug-Oct | Oak hardwoods | Ali *et al.* (2014) |
| *Bolbitius titubans* | Bolbitiaceae | Swabi | June-Oct | Dung | Yaseen *et al.* (2021) |
| *Calostoma insignis* | Calostomataceae | Gandaw | Jul–Sep | On Soil | Ullah *et al.* (2022) |
| *Cantharellus floccsus* | Gomphaceae | Haripur | Oct-Dec | Shady area | Bibi *et al.* (2019) |
| *Chlorophyllum hortense* | Agaricaceae | Punjab | Jun-Jul | Grassy lawns | Jabeen *et al.* (2021) |
| *Chlorophyllum molybdites* | Agaricaceae | Swabi | Jul-Aug | Soil | Khalid (2022) |
| *Clitocybe fragrans* | Tricholomataceae | Islamabad | Aug–Sep | Saprophytic | Khalid (2022) |
| *Coprinellus micaceus* | Psathyrellaceae | Swabi | Dec-Mar | Soil | Yaseen *et al.* (2021) |
| *Coprinopsis picacea* | Psathyrellaceae | Bajaur | Oct–Nov | Saprophytic | Zeb *et al.* (2023) |
| *Coprinopsis variegata* | Psathyrellaceae | Bajaur | Jun–Jul | Saprophytic | Zeb *et al.* (2023) |
| *Coprinus cofeicola* | Amanitaceae | AKJK | Mar-Apr | Saprobic | Ullah *et al.* (2022) |
| *Coprinus comatus* | Agaricaceae | Swabi | Mar-Aug | Dung | Yaseen *et al.* (2021) |
| *Coprinus xerophilus* | Agaricaceae | Swabi | Jan-Dec | Dung | Yaseen *et al.* (2021) |
| *Crepidotus iqbalii* | Crepidotaceae | Swabi | Mar-Apr | Dung | Yaseen *et al.* (2021) |
| *Cyclocybe parasitica* | Strophariaceae | Shukrata | Jun-Jul | On trees | Ullah *et al.* (2022) |
| *Fomes fomentarius* | Polyporaceae | Pakistan | Jun–Jul | On Oaks | Lee *et al.* (2005) |
| *Fomitopsis pinicola* | Fomitopsidaceae | Swabi | March | Soil | Yaseen *et al.* (2021) |
| *Ganoderma lucidum* | Ganodermataceae | AJK | Aug-Oct | On the ground | Gardezi *et al.* (2003) |
| *Geastrum triplex* | Geastraceae | AJK | Mar-Jun | Quercus trees | Hussain *et al.* (2018) |
| *Ganoderma adspersum* | Ganodermataceae | AJK | Jun-Jul | On the ground | Ullah *et al.* (2022) |
| *Ganoderma applanatum* | Ganodermataceae | Swabi | Apr-Aug | Soil | Yaseen *et al.* (2021) |
| *Geastrum saccatum* | Geastraceae | Pakistan | Aug-Sep | Quercus trees | Isildak *et al.* (2004) |
| *Gyromitra esculenta* | Discinaceae | N.W.F.P | Apr-May | On sandy soil | Lagrange *et al.* (2020) |
| *Helvella elastica* | Loranthaceae | AJK | Jun-Jul | On wood | Ullah *et al.* (2022) |
| *Hygrocybe miniata* | Hygrophoraceae | Haripur | Sep- Nov | Shady area | Bibi *et al.* (2019) |
| *Inocybe pallida* | Inocybaceae | Swabi | Mar-Apr | On sandy Soil | Yaseen *et al.* (2021) |
| *Lactarius helvus* | Xanthomonadaceae | Gilgit | May- Jun | On conifers | Razaq *et al.* (2012) |
| *Lepiota magnispora* | Agaricaceae | Neelum | Jan-Sep | Saprobic | Ullah *et al.* (2022) |
| *Lactarius torminosus* | Russulaceae | AJK | Apr-Aug | On Oaks tree | Ullah *et al.* (2022) |
| *Lactarius pubescens* | Polyporaceae | Bajaur | Jun–Oct | Parasitic | Zeb *et al.* (2023) |

