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# How to tell the mushroom you are holding will kill you or heal you: A mini review

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**Abstract**
Mushrooms are classified into different categories on different basis but here we are classifying them into edible, poisonous and medicinal based on their effect on human body after their ingestion. They have difference in their morphology and their nutrient content also which is the major reason for their effect on humans. We need to identify the differences between edible and poisonous mushroom in order to prevent accidental poisoning which have become one of the great concerns of modern world. On the other hand, there are some medicinal mushrooms which are boon to the society and human life, they are used to make a lot of life saving drugs to increase life expectancy. Bio fortified edible mushrooms also play an important role in this society of hidden hunger people.

**Keywords:** Fungus, poisonous mushroom, edible mushroom, medicinal mushroom

## Introduction
Mushrooms are the most famous edible fungi belonging to basidiomycetes family, they have gained popularity among new generation due to their nutritional qualities and distinct taste. Nowadays they have high market demand and even higher availability due to dedicated mushroom culture. Finding eatable mushrooms in the wild, however, is a challenge because there are also plenty of deadly mushrooms there, such as *Amanita* spp.

Every year, numerous incidents of mushroom poisoning are reported in different nations. 1,675 cases of mushroom intoxications were reported in France in 1998, and it is predicted that 8-10.000 cases will be reported annually in this one nation alone. The majority of these mishaps are brought on by inaccurate species identification, which is frequently done using empirical and conventional information.

Some mushrooms contain incredibly potent poisons that, even when consumed in modest amounts, pose a serious risk to health. Many toxins, including orellanine, which is nephrotoxic and causes damage to the kidneys and liver, and amatoxins, which are cytotoxic and do the same to the kidney and liver (Karlson-Stiber *et al.*, 2003) [1].

Due to the availability of pharmacologically active compounds and necessary nutrients, several species are ideally suited for use as food and medicine. In ancient oriental writings, mushrooms were referred to as common treatments because of these qualities, and some of them ended up as ingredients in traditional medicines (Wasser, 2002; Miyaji 2001; Delu *et al.*, 2006) [76, 3, 4].

So here we will discuss about the identification of edible mushrooms, medicinal mushrooms and poisonous mushroom along with their famous examples, properties and general effect on human body along with the importance of identifications and repercussion of eating poisonous mushroom.

## Morphology of mushrooms
A wide variety of fruiting bodies are produced by mushroom-forming fungus (Agaricomycetes, roughly syn.: Homobasidiomycetes), ranging from straightforward crust-like forms to intricate, progressively integrated forms, such stinkhorns, and veiled agarics. According to macromorphology, the Friesian system of the 19th century classified the fungus that produce mushrooms. Although the Friesian taxonomy has long been considered artificial, it nonetheless has an impact on the terminology used in mycology and how people view the diversity of fungal life. The evolutionary relevance of anatomical traits was clarified during the 20th century, and classification schemes that significantly deviated from the Friesian system were created.

Agaricomycetes produce a wide variety of fruiting bodies, including gilled mushrooms (agarics), chanterelles, stinkhorns, corticioid fungi, polypores, cyphelloid fungi, false truffles, coral fungi, bird's nest fungi, puffballs, and other forms that def (e.g. Sparassis). One of the primary aims of fungal systematics for many generations has been reconstructing the development of fruiting body morphologies. This article provides a summary of how our knowledge of phylogeny and morphological evolution in Agaricomycetes has evolved through time. The selection of literature listed is biased toward my interests and no attempt has been made to be exhaustive. With, this post is mostly meant for fresh mycology students who may be looking for dissertation ideas while also attempting to understand the literature from the past.

**Pre-molecular perspectives on the genesis of fruiting bodies**

The main organising concept of Elias Fries' 19th-century taxonomy was fruiting body shape. According to writers of the 20th century (e.g. Donk 1971), the Friesian taxonomy consists of two classes: the Hymenomycetes, which includes fungus that develop spores on an exposed hymenium, and the Gasteromycetes, which produce spores internally. The Hymenomycetes were divided into two orders: the Agaricales, which included all forms that were gilled, and the Aphyllophorales, which included all forms that were not gilled. Six more families of the Aphyllophorales were created based on the hymenophore's shape (e.g. Polyporaceae for poroid forms, Hydnaceae for toothed forms, etc.) From Fries' time to the present, the progress of agaricomycete systematics has mostly consisted of a decoupling of macromorphology and taxonomy with the inclusion of anatomical, biochemical, and ultimately molecular characteristics. Although it is now recognised that the Friesian higher taxa are polyphyletic, we still refer to forms like "agarics", "polypores", "hydnums", and we use these terms to categorise field guides and basic mycology courses. Therefore, the Friesian theory of microbial variety continues to be relevant. Long before the development of molecular systematics, the artificial character of the Friesian system was obvious. In fact, Patouillard (1900) [96] was utilising anatomical traits to divide macrofungi into groupings that were more 'natural' than the Friesian higher taxa at the start of the 20th century (Hibbett, 2007) [5].

**Morphological difference between poisonous mushroom and edible mushroom**

Edible mushrooms have a high nutritional content, which is why people eat them for their putative health benefits as well as their alleged nutritional worth. Those who practice folk medicine use medicinal mushrooms because of their nutraceutical content. Psilocybin mushrooms, for example, are ingested for recreational or religious purposes, and they can cause extreme nausea and disorientation, which is why they are not typically regarded edible fungi (Boa E, 2004) [6].

Fungi that bear fruiting structures large enough to be seen with the naked eye are edible mushrooms. They may be plucked by hand and can be hypogeous or epigeous. The absence of harmful effects on humans, as well as appealing flavor and aroma, highlight the edibility of mushrooms (Arora D, 1996) [7].

Species identification based on morphologic characteristics is typically difficult in situations of suspected mushroom poisoning; the morphology of the mushrooms, particularly the spores, might be changed by handling and cooking, and a mycologist may be unable to identify the species. Mushrooms such as *Amanita phalloides*, *Lepiota cristata*, *L. brunneoincarnata*, and *Inocybe asterospora* can be wrongly recognized as edible by collectors. If *A. phalloides* poisoning is suspected, stomach contents, mushroom samples, and residuals of food, if available, must be tested to confirm the presence of mushrooms or spores. The development of technologies for identifying hazardous mushrooms is so critical (Maeta *et al*., 2008) [8].

Ethno mycological understanding of edible mushrooms has traditionally been restricted to their apparent fruit bodies. Morphological identification is dependent on traits such as cap colour, cap shape, stipe colour and form, gill size, and fruiting body colour, which can change widely inside a species based on environmental conditions, leading to inaccuracies in species classification. Physical parameters such as cap size and stipe length, the substratum to which they are adhered, and spore development are frequently utilized to identify between species (Ukwuru *et al.*, 2018) [11].

