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Edible mushroom: occurrence, management and health benefits

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Abstract

Owing to medicinal and nutraceutical properties, mushrooms have been consumed worldwide for many years. They are valued for their unique flavor, texture, and versatility in cooking. Numerous species of edible mushrooms have different habitats, ecological niches, and growth patterns. In a vegetarian diet, mushrooms have been preferred and widely accepted over a non-vegetarian one because of their low-calorie, high-protein content and their good source of carbohydrates and lipids. Edible mushrooms provide various macronutrients, micronutrients, minerals, and vitamins. Bioactive compounds extracted from different species of mushrooms exhibit various medicinal properties, such as antitumor, antioxidant, hypocholesterolemic, antiallergic, anti-inflammatory, and hypoglycemic effects. These properties are mainly due to polysaccharides like β-glucan, polyphenols like phenolic acids and flavonoids, carotenoids, and vitamins. Edible mushrooms are also potential prebiotics and are beneficial for human gut health. Secondary metabolites extracted from edible mushrooms are used to develop drugs to treat chronic diseases. In conclusion, edible mushrooms contain essential food supplements and versatile food sources that provide numerous health benefits. Effective management of edible mushroom production is crucial to ensure their continued availability, quality, and sustainability. The study of edible mushrooms and their health benefits continues to be an area of active research, and additional benefits will likely be further discovered.

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Introduction

Fungi have been used since ancient times to treat several medical conditions and are recently more in demand for their medicinal properties[1]. About 2.2 to 3.8 million fungi species are estimated, out of which 120,000 are accepted. Medicinal mushrooms (MMs) are primarily members of the division Basidiomycota[2]. They are filamentous fungi having reproductive structures (fruiting bodies). They show various prominent pharmacological properties to human health[3]. The edible fruiting bodies have long been enjoyed as delicacies across the world, providing a wholesome experience and nutritional properties hand in hand. Such as *Fomes fomentarius* has been used since 450 BCE when the Greek physician Hippocrates categorized it as a potent anti-inflammatory and cauterization agent[4].Cauterization is a medical procedure that involves removing or burning a part of the human body to prevent bleeding, infection, and undesirable growth. In North America, mushrooms from the *Calvatia* genus have been used to treat wounds[2].

The increased understanding of mushrooms' good taste, nutritional, and therapeutic properties has resulted in a surge in mushroom cultivation. Mushroom cultivation requires composting, spawning, casing, harvesting, and washing[5]. Composting involves two phases; during the first phase, different organic matters are mixed to prepare a mixture, then microflora-like molds and bacteria are allowed to ferment the mixture. During the second phase, nitrogenous compounds and ammonia are treated and converted into microbial protein. It takes approx 20–30 d. The next step is spawning which takes 14 d. During spawning, mycelium is allowed to grow by inoculating the compost. After the proper growth of mycelium, they are ready to be planted. Finally, mushrooms are harvested through various methods and preserved.

China is the world's largest producer and consumer of farmed edible mushrooms, producing approximately 6,675,364 tonnes per year (almost 95% of global output), compared to about 294,656 tonnes per year in the rest of Asia. The medicinal value of mushrooms and their importance may likely enhance cultivation and consumption around the world in future. While the contribution of the European Union, the United States, and other sources remained at more than 3 billion tonnes per year[6]. India ranks 14th in global mushroom output, with 60,733 tonnes of mushrooms produced annually[7]. India has diversified soil, an abundance of agro-wastes, comparatively low-cost labor, and agro-climatic conditions that are perfect for mushroom culture and growth. During the monsoon season (June–October), the high humidity creates an ideal environment for mushroom development. In India, the government encourages mushroom cultivation by offering training and subsidies through various schemes such as the National Horticulture Board, the Ministry of Food Processing, and APEDA[7]. The rise in popularity of edible mushrooms increased with the development of a new scientific discipline known as functional food science, which encompasses a variety of functional