| | | | | | |
|---|---|---|---|---|---|
| *Lactifuus piperatus* | Russulaceae | AJK | Mar-Oct | On oak tree | Hussain *et al.* (2018) |
| *Lentinula edodes* | Marasmiaceae | Haripur | Jun-Jul | Shady area | Bibi *et al.* (2019) |
| *Lepiota brunneoincarnata* | Agaricaceae | Swabi | Jul-Nov | On soil /Dung | Varvenne *et al.* (2015) |
| *Lepiota cristata* | Agaricaceae | Khar | Jul-Oct | Shady areas | Khalid (2022) |
| *Lepiota flavoaurantiaca* | Agaricaceae | Swabi | Jun-Jul | Dead Wood | Yaseen *et al.* (2021) |
| *Lepiota oreadiformis* | Agaricaceae | Swabi | Jul-Dec | Dung | Bresinsky *et al.* (2004) |
| *Leucoagaricus nivalis* | Agaricaceae | Kausar | Jun–Jul | On soil | Ullah *et al.* (2022) |
| *Leucopaxillus giganteus* | Tricholomataceae | Miandam | Jun-Jul | On oaks | Ullah *et al.* (2022) |
| *Marasmius acerinus* | Marasmiaceae | AJK | Jan-Mar | On grasses | Ullah *et al.* (2022) |
| *Marasmius rotula* | Marasmiaceae. | AJK | Jun-Jul | On deadwood | Ullah *et al.* (2022) |
| *Marasmius strictipes* | Marasmiaceae | AJK | Aug-Dec | On deadwood | Ullah *et al.* (2022) |
| *Marasmiellus* sp. | Marasmiaceae | Haripur | Feb-Mar | Shady area | Bibi *et al.* (2019) |
| *Marasmius abrubtipes* | Marasmiaceae | AJK | Mar-Apr | On humus soil | Ullah *et al.* (2022) |
| *Panaeolus foenisecii* | Bolbitiaceae | Punjab | Jun-Jul | Grassy areas | Asif *et al.* (2023) |
| *Panaeolus subbalteatus* | Psathyrellaceae | Swabi | Feb-Nov | Dung | Yaseen *et al.* (2021) |
| *Panellus mitis* | Mycenaceae | Swabi | Jun-Jul | Dead Wood | Yaseen *et al.* (2021) |
| *Phallus* sp. | Phallaceae | Punjab | Mar-Aug | Wood | Moreno *et al.* (2023) |
| *Pholiota brunnescens* | Strophariaceae | AJK | Apr-Aug | On wood | Ullah *et al.* (2022) |
| *Pleurotus djamor var. djamor* | Pleurotaceae | Haripur | Jun-Aug | Shady area | Bibi *et al.* (2019) |
| *Pleurotus giganteus* | Pleurotaceae | Haripur | Feb-Mar | Shady area | Bibi *et al.* (2019) |
| *Pleurotus ostreatus* | Pleurotaceae | Haripur | Apr-Oct | Shady area | Bibi *et al.* (2019) |
| *Pleurotus tuber regium* | Pleurotaceae | Haripur | Mar-Apr | Shady area | Bibi *et al.* (2019) |
| *Polyporus alveolaris* | Polyporaceae | Swabi | May–Nov | Dead wood | Yaseen *et al.* (2021) |
| *Russula collina* | Russulaceae | AJK | Jan-Apr | On conifers | Ullah *et al.* (2022) |
| *Russula fragrantissima* | Russulaceae | AJK | Jun-Oct | On hardwood | Ullah *et al.* (2022) |
| *Russula tenuiceps* | Rhinesuchidae | AJK | Jan-Aug | On oaks | Ullah *et al.* (2022) |
| *Russula cinereovinosa* | Russulaceae | AJK | Jan-Feb | Mycorrhizal | Ullah *et al.* (2022) |
| *Rhodocollybia butyracea* | Marasmiaceae | AJK | May-Oct | Saprobic | Ullah *et al.* (2022) |
| *Russula sanguinaria* | Russulaceae | Salarzai | Jun–Oct | On sandy soils | Khalid (2022) |
| *Russula umbra* | Russulaceae | Swabi | Jan-Dec | Tree | Yaseen *et al.* (2021) |
| *Schizophyllum commune* | Schizophyllaceae | Gandaw | Mar-Jul | On wood | Khalid (2022) |
| *Scleroderma bovista* | Sclerodermataceae | Kaghan | Feb-Mar | Saprobic | Ruán *et al.* (2006) |

| | | | | | |
|---|---|---|---|---|---|
| *Spongipellis pachyodon* | Polyporaceae | Swabi | Oct | Dead Wood | Yaseen *et al.* (2021) |
| *Trametes gibbosa* | Polyporaceae | Swabi | Jan-Aug | Soil | Yaseen *et al.* (2021) |
| *Trametes versicolor* | Polyporaceae | Salarzai | Jan–Dec | On oaks | Khalid (2022) |
| *Tremella fuciformis* | Tremellaceae | Haripur | Feb-Aug | Shady area | Bibi *et al.* (2019) |
| *Tyromyces chioneus* | Polyporaceae | Khairabad | Apr-Aug | On wood | Khalid (2022) |
| *Volvariella volvacea* | Pluteaceae | Haripur | Apr-Jun | Deadwood | Bibi *et al.* (2019) |
| *Xylaria polymorpha* | Xylariaceae | Dag Qala | Dec-Jan | On woody | Khalid (2022) |
| *Astraeus hygrometricus* | Diplocystaceae | Pakistan | Mar-Apr | On pine trees | Yasin *et al.* (2019), Roody (2003) |

**Table 4:** Family-wise distribution of recorded species of mushroom in Pakistan.

| Family | No. of species | Family | No. of species |
|---|---|---|---|
| Agaricaceae | 12 | Pluteaceae | 1 |
| Amanitaceae | 10 | Ganodermataceae | 3 |
| Marasmiaceae | 7 | Bolbitiaceae | 2 |
| Polyporaceae | 7 | Calostomataceae | 1 |
| Pleurotaceae | 4 | Xylariaceae | 1 |
| Strophariaceae | 3 | Russulaceae | 7 |
| Inocybaceae | 1 | Xanthomonadaceae | 1 |
| Hygrophoraceae | 1 | Schizophyllaceae | 1 |
| Geastraceae | 2 | Tremellaceae | 1 |
| Loranthaceae | 1 | Discinaceae | 1 |
| Psathyrellaceae | 4 | Tricholomataceae | 2 |
| Mycenaceae | 1 | Rhinesuchidae | 1 |
| Phallaceae | 1 | Sclerodermataceae | 1 |
| Crepidotaceae | 1 | Fomitopsidaceae | 1 |
| Gomphaceae | 1 | | |

## References


Alagözlü H, Sezer H, Candan F, Tabak E, Elaldi H, 2002. A survey of patients with acute poisoning in the Sivas region, Turkey, between 1994 and 1998. *Turk. J. Med. Sci.*, **32**: 39-42.