Indigenous knowledge of edible mushrooms and their use by locals is an essential aspect of ethno mycology. According to published research, the Bodo people in Kokrajhar district, BTAD Assam, India, have substantial mycological knowledge that allows them to quickly differentiate the edibility of wild macrofungi.

Most rural tribes, particularly in Africa, have a widespread notion about identifying edible from dangerous mushrooms (Boa E, 2004) [6]. When a deadly mushroom is cooked, it becomes silver-black (Arora D, 1996) [7]. It is safe to consume if the mushroom cap is pulled off. These broad strokes may not provide complete guarantee of safety. Most edible mushrooms are known because someone ate them, and they were safe. This may not be a reliable approach to determine mushroom edibility because many edible and toxic mushroom species look quite similar. There are few instances of traditional mushroom usage in Africa. The accurate identification of mushrooms is critical in their intake by humans. Morphological identification, which has historically been used, is error-prone, laborious, and time-consuming (Ukwuru *et al.*, 2018) [11].

**Nutritional difference between poisonous mushroom and edible mushroom**

**Nutrients in Edible mushroom**

Proximate composition, dry matter, and energy value

The dry matter content of mushrooms is quite low, ranging from 60 to 140 g/kg (Kalac, 2009) [12]. The research conducted by Bano and Rajarathnam supports this finding (Rajarathnam *et al.*, 1988) [13]. They stated that the 81.8 to 94.8% moisture content of the edible mushrooms was high. The variation in moisture content in mushrooms is influenced by the species of mushroom as well as other factors linked to the conditions of harvest, growth, and storage. The high moisture content of fresh mushrooms means that they have a short shelf life (Guillamón *et al.*, 2010) [14]. On a dry-weight basis, mushrooms typically include 63% carbs, 25% protein, 4% fat, and 8% minerals represented by ash, according to Rajarathnam and Sashirekha (Rajarathnam and Shashirekha, 2003) [15].

**Table 1:** Differentiating edible and poisonous fungus based on morphological features (Das *et al.*, 2014; Basumatary M and Gogoi M, 2016; Ukwuru *et al.*, 2018) [9, 10, 11].

| Poisonous mushroom | Edible mushroom |
|---|---|
| Turns white on touch | Turns black on touch |
| Have a pointed cap. | Have a rounded, flat top. |
| Macrofungi without ring and black gills grow directly on partially decomposed cow manure. | Macrofungi has a prominent ring on the stem when mature. |
| Colorful fruiting body with black markings on the gills that become black when broken. | When the fruiting body or gills are harvested, they become crimson, brown. |
| Net Mushrooms, also known as "Jeymwikhu (Bodo); the macrofungi with a web all over its mycelium, are very poisonous. | Macrofungi thrive in known substrates such as dying tree trunks. |
| When you chop the mushroom, it either turns green or purple. | The mushroom does not discolor green or purple when chopped. |
| There is no presence of worms. | There is presence of worms. |
| fruiting bodies are often bright in colour | fruiting bodies are pale or white in colour |
| insects and worm avoid toxins in poisonous mushrooms | presence of worms and insects can be found near edible mushrooms |
| On the cap, scales can be found. | The cap does not have a scale. |
| When rice is cooked, it becomes crimson. | When boiling, there is no discernible colour change. |
| Stipe becomes black when broken or taken up from the soil. | Stipe becomes dark when broken and emits brown colour into the water when maintained in water. |

**Carbohydrates**

Carbohydrate is essentially the main element in the makeup of mushroom fruiting bodies. The most common forms of carbohydrates are glucan and hemicellulose, which are polymeric in nature. However, there is no starch as such (Rajarathnam and Shashirekha, 2003) [15]. Glycogen, not starch like in plants, is the reserve carbohydrate present in certain mushrooms. The typical dry matter content is between 5 and 10% (Kalac, 2009) [12]. Up to 80% of the dry substance in mushroom cell walls is a structural polymer called chitin that is water insoluble. Chitin is indigestible to humans and limits the availability of other mushroom components (Kalac, 2009) [12]. Additionally to chitin, mushrooms contain a sizable quantity of dietary fibre. Guillamón demonstrated the wide variation in the availability of dietary fibre among mushroom species (Guillamón *et al.*, 2010) [14]. Total fibre content ranged from 5.5 to 42.6% of dry matter in the analyses of the *Boletus* group, *Agrocybe aegerita, A. bisporus, Pleurotus eryngii, and ostreatus*, with -glucans and chitin serving as the major fibre polysaccharides. Compared to soluble dietary fibre (0.32-2.20 g/100 g edible weight), mushrooms have larger quantities of insoluble dietary fibre (2.28-8.99 g/100 g edible weight). With a variation in the dietary fibre fractions dependent on the type of mushrooms, -glucans make up 4–13% of the total fibre (Manzi *et al.*, 2004) [16]. Since they have been shown to have the ability to modulate humoral and cellular immunity as well as to stimulate the immunomodulatory response, beta-glucans have been recognised as useful substances (Wakshull *et al.*, 1999) [17]. Therefore, because of their anti-infective, anticytotoxic, antimutagenic, and anti-tumorogenic qualities, they have been intriguing candidates for pharmaceutical drugs. Additionally, beta-glucans are employed as anticoagulants.

**Amino acids and protein**

In addition to carbs, protein makes up most mushrooms. Because of the significant species differences across mushroom species as well as the usage of various conversion factors determined by the Kjeldahl technique, there are significant variances in the concentration of crude protein. Although many scientists routinely calculated the amount of crude protein in mushrooms using the nitrogen conversion factor of 6.25, (Guillamón *et al.*, 2010; Rajarathnam and Shashirekha, 2003) [14, 15] chitin, which has a high percentage of non-protein nitrogen, was multiplied by 4.38. When mushrooms were air dried at 40 °C or frozen at –20 °C, the protein content reported as a percentage in dry matter essentially did not change, while boiling fresh mushrooms resulted in a considerable decrease (Barros *et al.*, 2007) [18].

**Vitamins**

Due to its high quantities of riboflavin (vitamin B2), niacin, folic acid, and traces of vitamin C, vitamin B1, vitamin D, carotene (a precursor to vitamin A), vitamin E, and vitamin B12, mushrooms have been regarded as a rich source of vitamins (Mattila *et al.*, 2001) [19]. The B-complex vitamins (niacin, thiamine, and B12) and folic acid found in mushrooms are particularly noteworthy. Even when they are grown on lignocellulosic wastes, their capacity to assemble these vitamins finally proves their biosynthetic abilities. The existence of the B12 and folate synthetase enzyme systems in mushroom cells has been shown (Rajarathnam and Shashirekha, 2003) [15]. Unlike plants, mushrooms carotenoids, particularly those that potentially serve as antioxidants, appear to be scarce retinol precursors. Since there is no other natural food source that can feed vegetarians with vitamin D mushrooms. They are the only source of vitamin D that is not derived from animals. There is an incredible quantity. of vitamin D2 (Ergocalciferol) in a variety of wild mushroom species but is nearly non-existent in due to lack of sunlight exposure, farmed species (Mattila *et al.*, 2001) [19]. It is generally known that photoirradiation creates vitamin D2 from its precursor ergosterol. Ergosterol undergoes photolysis when exposed to UV light, producing a variety of photoirradiation products, primarily provitamin D2, tachysterol, and lumisterol. The provitamin D2 then undergoes spontaneous thermal rearrangement to vitamin D2 (Mattila *et al.*, 2002) [20]. Jasinghe and Perera (Mattila *et al.*, 2001; Jasinghe *et al.*, 2006) [19, 22] showed that a number of variables, including the irradiation time and temperature, the moisture content of the mushrooms, and the kind and intensity of the UV irradiation, influenced the conversion of ergosterol in mushrooms to vitamin D2. Ergosterol is unevenly distributed throughout the shiitake mushroom. Since this method provided a high conversion rate that was roughly four times that when the gills were facing away from the source of