foods such as dietary supplements, foods rich in medicinal properties, vita foods consumed to improve mental and physical health, phytochemicals, mycochemicals, and pharma food, all of which are specifically designed and consumed for specific health benefits[8]. Around 30 genera with about 3000 species fall into the category of edible mushrooms, and approximately 700 are considered beneficial therapeutic mushrooms[9]. The most commonly cultivated mushroom species are shiitake (*Lentinula edodes*), oyster mushroom (*Pleurotus* spp.), white button mushroom (*Agaricus bisporus*), black fungus or wood-ear mushrooms (*Auricularia auricula*, *Auricularia polytricha*), and paddy straw mushroom (*Volvariella* spp). Increased awareness of their nutritional and medicinal qualities has fuelled demand, and they are now commercially grown and consumed worldwide[10]. They provide a good source of essential nutrients like copper (Cu), phosphorus (P), potassium (K), zinc (Zn), selenium (Se), riboflavin (vitamin B2), niacin (vitamin B3), choline, and vitamin B6 if supplemented in the consortium in regular diets[8]. . These mushrooms are considered primarily for their bioactive compounds over other foods, providing a resource material to boost the immune systems and prevent life-threatening diseases[11].

Mushrooms, which have been appreciated for their medicinal capabilities since ancient times, have seen a spike in popularity due to their possible involvement in treating a variety of medically significant disorders. Several recent studies indicate the potential benefits of introducing mushrooms in the diet, which might help us meet the daily nutrient requirements and be beneficial in preventing severe diseases. Several species of *Flammulina velutipes, Grifola frondosa, Ganoderma lucidium*, *Lentinula edodes,* and *Pleurotus ostreatus* are reported to carry free radical scavenging properties that play a pivotal role in reducing the potential adverse effects of reactive oxygen species, for instance, hydroxyl radical [OH], superoxide radical [O_2^-], and H_2O_2 carrying DNA nicking properties[3,5]. Mushrooms like *Agaricus bisporus, Flammulina velutipes, Lentinula edodes,* and *Pleurotus ostreatus*, have been seen as an effective hypocholesterolemic agents, aiding in reducing blood cholesterol levels. These medicinal properties are ascribed to the presence of secondary metabolites (SMs), which confer medicinal mushrooms as some superfood[9]. SMs are bioactive compounds produced in response to any stress and help the host survive by signaling and defensive mechanisms. They are considered not essential for the flourishing growth and reproduction of fungi[11].

However, the idea of SMs not being crucial for fungal survival has been challenged in recent scientific studies. Recent studies provided novel insights into these metabolites and their roles in better health. These metabolites are produced by biosynthetic gene clusters (BGCs) which are regulated in a way that is consistent and favorable for fungal development or in response to stress that can be both abiotic and biotic[11]. Thus review article focuses on the nutritional value of the mushrrom as a functional food, productivity and its application.

Mushroom management and cultivation

Management of mushrooms included various steps like preparation of media, inoculation, and filling of the containers, the spawn run, complete colonization, the rest period, maturation and harvesting, and initiation and pining[12] (Fig. 1). Hardwood chips, manure-based compost, and hardwood logs can be utilized as media. Inoculation of the substrate should be done and mixed into media. It majorly depends upon the cultivation location. The colonization of media is known as spawn run. This process runs for a few weeks or a few days and after that mushrooms appear. Complete colonization leads to the formation of colonized mycelia which is known as primordia. Temperature, light, and water affect the growth of primordia. It ruptures and enlarges based on these factors. After harvesting primordia growth stops or slows then it matures or enlarges[7]. The rest of the steps are important before the next flush because mycelia need proper rest for growth. Pest and disease management is done through various steps like maintaining cleanliness, use of predatory mites, and nematodes, monitoring, and integrated pest management. After harvesting and post-harvesting sorting and grading of mushrooms was done based on their size, appearance, and quality. This step is important based on market value. After packaging mushrooms are stored in a cool, humid environment that extends their shelf life[9]. Maintaining records of the cultivation process, including environmental conditions, pest and disease occurrence, and yield data improves edible mushroom management techniques and also optimizes future production[13].