Ali M, Shahid AA, Azeem Haider AH, 2014. A contribution to the previous study for genus Amanita from Ayubia National Park, Pakistan. *J. Biol. Agric. Healthcare*, **4**: 246-254.

Altunay N, Elik A, Gürkan R, 2019. Monitoring of some trace metals in honeys by flame atomic absorption spectrometry after ultrasound assisted-dispersive liquid micro extraction using natural deep eutectic solvent. *J. Microchem.*, **147**: 49-59.

Arif S, Khan A, Alamgir K, 2012. Building Orientation and its effect on house plan configuration for the climate of Lahore. *J. Life Sci.*, **9**: 362-368.

Arłukowicz-Grabowska M, Wójcicki M, Raszeja-Wyszomirska J, Szydłowska-Jakimiuk M, Piotuch B, Milkiewicz P, 2019. Acute liver injury, acute liver failure and acute on chronic liver failure: A clinical spectrum of poisoning due to *Gyromitra esculenta*. *Ann. Hepatol.*, **18**: 514-516.

Arora D, AV I.D, 2001. Wild mushrooms and rural economies. *In British Mycological Society Symposium Serie*, **22**: 105-110.

Asif M, Firdous Q, Izhar A, Niazi AR, Sarwar S, Khalid AN, 2023. Molecular and morphological studies reveal a new species of *Panaeolus* (Agaricales, Basidiomycota) from Punjab, Pakistan. *Eur. J. Taxon.*, **888**: 77-96.

Badshah MA, Kim J, Yeom J, Abbas N, Haq MR, Kim Y, Lu X, Kim SM, 2021. Glass nanoimprinted plasmonic nanostructure for high power laser stable surface-enhanced Raman spectroscopy substrate. *Appl. Surf. Sci.*, **542**: 148587.

Bajwa R, Kausar R, Javaid A, 1999. Yield performance of *Pleurotus ostreatus* (oyster mushroom) cultivated on cereal crop residues amended with *Sesbania sesban* leaves. In: *Proceedings of 2nd National Conference of Plant Pathology*, September 27-29, 1999, University of Agriculture Faisalabad, Pakistan. pp. 160-164.

Bajwa R, Majeed S, Javaid A, 1999. Use of EM in mushroom cultivation. I: Yield performance of oyster mushroom (*Pleurotus ostreatus*) on EM treated cotton waste and wheat straw. In: *Proceedings of 2nd National Conference of Plant Pathology*, September 27-29, 1999, University of Agriculture Faisalabad, Pakistan. pp. 165-169.

Barron GL, 2003. Predatory fungi, wood decay, and the carbon cycle. *Biodiversity*, **4**: 3-9.

Bas C, 1969. Morphology and subdivision of *Amanita* and a monograph of its section Lepidella. *Pers. Mol. Phylogeny. Evol. Fungi.*, **5**: 285-573.

Becker G, 1956. Observation sur I'ecologie des champignons superieurs. *Ann. Sci. Univ. Besançon Bot.*, **7**: 15-128.

Benjamin DR, 1996. Mushrooms: Poisons and Panaceas. *Trend. Pharmacol. Sci.*, **17**: 173.

Berger KJ, Guss DA, 2005. Mycotoxins revisited: Part I. *J. Emerg. Med.*, **28**: 53-62.

Biagi M, Vegni AM, Pergoloni S, Butala PM, Little TD, 2014. Trace-orthogonal PPM-space time block coding under rate constraints for visible light communication. *J. Lightwave Technol.*, **33**: 481-494.

Bibi S, Khan MF, Rehman A, 2019. Diversity and characterization of mushrooms from district Haripur, KPK, Pakistan. *Biomed. J. Sci. Tech. Res.*, **18**: 13670-13674.

Blackwell M, 2011. The Fungi: 1, 2, 3… 5.1 million species? *Am. J. Bot.*, **98**: 426-438.

Boddy L, Büntgen U, Egli S, Gange AC, Heegaard E, Kirk PM, Mohammad A, Kauserud H, 2014. Climate variation effects on fungal fruiting. *Fungal Ecol.*, **10**: 20-33.

Brandenburg WE, Ward KJ, 2018. Mushroom poisoning epidemiology in the United States. *Mycologia*, **110**: 637-641.

Bresinsky A, 1990. A colour atlas of poisonous fungi: A handbook for pharmacists, doctors, and biologists. CRC Press.

Britting S, Legacy SF, VanVelsor S, 2016. Draft environmental impact statement for revision of the Inyo, Sequoia, and Sierra national forests land management plans. United States Department of Agriculture.

Bujakiewicz A, 1969. Udział grzybów wyższych w lasach łęgowych i olesach Puszczy Bukowej pod Szczecinem. *Bad. Fizjogr. Pol. Zach., B*, **23**: 61-96.

Büntgen U, Egli S, Galván JD, Diez JM, Aldea J, Latorre J, Martínez-Peña F, 2015. Drought-induced changes in the phenology, productivity and diversity of Spanish fungi. *Fungal Ecol.*, **16**: 6-18.

Çağli G, Öztürk A, Koçak MZ, 2019. Two new basidiomycete records for the mycobiota of Turkey. *Anatol. J. Bot.*, **3**: 40-43.