irradiation, it was possible to maximise the conversion of ergosterol to vitamin D2 (Mattila *et al.*, 2001) [19]. After exposing the mushrooms to UV light for one hour on each side, the conversion was fully complete (Jasinghe *et al.*, 2006) [22]. Mushrooms contain of ergosterol, for vegetarians and vegans who only get a little amount of ergocalciferol from meals of animal origin, the comparatively high ergosterol concentration may be significant (Kalac, 2009) [12]. There are several different minor sterols that are found in mushrooms, including fungi sterol, ergosta-5,7-dienol, 24-methyl cholesterol, and methylene cholesterol (Mattila *et al.*, 2002) [20].

**Lipids**

Fat content in mushrooms is often low. All different lipid molecules are represented in the fat, including free fatty acids, mono-, di-, and triglycerides, sterols, sterol esters, and phospholipids (Rajarathnam and Shashirekha, 2003) [15].

**Minerals**

Mushrooms have a good amount of several different mineral elements. Ash content of mushrooms was found to be between 6 and 10.5% of the dry mass; Kalac (2009) [12] confirmed this finding by estimating it to be between 5 and 12%. Potassium, phosphorus, magnesium, calcium, copper, iron, and zinc are the main elements found in ash (Kalac, 2009; Guillamón *et al.*, 2010) [12, 14]. Potassium is not distributed evenly in fruiting bodies. The concentration of it suggests a Cap > stipe > spore-forming portion > spores, in decreasing sequence (Kalac, 2009) [12]. Additionally, certain species contain germanium, which can keep people alive (Rajarathnam and Shashirekha, 2003) [15].

The unique ability of mushrooms to store accessible minerals in their growing medium. This trait can be contradictory since, in addition to being helpful in supplying necessary minerals in sufficient amounts, it can also be harmful to consume when hazardous elements build up (Kalac, 2009; Rajarathnam and Shashirekha, 2003) [12, 15]. Potassium and phosphorus can build up in the fruiting bodies of mushrooms. Potassium and phosphorus concentrations are 20–40 and 10–50 times greater, respectively, than those in the underlying substrates. On the other hand, mushrooms growing in heavily polluted environments or some accumulating species tend to have noticeably greater levels of hazardous components, even one or two orders of magnitude more than those in substrates. The development of has received a lot of attention. trace amounts of heavy metals, particularly dangerous ones like silver, tin, lead, mercury, chromium, and poisonous metals like cadmium and arsenic (Kalac, 2009; Guillamón *et al.*, 2010) [12, 14].

**Flavouring ingredients**

According to Kalac, the octane derivatives 1-octene and 2-octene, alcohols and their esters with volatile fatty acids, and ketones make up the distinctive group of mushroom fragrance. One of the main contributors is 1-octen-3-ol, sometimes known as mushroom alcohol (Kalac, 2009) [12].

**Poisonous mushrooms' toxic ingredients**

There are hundreds of different types of mushrooms, but only 30-50 of them are deadly. While just 10 types of mushrooms are severely toxic, they account for around 70% of all natural poisoning cases and frequently result in fatalities. Instead of doing the practical testing of folklore claims, learning the physical characteristics of each species of poisoned mushrooms is the best method to reduce danger. For instance, it has been demonstrated that cooking silver spoons with toxic mushrooms would not cause them to turn black (Rajarathnam and Shashirekha, 2003) [15].

The most toxic and poisonous mushroom, *Amanita phalloides*, or the "green death cap," is to blame for 90–95% of fatal mushroom poisonings. Amanita poisonings are caused by harmful substances such cyclic peptides, amatoxins, and phallatoxins. As dangerous as *A. phalloides*, *Amanita virosa* is known as the "destroying angel" and contains the amatoxin amaninamide. Mushroom poisons have been shown to be amino acids with a structure like glutamic acid. *Clitocybe acromelalga* produces acromeric acids, which are exceptionally strong glutamate agonists and neurotoxins. The most well-known toxic mushroom in the world is *Amanita muscaria*, which has a vivid red crown with white dots on it. These mushrooms belong to the species *Inocybe*, which contains a poisonous toxin called muscarine in large amounts. Additionally, some alkaloids, such as psilocybin and psilocin, which are present in the majority of *Psilocybe* species, can affect the central nervous system due to similarities in their structure and mode of action to the hallucinogen lysergic acid diethylamide (LSD) (Rajarathnam and Shashirekha, 2003) [15].

**Antibacterial capacity**

Antibacterial and antioxidant characteristics of mushroom polysaccharides might be examined in order to better understand how well they fight cancer, as there may be connections between their biological mechanisms. The body of data suggests that polysaccharides are the main cell recognition signals. Practical applications to the prevention and treatment of many illnesses, including cancer, will result from the insights on the involvement of certain polysaccharides in recognition. Since -D-glucans are not produced by humans, the immune systems of humans can identify them as alien molecules. These substances can activate innate and adaptive immune responses (Brown, G. D., & Gordon, S. 2005) [23]. It is well acknowledged that cells identify one another by having complementary pairs of features on their surfaces. An extension of the lock-and-key idea, these cell structures contain biological information that is encoded and decoded by the structures on other cells (Sharon, N., & Lis, H., 1993) [24]. For instance, to infect a host and spread illness, viruses, bacteria, or protozoa must be able to cling to at least one tissue surface. The body's natural cleansing processes sweep infectious pathogens lacking such capability away from possible infection sites. Bacterial adhesion differs not just across tissues but also between species, and occasionally even between members of the same species, depending on the individual's age, genetic make-up, and state of health. For instance, Streptococci exclusively colonise the upper respiratory tract and skin, but E. coli likes to cling to the tissues surrounding the ducts that link the kidneys and the bladder. It has been suggested to utilise sugars for both prevention and therapy as bacterial adhesion is so important for infection. When used as molecular decoys, sugars with the potential to selectively prevent adhesion can stop harmful bacteria before they reach their tissue targets. It has been shown that bacteria may occasionally connect to sugars inside the structure as well as the terminals of surface carbohydrates. Furthermore, various bacteria may adhere to

various regions of the same carbohydrate. There is strong experimental support for the idea that infection starts when bacteria adhere to the sugars on the surface of the host cell (Sharon, N., & Lis, H., 1993) [24].