Nutritional value of mushrooms

As more people switch to a vegetarian diet, mushrooms are becoming one of the choices. The essential constituents of edible mushrooms are carbohydrates, vitamins (A, B, C, D, and E), protein, minerals, and fiber. Because of their high protein content (200–250 g/kg DW), mushrooms have high pharmaceutical potential. Protein like lectins produced by edible mushrooms has various pharmaceutical properties like antibacterial, antitumoral, antifungal, and antiviral activity[14]. Different edible mushrooms also produce immunomodulatory proteins, which are used in cancer treatment as adjuvants[15]. Besides these compounds, mushrooms have many bioactive compounds like minerals, volatile oils, glycosides, carotenoids, terpenoids, alkaloids, tocopherols, flavonoids, folates, ascorbic acids, and lectins[16]. Mushrooms can also be considered as a good source of prebiotics due to their high polysaccharide content, like α- and β-glucans, chitin, mannans, galactan, and xylans[17,18]. Prebiotics are compounds that promote the growth of friendly microorganisms in the gut that improve the overall health of their host[17].

White button mushrooms increase and promote microbial diversity in the gut. It is also responsible for inflammatory responses and induces the production of the neurotransmitter catecholamines[19]. Reishi mushrooms (*Ganoderma lucidium*) can modulate the composition of microbes present in the gut and reverses dysbiosis. It also reduces inflammation and obesity. Mushrooms as prebiotics are an intense area of research[20].

Common mushrooms and their medicinal properties

Agaricus

Agarucu sblazei, A. polytricha, and *A. bisporus* are some of the most prominent species under the genus *Agaricus*. Among these, *A. bisporus* is the most cultivated in the entire