Cairney JW, Meharg AA, 2002. Interactions between ectomycorrhizal fungi and soil saprotrophs: implications for decomposition of organic matter in soils and degradation of organic pollutants in the rhizosphere. *Can. J. Bot.*, **80**: 803-809.

Cao H, Wang S, Cui X, Guo H, Xi X, Xu F, Li Y, Zheng M, Han C, 2019. Taking ingredients as an entry point to explore the relationship between the shaggy ink cap medicinal mushroom, *Coprinus comatus* (Agaricomycetes), and diabetes mellitus. *Int. J. Med. Mush*, **21**: 493-502.

Champion HG, Seth SK, 1968. A revised survey of the forest types of India. Manager of Publications, the University of Michigan.

Chandra A, Purkayastha RP, 1977. Physiological studies on Indian edible mushrooms. *Trans. Br. Mycol. Soc.*, **69**: 63-70.

Chaudhary H, Modi N, Rawal R, 2023. Preliminary screening, Quantitative analysis, antioxidant and antimicrobial activities of mushrooms along with FTIR analysis. *Vidya: J. Gujarat Univ.*, **2**: 242-250.

Chen Z, Zhang P, Zhang Z, 2014. Investigation and analysis of 102 mushroom poisoning cases in Southern China from 1994 to 2012. *Fungal Divers.*, **64**: 123-131.

Cordaro M, Modafferi S, D'Amico R, Fusco R, Genovese T, Peritore AF, Gugliandolo E, Crupi R, Interdonato L, Di Paola D, Impellizzeri D, 2022. Natural compounds such as *Hericium erinaceus* and *Coriolus versicolor* modulate neuroinflammation, oxidative stress and lipoxin a4 expression in rotenone-induced parkinson's disease in mice. *Biomedicine*, **10**: 2505.

Dadpour B, Tajoddini S, Rajabi M, Afshari R, 2017. Mushroom poisoning in the northeast of Iran; a retrospective 6-year epidemiologic study. *Emergency*, **5**: e23.

Dai R, Feng H, Hu J, Jin Q, Li H, Wang R, Wang R, Xu L, Zhang X, 2021. The impact of COVID-19 on small and medium-sized enterprises (SMEs): Evidence from two-wave phone surveys in China. *China Ecol. Rev.*, **67**: 101607.

Daker M, Abdullah N, Vikineswary S, Goh PC, Kuppusamy UR, 2008. Antioxidant from maize and maize fermented by Marasmiellus sp. as stabiliser of lipid-rich foods. *Food Chem.*, **107:** 1092-1098.

De Leon AM, Diego EO, Domingo LKF, Kalaw SP, 2020. Mycochemical screening, antioxidant evaluation and assessment of bioactivities of *Xylaria papulis*: a newly reported macrofungi from Paracelis, Mountain Province, Philippines. *Curr. Res. Environ. Appl. Mycol.*, **10**: 300-318.

Denning DW, Pashley C, Hartl D, Wardlaw A, Godet C, Del Giacco S, Delhaes L, Sergejeva S, 2014. Fungal allergy in asthma–state of the art and research needs. *Clin. Transl. Allergy*, **4**: 1-23.

Diamandis S, Perlerou C, 2008. Recent records of hypogeous fungi in Greece. *Acta Mycol.*, **43**: 139.

Diaz JH, 2005. Syndromic diagnosis and management of confirmed mushroom poisonings. *Crit. Care Med.*, **33**: 427-436.

Diaz JH, 2018. Amatoxin-containing mushroom poisonings: species, toxidromes, treatments, and outcomes. *Wilderness Environ. Med.*, **29**: 111-118.

Dicks L, Ellinger S, 2020. Effect of the intake of oyster mushrooms (*Pleurotus ostreatus*) on cardio metabolic parameters—A systematic review of clinical trials. *Nutrients*, **12**: 1134.

Dinis-Oliveira RJ, 2017. Metabolism of psilocybin and psilocin: clinical and forensic toxicological relevance. *Drug Metab. Rev.*, **49**: 84-91.

Dinis-Oliveira RJ, Soares M, Rocha-Pereira C, Carvalho F, 2016. Human and experimental toxicology of orellanine. *Human. Exp. Txicol.*, **35**: 1016-1029.

Dunk CW, Lebel T, Keane PJ, 2012. Characterisation of ectomycorrhizal formation by the exotic fungus *Amanita muscaria* with *Nothofagus cunninghamii* in Victoria, Australia. *Mycorrhiza*, **22**: 135-147.

Dwivedi RS, Rao BRM, 1992. The selection of the best possible Landsat TM band combination for delineating salt-affected soils. *Int. J. Remote Sen.*, **13**: 2051-2058.

Elsayed EA, El Enshasy H, Wadaan MA, Aziz R, 2014. Mushrooms: a potential natural source of anti-inflammatory compounds for medical applications. *Mediators Inflam*, **2014**: 805841.

Erguven M, Yilmaz O, Deveci M, Aksu N, Dursun F, Pelit M, 2007. Mushroom poisoning. *Indian J. Pediatr.*, **74**: 847-852.

Escudié L, Francoz C, Vinel JP, Moucari R, Cournot M, Paradis V, Sauvanet A, Belghiti J, Valla D, Bernuau J, Durand F, 2007. *Amanita phalloides* poisoning: reassessment of prognostic factors and indications for emergency liver transplantation. *J. Hepatol.*, **46**: 466-473.

Eugster CH, Takemoto T, 1967. Zur nomenklatur der neuen verbindungen aus *Amanita*-arten. *Helv. Chim. Acta*, **50**: 126-127.