Carbohydrate- directed interactions between cells are important for the proper operation of the immune system as well as pathogenic events. The spread of cancer cells from the primary tumour throughout the body is another illness that cell- adhesion molecules may be involved in. In one experiment, melanoma cells were treated with lactose-containing substances before being injected into mice. The outcome demonstrated that the cells' ability to propagate metastatic ally was diminished (Sharon, N., & Lis, H., 1993) [24]. Hence, anti-adhesive drugs may turn out to be anti-metastatic. Certain polysaccharides obtained from mushrooms, such as those from *Lentinula edodes* against *Bacillus cereus, Listeria monocytogenes,* and *Staphylococcus aureus*, have been demonstrated to have antibacterial action (Venturini *et al.*, 2008) [25]. *Pleurotus ostreatus* polysaccharide extracts against *Bacillus subtilis,* and *E. coli.* (Wolff *et al.*, 2008) [26]. The two types of mushrooms' polysaccharides also have anticancer properties since the former prevented breast cancer, and the latter was effective against Ehrlich ascitic tumour (Wolff *et al.*, 2008) [26]. Therefore, a better understanding of polysaccharides structures and their antibacterial abilities could hypothetically provide a clue for clearly describing their anticancer abilities.

**Antioxidant capacity**

Basically, the generation of reactive oxygen species (ROS) occurs during regular cell metabolism, which is a frequent biological function. As it is crucial for many different biological processes, oxygen is also necessary for life. However, excessive ROS production can cause a variety of illnesses and hasten the ageing process (Luo *et al.*, 2008) [27]. Because too many oxygen-derived free radicals can change into more reactive forms like superoxide, hydroxyl, and hydrogen peroxide, which can start unchecked chain reactions, lipid peroxidation, or autooxidation events (Halliwell *et al.*, 1994) [28]. This can lead to oxidative damage within cells. Additionally, they have the potential to disrupt DNA and result in cell injury, necrosis, or apoptosis, which can lead to bodily dysfunction and several disorders include cancer, cardiovascular disease, and diabetes (Tian *et al.*, 2011) [29]. Natural antioxidants from fruits, vegetables, cereals, herbs, and seeds, such as -tocopherol, ascorbic acid, and carotenoids, are therefore preferred in dietary applications to create team-based defensive mechanisms. Mushrooms have also been explored as a possible source of powerful antioxidants, as evidenced by the exceptional anti-oxidative properties of their bioactive, particularly polysaccharides. In addition, mushroom polysaccharides are useful against malignancies. Theoretically, they could also be able to show cancer's occurrence from the start. Therefore, in order to perhaps aid in the discovery of the mechanisms that may be employed to prevent cancer, it is vital to learn more about the antioxidant properties of mushroom polysaccharides.

**Edible Mushroom**

The fleshy and palatable fruiting bodies of several macro fungal species are categorized as edible mushrooms. They can appear above ground (epigeous) or below ground (hypogenous), where they can be manually harvested. A nice taste and aroma as well as the absence of harmful effects on humans can be used to characterize as edible substances. Because of their culinary and nutritional significance, edible mushrooms are consumed.

**Examples of edible mushroom**

**Commercially cultivated species**

*Agaricus bisporus, Pleurotus sp., Lentinula edodes, Auricularia heimuer, Volvariella volvacea, Flammulina filiformis, Tremella fuciformis, Hypsizygus tessellatus.*

**Commercially harvested wild fungi species**

*Boletus edulis, Calbovista subsculpta, Calvatia gigantea, Cantharellus cibarius, Morchella* spp.

**Other edible wild species**

*Agaricus arvensis, Agaricus silvaticus, Aleuria aurantia, Boletus badius, Calocybe gambosa.*

**Conditionally edible species**

*Amanita fulva, Amanita muscaria, Amanita rubescens.*

**Edible Mushroom**

***Agaricus bisporus* (button mushroom)**

The most widely farmed mushroom in the world is *A. bisporus*, which belongs to the *Agaricus* genus. These edible mushrooms are now extensively used and researched for their potential medical and therapeutic benefits. Since lectins from *Agaricus bisporus* has been proven to be powerful immune stimulants, this macromolecule might be used in pharmaceuticals and as food for healthy people. Extract from *A. bisporus* has been demonstrated to stop cell development of breast cancer (Valverde *et al.*, 2015) [31].

**Fig 1:** *Agaricus bisporus* fruiting body on casing soil (ISLAM, M. S)

Three new strains of *A. bisporus* have been created by the Directorate of Mushroom Research (ICAR-DMR), and they are NCH-102, NCS-100, and NCS-101 (hybrid). *Agaricus bisporus* has two colour states while it is still an immature: white and brown. Each of these states has a different name, and the adult state has even more names. The pileus or cap of the original wild species has broad, flat scales on a lighter background that progressively get dimmer toward the margins. It has a light grey-brown tint. Its initial shape is hemispherical before it flattens out as it ages and has a diameter of 5–10 centimetres. This mushroom comes in at number four with 15% of the world's production. The grasslands of Europe and North America are home to the edible basidiomycete mushroom known as *Agaricus bisporus*.

***Pleurotus* spp. (Oyster mushroom)**

One of the most often consumed mushrooms, *P. ostreatus*, belongs to the genus Pleurotus of gilled mushrooms. Some *Pleurotus* spp. go by the names oyster, abalone, or tree mushrooms. Additionally, *Pleurotus* fungi have been employed in the mycoremediation of contaminants like polycyclic aromatic hydrocarbons and petroleum. The caps could have lateral attachments (with no stipe). When a stipe exists, it is typically eccentric, and the gills run decurrently along it. Any mushroom having this basic form is referred to as pleurotoid.

The spores are elongated and smooth (described as "cylindrical"). Clamp connections connect the hyphae where they come together. Most of the species of Pleurotus are monomitic, and it is not thought of as a bracket fungus (with a soft consistency). Amazingly, *Pleurotus dryinus* occasionally becomes dimitic, which means it has more skeleton hyphae and has a harder consistency like bracket fungus. (Valverde *et al.* 2015) [31]

**Fig 2:** Pleurotus sp. or "oyster mushroom" possesses medicinal properties and health-promoting effects (Valverde *et al*., 2015) [31]

***Lentinus edodes* (Shiitake mushroom)**

The world's top variety, accounting for 22% of all production, is a superior culinary and therapeutic mushroom. Technology for production, processing, and spawn is accessible at ICAR-IIHR. Origin is from East Asia, the edible fungus *Lentinus edodes* is now grown and eaten all over the world. In certain traditional medical systems, it is regarded as a therapeutic fungus. The most researched species, *Lentinus edodes*, appears to exert antibacterial effects on both gram-positive and gram-negative bacteria (M. Alves *et al*.). Due to its beneficial benefits on human health, *Lentinus*. *L. edodes*, sometimes known as the "shiitake mushroom," has been utilised for many years to research functional qualities and isolate chemicals for medicinal use. It has been used for hundreds of years to treat the common cold, and some scientific research has backed up this claim (M. Eurola *et al*.).