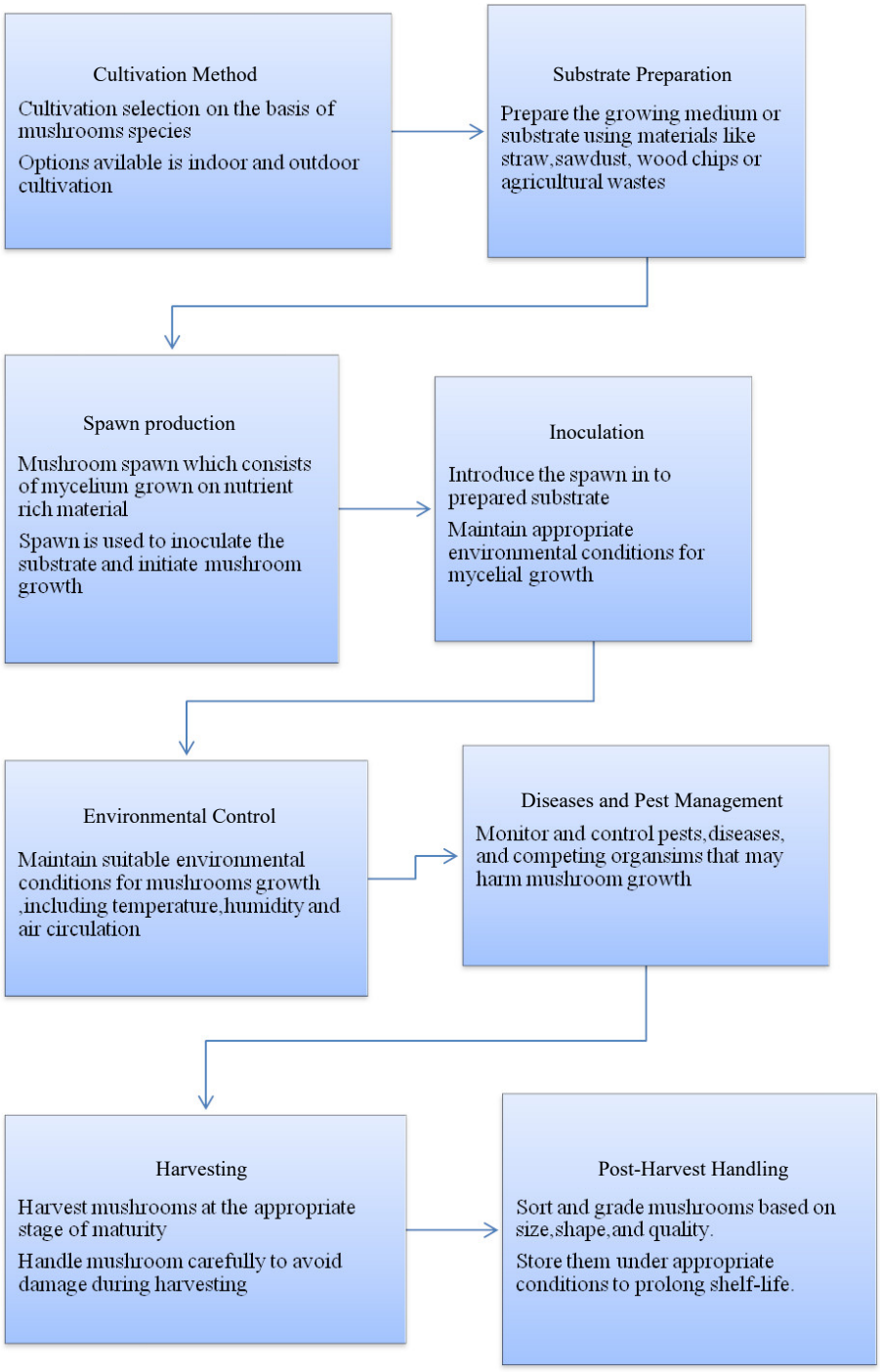

Fig. 1 Flow chart representing different stages of mushroom cultivation.

world. *Agaricus* extracts have many therapeutic and medicinal properties[21]. Lectin isolated from *A. bisporus* and *A. polytricha* was reported to be very effective immunostimulants[16]. Fruiting bodies of *A. blazei* have antimutagenic, anticarcinogenic, and immunomodulatory properties.

Many antioxidant compounds like phenolic compounds, *β*-glucans, tocopherols, and steroids are present in *A. blazei*. These compounds have medicinal properties and are widely used to treat various diseases including cancer, chronic hepatitis, diabetes, arteriosclerosis, and hyperlipidemia[22].

Ganoderma

Also known as Lingzhi or Reishi, *Ganoderma* is one of the edible mushrooms with a high level of medicinal properties. China, Korea, and Japan are leading producers of this mushroom. Chinese people use this mushroom for longevity and also to treat carcinoma and hypertension. *Ganoderma* has many medicinal properties, like antioxidant, anti-inflammatory, antiallergic, immunomodulating, and antitumor properties[21]. This mushroom has been used in cancer treatment for centuries as polysaccharides extracted from *Ganoderma*

possess anticancer properties. For the treatment of diabetes, and hepatitis, *Ganoderma* has been used as an adjuvant[23].

Pleurotus

Pleurotus is popularly known as oyster mushroom. It has been used for centuries because of its medicinal properties and has been cultivated worldwide. Compounds extracted from this mushroom have many nutraceutical properties. Bobek et al. reported that oyster mushroom has anti-inflammatory properties and can be used as a functional food. Some authors also reported that oyster mushroom has a hypocholesterolemic effect on model rats with hereditary cholesterol disorders and hypercholesterolemia or cholesterolemia[24]. *Pleurotus giganteus*, a popular culinary mushroom, contains dietary fiber (33.3/100 g of mushroom) and 15.4 g of protein. It is also a rich source of minerals like potassium (1,345.7 mg/100 g dry weight) and magnesium (67.64 mg/100 g dry weight). Also carbohydrate content of *Pleurotus giganteus* is much higher than other edible mushrooms[25]. About 40 species are reported under the genus *Pleurotus; some* common species are *P. eryngii, P. citrinopileatus, P. flabellatus, P. djamor, P. florida, P. sajor-caju,* and *P. ostreatus. Pleurotus pulmunarius* is known to have the highest amount of β-glucan[25]. Some of the most common mushrooms and their medicinal properties are shown in Table 1 and represented in (Fig. 2).

Bioactive compounds

Mushrooms like *Grifola frondose (*maitake), *Agaricus bisporus* (button mushroom)*, Phellinus linteus* (black hoof), *Ophiocordyceps sinensis,* and *Agaricus blazei,* show antidiabetic and hypoglycemic activity. Bioactive compounds of Maitake mushroom (*Grifola frondose),* when administered orally to diabetic mice, reduces blood glucose level[26]. Polysaccharides extracted from *Phellinus linteus* were also reported to have anti-diabetic properties and show hypoglycaemic activity in non-obese mice with diabetes[27]. Polysaccharides such as β-glucans can increase insulin secretion, which reduces blood glucose levels[28]. β-glucans and glycoproteins isolated from *Agaricus blazei* showed hypoglycaemic activity in the streptozotocin-induced diabetic rat[29,30]. Compounds such as flavonoids, phenols, terpenoids, tannins, alkaloids, glycosides, and saponins are present in *Pleurotus florida,* which have anti-diabetic properties.