Fay C, 2024. Raising mentally strong kids: How to combine the power of neuroscience with love and logic to grow confident, kind, responsible, and resilient children and young adults. Tyndale House Publishers.

Ferrer A, Gilbert GS, 2003. Effect of tree host species on fungal community composition in a tropical rain forest in Panama. *Divers. Distrib.*, **9**: 455-468.

Flesch F, Saviuc P, 2004. Intoxications par les champignons: Principaux syndromes et traitement [Mushroom poisoning: Main syndromes and treatment]. *EMC Méd.*, **1**: 70-79.

Fuhrman MP, Charney P, Mueller CM, 2004. Hepatic proteins and nutrition assessment. *J. Am. Diet. Assoc.*, **104**: 1258-1264.

Fui FS, Saikim FH, Kulip J, Seelan JSS, 2018. Distribution and ethnomycological knowledge of wild edible mushrooms in Sabah (Northern Borneo), Malaysia. *J. Trop. Biol. Conserv*., **15**: 203-222.

Fukasawa Y, Matsukura K, 2021. Decay stages of wood and associated fungal communities characterise diversity–decomposition relationships. *Sci. Rep.*, **11:** 8972.

Fuller TC, McClintock EM, 1986. *Poisonous plants of California* (Vol. 53). Univ of California Press.

Garcia J, Costa VM, Carvalho A, Baptista P, de Pinho PG, de Lourdes Bastos M, Carvalho F, 2015. *Amanita phalloides* poisoning: Mechanisms of toxicity and treatment. *Food. chem. toxicol.*, **86**: 41-55.

Gardezi SRA, Ayub N, 2003. Mushrooms of Kashmir VII. *Asian J. Plant Sci.*, **2**: 644-652.

Ghareeb OA, Mahmoud JH, Qader HS, 2021. Efficacy of *Ganoderma lucidum* in reducing liver dysfunction induced by copper oxide nanoparticles. *J. Res. Med. Den. Sci.*, **9**: 14-17.

Giannini L, Vannacci A, Missanelli A, Mastroianni R, Mannaioni PF, Moroni F, Masini E, 2007. Amatoxin poisoning: a 15-year retrospective analysis and follow-up evaluation of 105 patients. *Clin. Toxicol.*, **45**: 539-542.

Gilardoni G, Malagòn O, Tosi S, Clericuzio M, Vidari G, 2014. Lactarane sesquiterpenes from the European mushrooms *Lactarius aurantiacus*, *L. subdulcis*, and *Russula sanguinaria*. *Nat. Prod. Commun.*, **9**: 319-322.

Gömöryová E, Ujházy K, Martinák M, Gömöry D, 2013. Soil microbial community response to variation in vegetation and abiotic environment in a temperate old-growth forest. *Appl. Soil Ecol.*, **68**: 10-19.

Gonmori K, Yoshioka N, 2003. The examination of mushroom poisonings at Akita University. *Leg. Med.*, **5**: S83-S86.

Grienke U, Zöll M, Peintner U, Rollinger JM, 2014. European medicinal polypores–A modern view on traditional uses. *J. Ethnopharmacol.*, **154**: 564-583.

He MQ, Zhao RL, Hyde KD, Begerow D, Kemler M, Yurkov A, McKenzie EH, Raspé O, Kakishima M, Sánchez-Ramírez S, Vellinga EC, 2019. Notes, outline and divergence times of Basidiomycota. *Fungal divers.*, **99**: 105-367.

Hruby KGMH, Csomos G, Fuhrmann M, Thaler H, 1983. Chemotherapy of *Amanita phalloides* poisoning with intravenous silibinin. *Human Toxicol.*, **2**: 183-195.

Huang HY, Korivi M, Chaing YY, Chien TY, Tsai YC, 2012. Pleurotus tuber-regium polysaccharides attenuate hyperglycemia and oxidative stress in experimental diabetic rats. *Evid. Based Complementary Altern. Med.*, **2012**: 856381.

Hussain S, Jabeen S, Khalid AN, Ahmad H, Afshan NUS, Sher H, Pfister DH, 2018. Underexplored regions of Pakistan yield five new species of Leucoagaricus. *Mycologia*, **110**: 387-400.

Hyde KD, Al-Hatmi AM, Andersen B, Boekhout T, Buzina W, Dawson TL, Eastwood DC, Jones EG, de Hoog S, Kang Y, Longcore JE, 2018. The world's ten most feared fungi. *Fungal Divers.*, **93**: 161-194.

Im KH, Nguyen TK, Choi J, Lee TS, 2016. In vitro antioxidant, anti-diabetes, anti-dementia, and inflammation inhibitory effect of Trametes pubescens fruiting body extracts. *Molecules*, **21**: 639.

Iqbal MA, Penas A, Cano-Ortiz A, Kersebaum KC, Herrero L, del Río S, 2016. Analysis of recent changes in maximum and minimum temperatures in Pakistan. *Atmos. Res.*, **168**: 234-249.

Isildak Ö, Turkekul I., Elmastas M, Tuzen M, 2004. Analysis of heavy metals in some wild-grown edible mushrooms from the middle black sea region, Turkey. *Food Chem.*, **86**: 547-552.

Izhar A, Usman M, Khalid AN, 2021. *Crepidotus iqbalii* (Crepidotaceae, Agaricales) a new stipitate species, from Pakistan. *Phytotaxa*, **500**: 95-107.