**Fig 3:** *Lentinus edodes* or "shiitake mushroom." (Valverde *et al.* 2015) [31]

***Auricularia Polytricha* (Wood ear mushroom)**

The genus *Auricularia* belongs to the family Auriculariaceae of fungus. Basidiocarps (fruit bodies) are typically gelatinous and ear-shaped, with an underside that is smooth, wrinkled, or veined and an upper surface that ranges from faintly downy to noticeably hirsute. On wood, all species flourishes. In China and East Asia, several *Auricularia* spp. are grown extensively for commercial purposes and are edible. All *Auricularia* spp. produce fruit bodies that are up to 120 mm broad, 5 mm thick, shelf-like, or ear-shaped, and are made of thin, brownish, rubbery-gelatinous fruit bodies. Fruit bodies can be seen alone or in groups. Fine pilose to dense hirsute hairs cover the upper surface. The underside of the spore-bearing structure might be smooth, wrinkled, veined, or reticulate (net-like). Occasionally, unpigmented white forms are found. 18% of the world's production is in this and occupies the third place. The majority of *Auricularia* spp. are cultivated commercially in China and are edible. In addition to having anticancer and anticoagulant effects, *A. polytricha* is thought to be beneficial at lowering LDL cholesterol and aortic atherosclerotic plaque (J. Yu *et al*.; Razak *et al*., 2013) [36].

**Fig 4:** *Auricularia Polytricha* fruit body (Razak *et al*., 2013) [36]

***Volvariella volvacea* (Paddy Straw mushroom)**

5% of the world's manufacturing, primarily in China, is popular in the Indian state of Odisha. India has access to both spawn and production technology. Because the paddy straw mushroom has a good balance of all characteristics, including flavour, scent, delicacy, high protein content, vitamins, and minerals, its acceptance is on par with that of the extremely well-liked white button mushroom. It is an edible subtropical and tropical mushroom. Primordia, which are teeny-tiny clusters of white hyphal aggregates, are the precursors of fruiting bodies, which evolve through several morphological phases. The following phases are referred to as "button," "eggs," "elongation," and "mature," accordingly. The 'button' stage is where differentiation is initially visible. At maturity, the buttons get larger, and once the volva ruptures, fruit bodies that resemble umbrellas appear.

A kind of edible fungus known as *Volvariella volvacea* is farmed across East and Southeast Asia and is widely utilised in Asian cooking. In the areas where they are grown, they are frequently found fresh, but elsewhere they are more frequently found canned or dried. The third-most popular mushroom consumed globally is straw mushroom [ISLAM, M. S].

**Fig 5:** *Volvariella volvacea* fruiting body on straw bed. (ISLAM, M. S.)

**Medicinal Mushrooms**

Fungus used in the development of pharmaceuticals are known as medicinal fungi because they either naturally create metabolites or can be coaxed to do so through biotechnology. Antibiotics, anti-cancer medications, inhibitors of cholesterol and ergosterol synthesis, psychiatric drugs, immune-suppressants, and fungicides are some of the substances that have been successfully developed into drugs or are currently being researched. Research on medicinal mushrooms has revealed potential benefits for the heart, against cancer, against viruses, against bacteria, against parasites, against inflammation, against hepatitis, and against diabetes.

**Examples of medicinal mushrooms**

***Hericium erinaceus* (Lions Mane Mushroom)**

A beneficial and edible fungus called *Hericium erinaceus* is native to numerous regions of eastern Asia. Though a spiny mushroom may not seem appealing, Lion's Mane is well-known for its intense pharmacological activity. The fungus is easily recognised by the long spines that emerge from its fruiting body, earning it the nicknames "the hedgehog mushroom" or "the bearded teeth fungus." It contains anti-tumour, hypoglycemia, and perhaps anti-aging effects in both its fruiting body and its fungal mycelia. Additionally, some scientific evidence supports the effectiveness of lion's mane as a "brain food," or a substance that improves cognition, memory, and focus. The importance of *Hericium erinaceus* as a medicinal fungus has been well recognised, and many of its bioactive components have been turned into dietary supplements and complementary treatments. However, it is frequently unclear how the active ingredients that produce the symptoms seen correspond to one another. There are various groups of bioactive compounds that can be produced by both the mushroom and fermented mycelia, including polysaccharides, proteins, lectins, phenols, and terpenoids. Most intriguingly, it has been discovered that two types of terpenoid chemicals, hericenones and erinacines, from cultured mycelia and fruiting bodies, respectively, induce the synthesis of nerve growth factor (NGF) (Thongbai 2015) [37].

***Ganoderma lucidum* (Reishi Mushroom)**

Lingzhi, or *Ganoderma lucidum*, is a polypore fungus (or "bracket fungus") that is indigenous to East Asia and a member of the genus Ganoderma. It is often referred to as Reishi. Its reddish-brown varnished kidney-shaped head with bands and peripherally inserted stem give it a distinctive fan-like appearance. The Lingzhi is soft, flat, and cork-like when it is young. Its underside is devoid of gills, and it instead exudes yellow spores through tiny pores (80–120 m). Consuming Lingzhi mushrooms or their extracts has no discernible impact on human health or disease, according to the available research. *G. lucidum* is distinct among farmed mushrooms in that its medicinal rather than nutritional value is of utmost importance. Commercial *G. lucidum* products come in a wide range of shapes and sizes, including powders, dietary supplements, and tea. These are made from various mushroom components, such as mycelia, spores, and fruit bodies. The specific uses and claimed health advantages of Lingzhi include regulating blood sugar levels, immune system regulation, hepatoprotection, bacteriostasis, and more (Wachtel-Galor *et al.*, 2011) [38]. The *G. lucidum* mushroom's bioactive ingredients have a wide range of medicinal benefits for treating a wide range of illnesses, including hepatopathy, nephritis, chronic hepatitis, hypertension, arthritis, neurasthenia, hyperlipemia, insomnia, bronchitis, asthma, gastric ulcers, atherosclerosis, diabetes, leukopenia, anorexia, and cancer. Despite the extensive body of research, *G. lucidum* is primarily utilised as a health supplement and immune booster rather than for medicinal purposes (Batra *et al.*, 2013) [39].