Antioxidant compounds

Mitochondria play an essential role in adenosine triphosphate (ATP) production. When cells use O_2 to create energy, different types of free radical oxygen species are generated, known as Reactive oxygen species (ROS). Examples of various

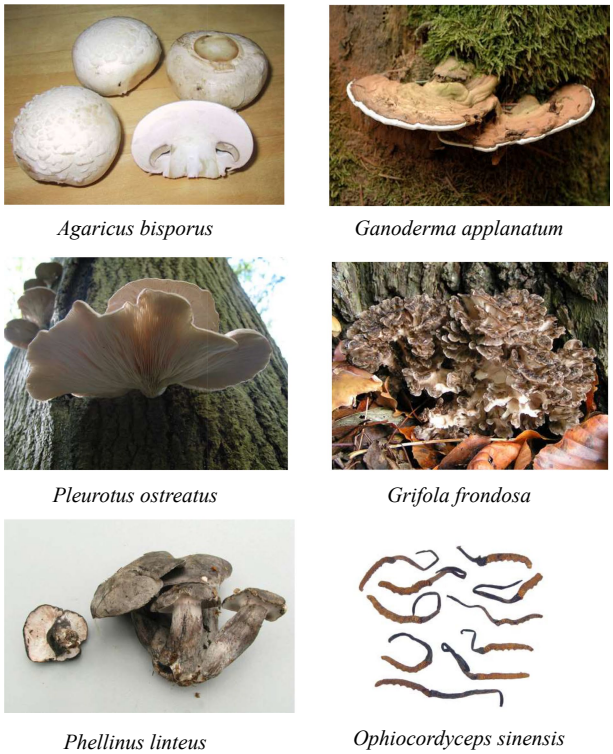

Fig. 2 List of some edible mushrooms including their scientific names. Sources: by user Chris73, CC-BY-SA-3.0, https://commons.wikimedia.org/wiki/File:ChampignonMushroom.jpg; by user Sarefo, CC-BY-SA-3.0, https://commons.wikimedia.org/wiki/File:-Ganoderma_applanatum_-_Lindsey.jpg; by user Jean-Pol, CC-BY-SA-3.0, https://upload.wikimedia.org/wikipedia/commons/f/f6/Pleurotus_ostreatus_JPG7.jpg; by user Siebot, CC-BY-SA-3.0, https://upload.wikimedia.org/wikipedia/commons/6/60/Eikhaas.JPG; by user Toter Alter Mann, CC-BY-SA-3.0, https://upload.wikimedia.org/wikipedia/commons/0/02/Boletopsis_nothofagi_fruitbodies.jpg; by user File upload Bot (Magnus Manske), CC-BY-SA-2.5, https://upload.wikimedia.org/wikipedia/commons/0/07/Cordyceps_Sinensis.jpg.

biological free radicals are NO• (nitric oxide), LOO• (lipid peroxyl), OH• (hydroxyl), NO_2• (nitrogen dioxide), OH– hydroxyl, ROO• (peroxyl), and various types of oxidants are H_2O_2 (hydrogen peroxide), LOOH (lipid peroxide), HNO_2 (nitrous acid), N_2O_3 (dinitrogen trioxide), HOCl (hypochlorous acid), $ONOO^-$ (peroxynitrite), $1O_2$ (singlet oxygen)[31]. When these free radicals are present in the human body at low concentrations, they can benefit the body as they play a role in cellular structure synthesis and immunity against microbial

Table 1. Common mushrooms and their medicinal properties.