Jabeen S, Arshad S, Bashir H, Hamid M, Yasmeen A, Khalid AN, 2021. *Chlorophyllum hortense* newly recorded, and *C. molybdites* confirmed, from Pakistan. *Mycotaxon*, **136**: 497-509.

Jan MA, Siddiqui TS, Ahmed N, Ul-Haq I, Khan Z, 2008. Mushroom poisoning in children: clinical presentation and outcome. *J. Ayub Med. Coll.*, **20**: 99-101.

Javaid A, Khan IH, (2019). Mycorrhizal fungi associated with mungbean. *Mycopath*, **17**: 45-48.

Jo WS, Hossain MA, Park SC, 2014. Toxicological profiles of poisonous, edible, and medicinal mushrooms. *Mycobiology*, **42**: 215-220.

Kadirvelraj R, Grant OC, Goldstein IJ, Winter HC, Tateno H, Fadda E, Woods RJ, 2011. Structure and binding analysis of Polyporus squamosus lectin in complex with the Neu5Acα2-6Galβ1-4GlcNAc human-type influenza receptor. *Glycobiology*, **21**: 973-984.

Kalitukha L, Galiano A, Harrison F, 2023. Medicinal potential of the insoluble extracted fibers isolated from the *Fomes fomentarius* (Agaricomycetes) fruiting bodies: A review. *Int. J. Med. Mushrooms*, **25:** 21-35.

Kalvoncu F, Oskay M, Sağlam H, Erdoğan TF, Tamer AÜ, 2010. Antimicrobial and antioxidant activities of mycelia of 10 wild mushroom species. *J. Med. Food.*, **13**: 415-419.

Karlson-Stiber C, Persson H, 2003. Cytotoxic fungi—an overview. *Toxicon*, **42**: 339-349.

Keskin F, Sarikurkcu C, Demirak A, Akata I, Sihoglu Tepe A, 2022. Wild mushrooms from Ilgaz Mountain National Park (Western Black Sea, Turkey): element concentrations and their health risk assessment. *Environ. Sci. Pollut. Res.*, **29**:31923-31942.

Khalid AN, 2022. A checklist of macrofungi of Pakistan published from 1998–2020. *Pak. J. Bot.*, **54**: 1947-1962.

Kotowski M, 2016. Differences between European regulations on wild mushroom commerce and actual trends in wild mushroom picking. *Slov. Národop.*, **64**: 169-178.

Lagrange E, Vernoux JP, 2020. Warning on false or true morels and button mushrooms with potential toxicity linked to hydrazinic toxins: An update. *Toxins*, **12**: 482.

Lee JS, 2005. Effects of *Fomes fomentarius* supplementation on antioxidant enzyme activities, blood glucose, and lipid profile in streptozotocin-induced diabetic rats. *Nutr. Res.*, **25**: 187-195.

Lentinan, 2009. About herbs Memorial gloan kettering Cancer Center. R Mussak and T Bechtold (2009). Handbook of Natural Colorants New York: Wiley, pp. 183-200.

Li H, Zhang H, Zhang Y, Zhou J, Yin Y, He Q, Jiang S, Ma P, Zhang Y, Wen K, Yuan Y, 2021. Mushroom poisoning outbreaks—China, 2020. *China CDC Weekly*, **3**: 41.

Li W, Pires SM, Liu Z, Liang J, Wang Y, Chen W, Liu C, Liu J, Han H, Fu P, Guo Y, 2021. Mushroom poisoning outbreaks—China, 2010–2020. *China CDC Weekly*, **3**: 518.

Li Y, Zhang Y, Timofte R, Van Gool L, Yu L, Li Y, Li X, Jiang T, Wu Q, Han M, Lin W, 2023. NTIRE 2023 challenge on efficient super-resolution: Methods and results. In proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. pp. 1921-1959.

Mao XL, 2006. Poisonous mushrooms and their toxins in China. *Mycosystema*, **25**: 345-63.

Mas A, 2005. Mushrooms, amatoxins and the liver. *J. Hepatol.*, **42**: 166-169.

Michelot D, 1992. Poisoning by *Coprinus atramentarius*. *Nat. Toxins.*, **1**: 73-80.

Miyaji CK, Cólus IDS, 2001. Mushroom Shiitake, is it mutagenic or antimutagenic agent? *Ciên. Biol. Saúde,* **22**: 11-17.

Moradali MF, Mostafavi H, Ghods S, Hedjaroude GA, 2007. Immunomodulating and anticancer agents in the realm of macromycetes fungi (macrofungi). *Int. Immunopharmacol.*, **7**: 701-724.

Moreno G, Khalid AN, Alvarado P, Kreisel H, 2013. *Phallus hadriani* and P. roseus from Pakistan. *Mycotaxon.*, **125**: 45-51.

Mueller GM, Wu QX, Huang YQ, Guo SY, Aldana-Gomez R, Vilgalys R, 2001. Assessing biogeographic relationships between North American and Chinese macrofungi. *J. Biogeog.*, **28**: 271-281.

Münstermann S, Heinicke HJ, Kayser M, Nüsslein H, 2002. Acute renal failure as a sequela of mushroom poisoning with *Cortinarius speciocissimus*. *Med, Klin.,* **97**: 96-98.

Najmanova L, Vídeňská P, Cahova M, 2022. Healthy microbiome–a mere idea or a sound concept? *Physiol. Res.*, **71**: 719.

Nieminen P, Kirsi M, Mustonen AM, 2006. Suspected myotoxicity of edible wild mushrooms. *Exp. Biol. Med.*, **231**: 221-228.