**Fig 6:** Lingzhi or reishi, *Ganoderma lucidum*, cultivated on bags filled with sawdust (Money, N. P. (2016) [45]

***Cordyceps* spp. Mushroom**

About 600 species of ascomycete fungi (sac fungi) belong to the genus *Cordyceps*. A small number of *Cordyceps* spp. are parasitic on other fungus, but the majority are endoparasites that prey mostly on insects and other arthropods. The elongated fruit body (ascocarp), which can be cylindrical, branching, or have complex shapes, invades, and eventually replaces the host tissue when a *Cordyceps* fungus assaults a host. The ascocarp contains numerous tiny, flask-shaped perithecia that are home to asci. These in turn contain ascospores that resemble threads, which typically fracture and appear to be infectious. They are thought to provide greater levels of energy and endurance, boost libido, assist the immune system, and fight weariness. There is some evidence that *Cordyceps* spp. can be used to treat rheumatism, arthritis, excessive cholesterol, kidney, and liver diseases, as well as bronchitis and other respiratory conditions. Additionally, *Cordyceps* may have anti-tumour properties. As certain rising diseases including cancer, SARS, AIDS, and swine flu have no comprehensive treatments yet, the anti-cancer agent cordycepin from *C. militaris* is projected to play evolutionary roles in the pharmacognosy sector, which can lead to create a viable base for pharmaceutical enterprises (Patel *et al.*, 2013) [40].


**Fig 7:** natural (A) and cultivated (B) *Cordyceps militaris* (Phull *et al*., 2022) [46]

***Wolfiporia extensa* (Poria)**

A member of the Polyporaceae fungi family is *Wolfiporia extensa*. It is a fungus that causes wood to deteriorate, yet it grows underground. It is famous for the growth of a sizable, long-lasting, and tiny coconut-shaped subsurface sclerotium. *W. extensa* is a medicinal mushroom that is widely utilised in Chinese medicine. Encourage urine, energise spleen function (i.e., the digestive function), and relax the mind are all indications for usage in traditional Chinese medicine.

A research paper has provided an overview of Poria's effects both *in vitro* and *in vivo*. They studied *in vitro* the effects of Poria polysaccharide extracts and their derivatives on human cancer cell lines for stomach, breast, liver, and leukaemia (Li *et al.*, 2019) [41]. The liver cancer cells showed promising outcomes, with cell growth suppression being noted. According to this information, administering Poria together with chemotherapy can be useful. According to a review of studies on cancer cells, the Poria mushroom's capacity is to activate immune cells crucial for innate immunity, resulting in an improvement of natural defensive systems, may be directly related to the good anti-tumour effects seen. Increase cytokines to support natural killer cells' capacity for cell eradication, promote controlled cell death (apoptosis), and Poria may be able to control key enzymes that limit the development, spread, and propensity for cancer in cancer cells.

**Fig 8:** The fruiting body of Mushroom Poria cocos. Poria cocos is an edible medicinal fungus known as “Fuling” in Chinese and has been used as a Chinese traditional medicine for more than two thousand years (Li *et al*., 2019) [41]

**Maitake /Hen of the Woods (*Grifola frondosa*)**

*G. frondosa* is a perennial fungus that frequently develops in the same location for several years in a row. *Grifola frondosa* is marketed as an anticancer medication, specifically for treating human stomach carcinoma. This effect is brought about by the induction of cell apoptosis, which could greatly speed up the anticancer action. (B. J. Shi *et al.*, 2007) [42]. *G. frondosa* develops from a sclerotium, a potato-sized underground tuber-like structure. The fruiting body, which can grow up to 100 centimetres in length, is made up of many spoon- or curled-shaped, greyish-brown caps with wavy borders. As the mushroom ages, the milky-white stipe (stalk) develops a branchy structure and toughens. Maitake, or *Grifola frondosa*, is said to protect the liver, strengthen the spleen, and strengthen qi. These days, most people utilise it to help with the treatment of malignancies and diabetes. In the past three decades, it has been shown that *G. frondosa* polysaccharides have several intriguing biological properties, including anticancer, immunomodulation, anti-oxidation, and anti-hyperglycemia. They can also have a significant impact on hematopoietic stem cells and skin (He *et al.*, 2017) [43]. A major public health issue worldwide is Type 2 Diabetes Mellitus (T2DM), a condition marked by impaired glucose, protein, and lipid metabolism as well as low-grade chronic inflammation and immunological dysfunction. *Grifola frondosa* possesses bioactivities that help diabetic rats' glycemic responses (Chen *et al.*, 2015) [44].

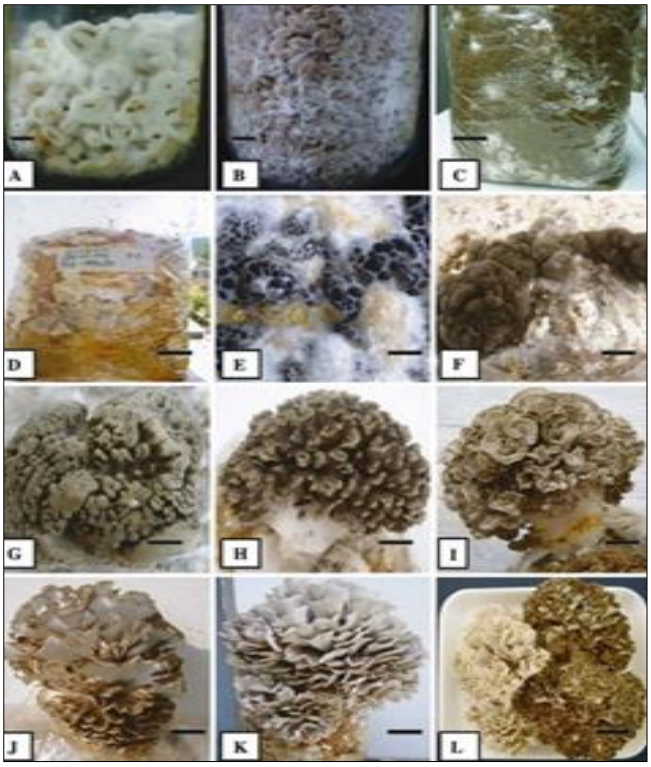


**Fig 9:** Maitake spawn on corn (a, scale: 1 cm) and barley (b, scale: 1 cm); Maitake fruiting body development in oak saw-dust substrate (c–l): undifferentiated white mycelia (c, scale: 2.4 cm), orange brown exudate (d, scale: 2.4 cm), dark grey exudate (e, scale: 1 cm), uneven topography when primordium stars to develop (f, scale: 1 cm), brain stage (g, scale: 1 cm), post-brain stage (h, scale: 1 cm), cauliflower stage (i, scale: 1 cm), cluster flower stage (j, scale: 3 cm), mature mushroom (k, scale: 3 cm), harvested mushrooms (l, left: older mushroom, right: young mushroom, scale: 3 cm) (Barreto *et al*., 2008) [47].