Medicinal mushroom	Properties	References
Agaricus bisporus	Hypocholesterolemic and hypoglycaemic	[21]
Boletus edulis bull	Antitumor	[22]
Flammulina velutipes	Antioxidant, hypocholesterolemic and antiallergic	[10]
Grifola frondosa	Antioxidant, hypotensive, hypoglycemic, immunotherapy, andanti-inflammatory activity	[26]
Ganoderma lucidium	Hypoglycemic, antioxidant and antitumor, antiviral (HIV-1), antiallergic, anti-inflammatory, antihepatotoxic, cholesterol biosynthesis inhibitor, and antioxidative	[23]
Lentinula edodes	Antioxidant, hypocholesterolemic, immunotherapy, antimicrobial, and antiprotozoal	[10]
Pleurotus ostreatus	Antioxidant, hypocholesterolemic and antiallergic	[24]

pathogens. When the production and concentration of oxygen-derived free radicals become uncontrollable, known as oxidative stress, it leads to many health complications[32]. Antioxidants control oxidative molecules to achieve balanced ROS homeostasis. Antioxidants are compounds that protect the cells against free radicals. It can be endogenous or exogenous (dietary supplements). Endogenous antioxidant compounds can be enzymatic such as catalase, glutathione peroxidase, and superoxide dismutase, or can be non-enzymatic, like melatonin. Vitamins also serve as antioxidants such as E and C. Other antioxidant molecules include carotenoids and thiol antioxidants like lipoic acid and glutathione[33]. Another fungal system, such as *Aspergillus* (non-edible), also contains thioredoxin, glutathione S-transferase, superoxide dismutase, and catalase, which is also involved in redox homeostasis[34].

Polysaccharides

Carbohydrates are the most potent substance in mushrooms, with immunomodulating and antitumor properties. Different types of carbohydrates such as fructose, mannitol, trehalose, glucose, rhamnose, arabinose, xylose, maltose, fucose, and mannose are found in mushrooms. The fungal cell wall contains β-glucan[35]. It is a critical bioactive element of mushrooms**.** Adaptogens and immune stimulators are their primary functions, along with immunomodulating, antioxidant, anticancer, neuroprotective, and anticholesterolemic activities[36]. The immunostimulatory action of mushroom polysaccharides is mostly preventative and belongs to non-invasive treatments, helping to avoid infectious illnesses and tumor metastases[21,37]. These polysaccharides activate the immune response against pathogens.

Polyphenols

Polyphenols are the most prevalent antioxidant in the diet and can be classified into different subgroups like flavonoids, phenolic acids, lignans, and stilbenes. Phenolic acids are one of the major phenolic compounds present in mushrooms. Hydroxycinnamic acids and hydroxybenzoic acids are the subgroups of phenolic compounds and are derived from cinnamic acid and benzoic acids, which are nonphenolic molecules[38]. Derivatives of benzoic acids like Protocatechuic, 5-sulphosalicylic, homogentisic, *p*-hydroxybenzoic, gentisic, syringic, vanillin, vanillic along with common derivatives of cinnamic acids like *o*-coumaric, *p*-coumaric, ferulic, 5-*o*-caffeoylquinic, 4-*o*-caffeoylquinic, 3-*o*-caffeoylquinic, caffeic and sinapic are also found in mushrooms[39]**.** The presence of tannic acids and ellagic acids was also reported[39]. Polyphenols show their antioxidant activity by directly interacting with free radicals or initiating different pathways like Nrf/ARE[40]. They promote cell survival, prevent tumor growth, trigger apoptosis, and fight against infections (bacterial and viral) by a different mechanism[41]. Flavonoids are abundant in edible mushrooms. They are divided into six subclasses flavonols, isoflavones, anthocyanidins, flavones, flavanones, and flavanols[38].

Vitamins

Vitamin C (L-ascorbic acid)

Edible mushrooms contain an enormous amount of vitamin C (L-ascorbic acid)[39]. Ascorbic acid is recognized as a highly effective reactive species (RS) scavenger. It demonstrates effective efficiency in preventing lipid peroxidation and also surpassing other plasma components[42]. A higher level of ascorbic acid has been found in certain mushrooms as compared to some fruits and vegetables, which are generally taken in a regular diet as a source of vitamins. *Cantharellus cibarius* contains 100 mg/100 g (DW) dry weight of vitamin C (ascorbic acid) in the methanolic extract reported by Kozarski et al.[43].

Vitamin E (tocopherols)

Mushrooms contain commonly four types of tocopherols (α, β, γ, and δ). Among all tocopherols, α is the biologically most active form[39]. Edible mushrooms contain substantially lower levels of tocopherols as compared to several grocery items that are suggested as good sources of Vitamin E[39]. 0.02 and 200 µg/100 g DW tocopherol level is present in some mushrooms[44].