Nordt SP, Manoguerra A, 2000. 5-Year analysis of mushroom exposures in California. *West. J. Med.*, **173**: 314.

Nowakowski P, Naliwajko SK, Markiewicz-Żukowska R, Borawska MH, Socha K, 2020. The two faces of *Coprinus comatus*—Functional properties and potential hazards. *Phytother. Res.*, **34**: 2932-2944.

Ojanperä I, 2008. Mushroom toxins. In: *Handbook of Analytical Separations* (vol. 6). Elsevier Science BV. pp. 391-399.

Orywal K, Socha K, Nowakowski P, Zoń W, Kaczyński P, Mroczko B, Łozowicka B, Perkowski M, 2021. Health risk assessment of exposure to toxic elements resulting from consumption of dried wild-grown mushrooms available for sale. *PLoS One*, **16**: e0252834.

Overbo CL, 2004. Common Lawn and Garden Mushrooms of Central Oklahoma. *Oklahoma Native Plant Record,* **4**: 48.

Oztekin-Mat A, 1998, January. Mushroom poisoning in Turkey. *Ann. Pharm. Fr*., **56**: 233-235.

Pajoumand A, Shadnia S, Efricheh H, Mandegary A, Hassanian-Moghadam H, Abdollahi M, 2005. A retrospective study of mushroom poisoning in Iran. *Hum. Exp. Toxicol.*, **24**: 609-613.

Perkins D, Blythe T, 1994. Putting understanding up front. *Edu. Leaders,* **51**: 4-4.

Phan CW, David P, Wong KH, Naidu M, Sabaratnam V, 2015. Uridine from *Pleurotus giganteus* and its neurite outgrowth stimulatory effects with underlying mechanism. *PLoS One*, **10**: e0143004.

Pykal J, 2001. Maintaining biodiversity through traditional animal husbandry. The Finnish Environment 495. *Finnish Environment Institute, Helsinki. (In Finnish with English summary)*.

Qi J, Ojika M, Sakagami Y, 2000. Termitomycesphins A–D, novel neuritogenic cerebrosides from the edible Chinese mushroom *Termitomyces albuminosus*. *Tetrahedron*, **56**: 5835-5841.

Raatikainen KM, Heikkinen RK, Pykälä J, 2007. Impacts of local and regional factors on vegetation of boreal semi-natural grasslands. *Plant Ecol.*, **189**: 155-173.

Razaq A, Shahzad S, Ali H, Noor A, 2014. New reported species of macrofungi from Pakistan. *J. Agri-food Appl. Sci.*, **2**: 67-71.

Razaq A, Shahzad S, 2012. New records of Lactarius species from Pakistan. *Pak. J. Bot.*, **44**: 403-405.

Richard F, Moreau PA, Selosse MA, Gardes M, 2004. Diversity and fruiting patterns of ectomycorrhizal and saprobic fungi in an old-growth Mediterranean forest dominated by *Quercus ilex* L. *Canad. J. Bot.*, **82**: 1711-1729.

Roody WC, 2003. Mushrooms of west Virginia and the central Appalachians (p. 523). Lexington, Kentucky: University Press of Kentucky.

Rosenthal J, Katz R, DuBois DB, Morrissey A, Machicao A, 1992. Chronic maxillary sinusitis associated with the mushroom *Schizophyllum commune* in a patient with AIDS. *Clin. Infect. Dis.*, **14**: 46-48.

Ruán-Soto F, Garibay-Orijel R and Cifuentes, J, 2006. Process and dynamics of traditional selling wild edible mushrooms in tropical Mexico. *J. Ethnobiol. Ethnomed.*, **2**: 1-13.

Rumack BH, Spoerke DG, 1994. Handbook of mushroom poisoning: diagnosis and treatment. CRC Ppress.

Salit RB, Shea YR, Gea-Banacloche J, Fahle GA, Abu-Asab M, Sugui JA, Carpenter AE, Quezado MM, Bishop MR, Kwon-Chung KJ, 2010. Death by edible mushroom: first report of *Volvariella volvacea* as an etiologic agent of invasive disease in a patient following double umbilical cord blood transplantation. *J. Clin. Microbiol.*, **48**: 4329-4332.

Salma S, Rehman S, Shah MA, 2012. Rainfall trends in different climate zones of Pakistan. *Pak. J. Meteorol.*, **9**: 37-45.

Saridogan BGO, Islek C, Baba H, Akata I, Sevindik M, 2021. Antioxidant antimicrobial oxidant and elements contents of *Xylaria polymorpha* and *X. hypoxylon* (Xylariaceae). *Fresenius Environ. Bull.*, **30**: 5400-5404.

Schenk-Jaeger KM, Hofer-Lentner KE, Plenert B, Eckart D, Haberl B, Schulze G, Borchert-Avalone J, Stedtler U, Pfab R, 2017. No clinically relevant effects in children after accidental ingestion of *Panaeolina foenisecii* (lawn mower's mushroom). *Clin. Toxicol.*, **55**: 217-220.

Schmidt SP, Hoveland CS, Clark EM, Davis ND, Smith LA, Grimes HW, Holliman JL, 1982. Association of an endophytic fungus with fescue toxicity in steers fed Kentucky 31 tall fescue seed or hay. *J. Anim. Sci.*, **55**: 1259-1263.