**Poisonous mushroom**

Biologically active mushrooms can be divided into three categories: poisonous, edible, and inedible. Even though just a handful of the 70–80 species of poisonous mushrooms are fatal when consumed, many of these deadly fungi are extremely harmful since they hauntingly resemble edible species. Amatoxins (Cyclopeptides), orellanus (*Cortinarius* spp.), gyromitrin (Monomethyl hydrazine), muscarine, ibotenic acid, psilocybin, and coprine are the seven primary groups of mushroom toxins (Lin YM, Wang TL.). The groups Amanitaceae (genus *Amanita*), Agaricaceae (genus *Lepiota*), and Cortinariaceae (genus *Galerina*) contain all amatoxin-producing fungus.

**Example of poisonous mushroom**

**Genus *Amanita***

Many toxic species can be found in the genus Amanita, which belongs to the family Amanitaceae. *Amanita phalloides, A. virosa, A. Verna, A. ocreata, A. bisporigera, A. suballiacea, A. tenuifolia, and A. hygroscopica* are only a few of the Amanita species that contain amatoxins. *Amanita* spp. can be toxic to people in some cases. White spores, a ring on the stem just below the cap, a veil (volva) ripped as the cap expands, and a cup from which the stalk emerges are characteristics of amanitas. Alpha-amanitin, a neutral component, betaamanitin, gamma, and delta-amanitin, as well as the non-toxic components amanullin is from *A. phalloides* and amaninamine from *A. virosa*, make up the family of amatoxin.

Bicyclic octapeptides called amatoxins are potent thermostable poisons. One of the nine identified amatoxins and the one with the greatest potency is α-amanitine. Amatoxin poisoning is frequently accompanied by ataxia, motor depression, euphoria, dizziness, gastrointestinal abnormalities, drowsiness, muscular twitching, and changes in insight, sentiments, and mood. The use of phenobarbitone or benzodiazepines during seizures is one of the primary suggested therapies for this poisoning (Michelot D *et al*., 2003; Satora L *et al*., 2006) [49, 50]. In patients who have been exposed to amatoxin, detoxification is crucial at the start of treatment, and they require close observation. In cases of severe toxicity, liver transplantation may be necessary. Phalloin, phalloidin, phallisin, phallacidin, phallacin, and phallisacin are among the phallotoxin family of toxins that are also present in the *Amanita* genus. This genus contains virotoxins as well, and they are closely related to the phallotoxins.

**Fig 10:** Image of the mushroom *Amanita phalloides*, commonly known as the death cap. (Santi *et al*., 2012) [65]

**Genus *Clitocybe***

Mushrooms belonging to the genus *Clitocybe* have gills that run down the stem, white, buff, cream, pink, or light-yellow spores, and a colour range from pale white to brown or lilac. Many of them are saprotrophic, decaying forest ground litter. The numerous genera are thought to have 300 or so species (Kirk *et al*., 2008) [54].

Muscarinic syndrome is brought on by *Clitocybe* spp. Due to the presence of muscarine in their chemical makeup, the species *C. dealbata, C. rivulosa, C. candicans, C. cerussata, and C. phyllophila* are all referred to in literature as dangerous mushrooms. After eating, the patient may experience gastrointestinal issues, miosis, hypersecretion, and in severe situations, bradycardia, and falls. This syndrome can be treated symptomatically, and atropine can be used to block muscarine's effects (Dehay MH *et al*., 2009) [52].

**Fig 11:** *Clitocybe amoenolens* is the culprit in several recent poisonings when eaten in France. Its similarity to other brown species of Clitocybe means all such species should be avoided for culinary purposes. (Stijve, T. (2001)) [66].

**Genus *Cortinarius***

In the family Cortinariaceae of mushrooms, the genus *Cortinarius* is found all over the world. (Bhambri *et al*., 2022) [53] With more than 2,000 widely distributed species, it is likely the biggest genus (Kirk *et al*., 2008) [54]. Young specimens of all species in the genus *Cortinarius* spp. have a cortina (veil) between the cap and the stem, giving the term, curtained, to the group of plants. The genus members are referred to by the popular names ‘cortinar’ and ‘webcap’. Non-expert ingestion of mushrooms from the genus is not advised due to the deadly toxicity of some species and the difficulty in differentiating between different species.

Up until 1950, the 2,000–3,000 species of mushrooms that make up the genus *Cortinarius* were thought to be non-toxic. From 1953 to 1962, there were 135 reported cases of *C. orellanus* related poisoning in Poland. A delayed acute tubulopathy that might develop into chronic renal insufficiency is a feature of poisoning syndrome (Danel VC *et al*., 2001) [55]. Because of the cyclopeptide orellanine, whose metabolites are thought to be most active, the mushrooms *C. speciosissimus and C. orellanus* have been shown in multiple case reports to be nephrotoxic. Additional research has demonstrated that the oxidation of orellanine in renal tissue can result in the accumulation of molecules called quinones that bind covalently to biological structures and cause cell harm (Karlson-Stiber and Persson, 2003) [1].

2 to 20 days after ingesting orellanine, poisoning symptoms may manifest. Initial symptoms for some patients include

nausea, vomiting, and discomfort in the abdomen. Intense thirst, chills, polyuria, or oliguria, and perhaps anuria follows. It may be necessary to undergo haemodialysis until renal function progressively gets better (Tegzes JH and Puschner B, 2002) [57]. Some *Cortinarius* spp. can be mistaken for *Psilocybe* spp., which are referred to as "magic" due to their hallucinogenic qualities. Because some people use *Psilocybe* mushrooms for recreational purposes, this fact has caused several incidents of unintentional intoxication (Wornle M *et al*.).


**Fig 12:** *Cortinarius albonigrellus* a. Basidiocarps b. Basidiospores (Uzun *et al*., 2013) [68]

**Genus *Gyromitra***

There are roughly 18 species of ascomycete fungus in the genus *Gyromitra*. They are a false morel, a deadly fungus of the species *Morchella* that is sometimes mistaken for an edible mushroom (morels). Due to their flavour, species of the genus *Gyromitra*, family Helvellaceae, are particularly appealing to hunters and food lovers. Some varieties of *Gyromitra* are extremely lethal when consumed uncooked, and these mushrooms have killed people. Clinical data are predominantly comprised of diarrhoea and vomiting, with jaundice, convulsions, and coma following. This poisoning can be distinguished by gastrointestinal problems. Hepatitis and neurological disorders can be brought on by excessive use. The primary species of concern are *G. esculenta and G. gigas* (Patocka *et al*., 2004) [59].

Gyromitrin is a well-known toxin found in some *Gyromitra* spp., but it is non-toxic in others. Toxic and non-toxic species can occasionally be hard to differentiate because they are mixed up, which is one of the causes of intoxications. The toxin is water soluble and volatile, which makes it possible to boil it for a long time and dry it up, allowing consumption without the risk of poisoning. However, if these steps are not taken carefully, intoxication could still happen (Patocka *et al*., 2004) [59].

False morels are referred to as the species *G. esculenta*, which are frequently confused with morels like *Morchella esculenta* and *M. elata*. The effects of this species are caused by the toxin gyromitrin. Not only have intoxications been brought on by eating fresh false morels, but also by breathing in cooking fumes. (Flesch F and Saviuc P; White J *et al*., 2003) [60].