Ergothioneine

Ergothioneine (ET) is an amino acid containing a sulphur atom. ET is mainly obtained *via* the diet, and mushrooms are reported to be a significant source of ergothioneine[45]. Mushrooms contain about 400–2,500 mg/g of dry weight. Edible mushrooms also show hepatoprotective activity. Secondary metabolites produced by various edible mushrooms, like phenolics, terpenes, steroids, and some compounds in their cell wall, show hepatoprotective activity. Extracts of *Ganoderma lucidum, Phellinus rimosus, Pleurotus florida,* and *Pleurotus sajor-caju* were reported to have antioxidant and hepatoprotective activity[46].

Antitumor activities of edible mushroom

Cancer is globally recognized as a fatal disease, causing a significant number of deaths each year. According to the World Health Organization (WHO), approximately 10 million fatalities are attributed to cancer each year. In 2020, WHO reported several statistics regarding different types of cancer; Breast cancer: Approximately 2.2 million reported cases of breast cancer, resulting in 685,000 deaths; Lung cancer: About 2.21 million cases of lung cancer were noted, leading to 1,180,000 deaths; Colorectal cancer: Approximately 1.93 million cases were recorded with 935,000 deaths; Gastric cancer: 1.09 million reported cases of gastric cancer and causing 769,000 deaths (www.who.int). Mushrooms are a promising addition to a cancer-fighting diet approximately 200 species of edible higher basidiomycetes are reported to inhibit the growth of various cancerous cells. Recent studies in Japan, Korea, China, and the USA showed mushroom extracts have potential antitumor compounds[47].

The active compounds are derived from cellular components and secondary metabolites of edible mushrooms. They have been shown to enhance host resistance for the treatment of cancer[48]. Some of the bioactive extracts isolated from mushrooms used in various cancer treatments are presented in Table 2. Medicinal mushrooms produce complex secondary metabolites such as polyketides, triterpenoids, phenolic, and steroids. These compounds found to be essential in the treatment of various health problems, including cancer. Some of the complex compounds like quinones, cerebrosides, isoflavones, catechol, amines, triacylglycerols, steroids, organic, organic germanium, and selenium are considered low molecular weight compounds ranging from

12–190 kDa[64–67]. There are high molecular weight compounds ranging from 200–400 kDa, such as glycans, homopolymer, and heteropolymer glucan complexes[68]. Some antitumor compounds extracted from mushrooms are listed in Table 3.

In addition to antitumor properties, mushrooms are currently utilized as meat analogs in the USA by various renowned companies cooperating with local food places and e-market platforms. Meat analogs such as Plant Plus's meat dumplings, meat zongzi, and vegetarian beef meatballs have been introduced in such companies. Since edible mushrooms are a rich source of protein, there is an emerging field for producing edible mushroom meat analog proteins. *A. bisporus*, *L. edodes*, *P. ostreatus*, and *C. comatus* have been listed as raw material sources subjected to satisfy the artificial meat composites. The commercialization of edible mushroom meat analog proteins has been introduced as 'pickled fish fillets' made from *H. erinaceus*[75]. Furthermore, the application of mushrooms as medicinal agents has also been introduced during COVID-19 as an immune-stimulating agent. Studies are reviewed on the applicability of mushrooms as an adjuvant in vaccines. Still, due to the high risk of mortality during SARS-CoV-2 infection, this approach has yet to be implemented as allergic reactions from edible mushrooms to some individuals may interfere with the actual mechanism studied[76].

Table 2. List of bioactive extracts isolated from mushrooms used in various cancer treatments.