Sivaprakasam E, Kavitha D, Balakumar R, Sridhar S, Kumar JS, 2011. Antimicrobial activity of whole fruiting bodies of *Trametes hirsuta* (Wulf. Fr.) Pil. against some common pathogenic bacteria and fungus. *Int. J. Pharm. Sci. Drug Res.*, **3**: 219-221.

Sułkowska-Ziaja K, Balik M, Szczepkowski A, Trepa M, Zengin G, Kała K, Muszyńska B, 2023. A review of chemical composition and bioactivity studies of the most promising species of *Ganoderma* spp. *Divers*ity, **15**: 882.

Suryavanshi RM, 2010. A reportorial approach in the management of primary marasmus in children (Doctoral dissertation, Rajiv Gandhi University of Health Sciences, India.

Tavassoli M, Afshari A, Arsene AL, Mégarbane B, Dumanov J, Paoliello MMB, Tsatsakis A, Carvalho F, Hashemzaei M, Karimi G, Rezaee R, 2019. Toxicological profile of *Amanita virosa*–A narrative review. *Toxicol. Rep.*, **6**: 143-150.

Taye ZM, Martínez-Peña F, Bonet JA, de Aragón JM, de-Miguel S, 2016. Meteorological conditions and site characteristics driving edible mushroom production in *Pinus pinaster* forests of central Spain. *Fungal Ecol.*, **23**: 30-41.

Taylor J, 2019. Notes from the field: acute intoxications from consumption of *Amanita muscaria* mushrooms -Minnesota, 2018. *MMWR. Morb. Mortal. Weekly Rep.*, **68**: 483.

Thoen D, 1976. Facteurs physiques et fructification des champignons supérieurs dans quelques pessières d'Ardenne Meridionale (Belgique). *Publications de la Société Linnéenne de Lyon*, **45**: 269-284.

Tibpromma S, Hyde KD, McKenzie EH, Bhat DJ, Phillips AJ, Wanasinghe DN, Samarakoon MC, Jayawardena RS, Dissanayake AJ, Tennakoon DS, Doilom M, 2018. Fungal diversity notes: Micro-fungi associated with Pandanaceae. *Fungal Divers.*, **93**: 1-160.

Ullah TS, Firdous SS, Shier WT, Hussain J, Shaheen H, Usman M, Akram M, Khalid AN, 2022. Diversity and ethnomycological importance of mushrooms from Western Himalayas, Kashmir. *J. Ethnobiol. Ethnomed.*, **18**: 32.

Varvenne D, Retornaz K, Metge P, De Haro L, Minodier P, 2015. Amatoxin-containing mushroom (*Lepiota brunneoincarnata*) familial poisoning. *Pediatr. Emerg. Care*, **31**: 277-278.

Větrovský T, Baldrian P, Gabriel J, 2013. Extracellular enzymes of the white-rot fungus *Fomes fomentarius* and purification of 1, 4-β-glucosidase. *Appl. Biochem. Biotechnol.*, **169**: 100-109.

Warner M, Chen LH, Makuc DM, Anderson RN, Minino AM, 2011. Drug poisoning deaths in the United States, 1980–2008. *NCHS Data Brief*, 81: 1-8.

Webster J, Weber R, 2007. Introduction to fungi. Cambridge University Press.

Wennig R, Eyer F, Schaper A, Zilker T, Andresen-Streichert H, 2020. Mushroom poisoning. *Deutsch. Ärztebl. Int.*, **117**: 701.

West PL, Lindgren J, Horowitz BZ, 2009. *Amanita smithiana* mushroom ingestion: a case of delayed renal failure and literature review. *J. Med. Toxicol.*, **5**: 32-38.

White J, Weinstein SA, De Haro L, Bédry R, Schaper A, Rumack BH, Zilker T, 2019. Mushroom poisoning: A proposed new clinical classification. *Toxicon*, **157**: 53-65.

Widén KG, Seppä EL, 1979. 15-Hydroxyblennin A, a new lactarane-type sesquiterpene lactone isolated from *Lactarius torminosus*. *Phytochemistry*, **18**: 1226-1227.

Wong JH, Ng TB, 2006. Toxins from basidiomycete fungi (mushroom): amatoxins, phallotoxins, and virotoxins. In *Handbook of biologically active peptides*. Academic Press, pp. 131-135.

Wu F, Zhou LW, Yang ZL, Bau T, Li TH, Dai YC, 2019. Resource diversity of Chinese macrofungi: edible, medicinal and poisonous species. *Fungal Divers*., **98**: 1-76.

Yaseen T, Khan M, Shakeel M, Ara H, 2021. 28. Morphological study of edible and non-edible mushrooms, district Swabi, Khyber Pakhtunkhwa, Pakistan. *Pure Appl. Biol.,* **5**: 889-894.

Yasin H, Zahoor M, Yousaf Z, Aftab A, Saleh N, Riaz N, Shamsheer B, 2019. Ethnopharmacological exploration of medicinal mushroom from Pakistan. *Phytomedicine,* **54:** 43-55.

Zeb M, Ullah A, Ullah F, Haq A, Ullah I, Badshah L, Haq MA, 2023. Diversity and biological characteristics of macrofungi of district Bajaur, a remote area of Pakistan in the Hindu Kush range. *Heliyon*, **9**: e17818.

Zhao L, Zhao X, Hengchao E, Fan T, Tian E, Wang C, Zhang Y, Li X, Zhao Z, Zhou C, 2023. Multiplex TaqMan real-time PCR assay for high-throughput identification of highly toxic mushroom species-induced foodborne poisoning. LWT **186**: 1f15211.