**Fig 13:** *Gyromitra esculenta*. [Xie *et al*., 2022] [67]

**Genus *Psilocybe***

A genus of gilled mushrooms belonging to the Hymenogastraceae family called *Psilocybe* grows all over the world. Psilocybin, psilocin, and baeocystin, three hallucinogenic substances, are present in the majority or nearly all species. The name *Psilocybe*, which means "bare-headed" (Or "bald") in Greek, refers to the mushroom's detachable pellicle, or loose skin above the cap, which might resemble a bald pate. Psilocybin-induced hallucinogenic properties make species of the *Psilocybe* genus notable (Keller T *et al*., 1999) [63]. The *P. semilanceata, P. Mexicana, P. bohemica, P. cubensis*, and *P. baeocystis* are common psylocibin-containing mushrooms (Berger KJ and Guss DA, 2005; Lima *et al*., 2012) [62, 64].

Anxiety, nausea, vertigo, and asthenia are the first signs of intoxication, followed by neurosensorial symptoms like visual issues, disorientation, and motor incoordination, and sympathomimetic symptoms like mydriasis, tachycardia, and hypertension. These symptoms start to appear 30 minutes after ingesting fresh or dried mushrooms. After consumption, recovery is complete 4 to 12 hours later. Although myocardial infarction in adults may occasionally require hospitalisation, children may have hyperthermia, seizures, or a coma (Berger KJ and Guss DA, 2005) [62].

**Fig 14:** *Psilocybe* cyanescens, a psilocybin and β-carboline producer that occurs in Europe and North America. This species grows on lignin-rich substrates, such as wood chips, used to mulch plant beds or park areas. The mushrooms typically grow in clusters. (Lenz, C.*et al*., 2021) [69]

**Beneficial nature of toxic mushrooms**

Toxic mushrooms have a long history of development and use. Prior to clearly classifying and comprehending the molecular mechanisms of many toxic mushrooms, our forefathers began to use toxic mushrooms as tools based on their knowledge at the time. Some of these macrofungi were worshipped and venerated as gods and played important roles in some civilizations due to their psychedelic properties (e.g., *Amanita muscaria*; psilocybin-producing mushrooms) (Wasson and R.G., 1957.; Crundwell and E., 1987.; Furst and P.T., 2004; Carod-Artal 2015; Guzman, G., 2015) [70-74].

Biologically active polysaccharides can be found in mushroom fruit bodies, cultured mycelium, and culture broth. Medicinal mushrooms also involve antitumor polysaccharides as well as polysaccharide-protein complexes, which boost innate immune responses. Many mushroom extracts have also been shown to induce apoptosis or have anti-proliferative effects on carcinomas and cell lines (Wasser *et al*., 2002) [76].

*Ganoderma lucidum* (Reishi) aids in the inhibition of cancer cell viability in breast cancer caused by inflammation, as well as the inhibition of cell invasion and disruption of cell spheroids. G. lucidum reduces gene expression in cancerous cells involved in survival, proliferation, invasion, and metastasis (Martínez- Montemayor *et al*., 2011) [75]. Ganoderic acid DM (GADM) is a triterpenoid isolated from G. lucidum that has been shown *in vitro* to inhibit cell proliferation and colony formation in MCF-7 human breast cancer cells (Wu. G *et al*., 2012) [77]. Up until recently, two mannoga-lactoglucan-type polysaccharides isolated from *Lentinula edodes* fruiting bodies were found to have anti-tumour activity against Sarcoma 180 (S-180) solid tumour (Iteku *et al*., 2013) [78].

Nowadays, we can use poisonous mushroom toxins in a variety of ways thanks to new discoveries and knowledge. One of them is cytotoxic toxins from toxic mushrooms like amanitin, for example, can kill cells by inhibiting DNA transcription. As a result, scientists hypothesised that tumour targeting therapy using these toxins could be used to kill tumour cells and cure cancer (Andreev *et al*., 2007) [81]. One of the first tumour-associated antigens discovered was human epithelial cell adhesion molecule (EpCAM). It is overexpressed in many cancers, making it an ideal target for tumour cells. Researchers created an antibody-drug called a-amanitin-glutarate-chiHEA125 using chemical cross-linking (chiHEA125-Ama) (Baeuerle *et al*., 2007; Moldenhauer *et al*., 2012) [79-80]. Due to the unique dynamics of the toxins' effects on cells, many of them are or could be used as research tools in structural biology, developmental biology, cell biology, and other fields. At nanomolar concentrations, amanitin, for example, can specifically bind to RNA-polymerases II of eukaryotic cells, inhibiting transcription (Brueckner *et al*., 2008; Samwer *et al*., 2013) [84-85]. Other research which used toxins from toxic mushrooms, such as phalloidin and orellanine, generated similar results (Andreev *et al*., 2007; Buvall *et al*., 2010) [81-82].

Another kind of toxins known as hallucinogenic toxin would be psilocybin which is obtained from hallucinogenic mushrooms.

Psilocybin, when combined with psychological support, has the potential to safely treat a variety of psychiatric conditions, as an example this toxin has been used successfully to treat end-of-life depression and anxiety disorders. As per about one study, the beneficial impacts Psilocybin was discovered to be effective on 51 cancer patients who had life-threatening diagnoses and symptoms of depression and anxiety. At the six-month follow-up, approximately 80% of participants still had clinically significant decreases in depression and anxiety (Griffiths *et al*., 2016) [86] and powerful beneficial outcomes have been reported in these other research (Grob *et al*., 2011; Ross *et al*., 2016) [87-88]. Psilocybin can also help people overcome addictions like alcohol and tobacco, with a higher cessation rate (80%) than other behavioral and pharmacological therapies (typically 35%) (Johnson *et al*., 2014; Bogenschutz *et al*., 2015) [89-90]. Psilocybin is already widely used as a psychedelic in human studies, especially in neurobiology-related research, because of its relative safety (Hasler *et al*., 2004; Johnson *et al*., 2008; Carhart-Harris *et al*., 2017) [91-93]. For instance, it is used as a serotonin-2A receptor agonist, that assist in understanding the link with both stress hormones and both drug-induced and disorder-based psychotic states (Geyer *et al*., 2008; Petri *et al*., 2014) [94-95].

**Conclusion**

Many intoxications are reported each year in nations where mushrooms are widely consumed, mostly as a result of species misidentification. These species contain dangerous poisons that can cause a variety of deadly illnesses based on the volume consumed. It is challenging to prevent accidental mushroom consumption, especially in nations where eating wild animals is widespread. Proper identification is crucial to preventing mishaps and the identification of intoxication symptoms and indicators as the success of treatment is enabled as soon as possible. Commonly ingested mushrooms have been known to produce intoxications; hence, edible mushrooms and those with medicinal properties to identify potential, careful research must be done.

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