Cancer	Bioactive extracts	*In vitro* study	*In vivo* study	References
Breast	Ganoderic acid Methanol extract	*Agaricus bisporus, Cordyceps sinensis, Ganoderma lucidum, Inonotus obliquus, Poriacocos Tricholoma mongolicum*	*Agaricus bisporus, Ganoderma lucidum, Schizophyllum commune*	[49–52]
Colorectal	Methanol extract Polysaccharide's extract	*Grifola frondose, Inonotus oblicuus, Agaricus bisporis, Agaricus blazei*	*Agaricus blazei*	[53–55]
Gastric	Methanol extract	*Agaricus blazei*		[50]
Liver	Polysaccharide	*Agaricus blazei, Coriolus versicolor Lentinan, Cordyceps sinenses*	*Agaricus blazei, Ganoderma lucidum, Phellinus linteus, Schizophyluum commune*	[56–59]
Lung	Ethanol extract	*Agaricus blazie, Ganoderma lucidum, Inonotus obliquus, Lentinula edodes*	*Poria cocos*	[60]
Prostate	Fruit body powder	*Ganoderma lucidum, Lentinula edodes, Phellinus linteus*		[61–63]

Table 3. List of antitumor compounds extracted from various medicinal mushrooms.

Class	Antitumor agents	Mushroom species	References
Quinones	Panepoxydone	*Panus conchatus* *Lentinus crinitus*	[69]
	Cycloepoxydon	*Xylaria strain*	
	Clavilactones CB, CD and CA	*Cliticybe claviceps*	
	Quinone 490	*Agaricus bisporus*	
Amines	Putrescine-1,4-dicinnamide	*Pholiota spumosa*	[70]
Isoflavones	Genistein	*Flammulina velupites*	[69]
Triacylglycerols	1-oleoyl-2-linoleoyl-3-palmitoylglycerol	*Grifola frondosa*	[69]
Steroids	Ergosterol	*Grifola frondose* *Agaricus blazei*	[69]
	Lucidenic lactone Cerevisterol Ganoderiol F Ganodermanontriol	*Ganoderma lucidum*	[71–73]
	Dehydroebriconic acid	*Daedaleadic kinsii*	[69]
Organic germanium	Bis-β-carboxyethylgermaniumsequioxide	*Ganoderma lucidum*	[72]
Homoglucans	(1→3)- β-D-glucan with (1→6)-β-D branches: Lentinum	*Lentinus edodes*	[72]
	Schizophyllan	*Schizophyllum commune*	[74]
	Grifolan	*Grifola frondose*	[71,74]
	(1→3)-β-D-glucan with (1→2) or (1→6) branches	*Pachyman* from *poriacocos*	[37]
	(1→6)-β-D-glucan with (1→4)-α branches	*Agaricus blazei*	[37]
Heteroglucans	Galactoxyloglucan Mannogalactoglucan Xylogalactoglucan	*Hericiumerinaceus* *Agaricus blazei, Ganoderma lucidum* *Inonotuso bluquus*	[72]
Glycans	Glucogalactan	*Ganoderma tsugae*	[63]
	Xylan	*Hericium erinaceus*	[37]
Glycoproteins	Galactoxyloglucan- protein complex	*Hericinum erinaceus*	[74]
Glycopeptides	Polysaccharide peptide	*Trametes versicolor*	[74]
Proteoglycans	GLIS	*Ganoderma lucidum*	[72]
	PL	*Phellinus linteus*	

Conclusions and perspectives

Mushrooms are very common in food and used since ancient times for their medicinal properties. Edible mushrooms are a potential functional food. It can be a good choice among people who trying to lose weight because of its low-calorie content. Due to its high protein and low-fat content, it increases the nutritional level and is good for muscle building. The presence of various bioactive compounds provides mushrooms with many medicinal and nutraceutical properties. It does not only provide macronutrients like carbohydrates and proteins but also provides various micronutrients which are required daily. Edible mushrooms can be considered as a good source of vitamins, especially vitamin D as it presents in high amounts in various species of mushrooms compared to various other food items. To supplement vitamin D during an infection such as in the COVID-19 pandemic, mushrooms could be a valuable source to boost the requirement for vitamin D. It is a good option for people who follow a vegan lifestyle and those who are lactose intolerant, and those who only consume egg and milk for daily vitamin D requirement. Mushrooms can also be used to treat chronic diseases. They can also be considered good antioxidant dietary supplements because of the various compounds present in them. As an antioxidant, it helps to reduce oxidative stress in the tissue due to the generation of ROS and it can be used to detoxify the ROS in cancer patients. Different metabolite extracts of medicinal mushrooms and their mode of action require further investigation.

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Conflict of interest

The authors declare that they have no conflict of interest.

Dates

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