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Bioactive compounds of edible and medicinal mushrooms

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ABSTRACT

Edible and medicinal mushrooms have attracted considerable attention due to their nutritional composition and diverse bioactive compounds with potential health benefits. They are characterised by a rich nutritional profile, including high-quality proteins, dietary fibre, essential minerals and vitamins, which contribute to their role as functional foods. In addition to these nutrients, mushrooms contain various bioactive components such as polysaccharides (especially β-glucans), terpenes, phenolic compounds and sterols. These bioactive compounds are associated with numerous biological activities, including antioxidant, antimicrobial, anticancer, immunomodulatory, anti-inflammatory and neuroprotective activities. The combined nutritional and bioactive profile of edible and medicinal mushrooms supports their use in dietary strategies for health promotion and disease prevention. This review provides a comprehensive overview of the nutritional composition and bioactive components of edible and medicinal mushrooms, highlighting their promising role in promoting health and their potential in the production of functional foods and nutraceutical products. Special attention is given to some representative mushroom species, including *Hericium erinaceus*, *Ganoderma lucidum* and *Lentinula edodes*. Given the growing interest in natural health-promoting compounds, mushrooms represent a promising and sustainable resource for the future development of functional foods and nutraceuticals.

Introduction

Mushrooms have long been recognised not only as culinary delicacies but also as potent sources of nutrition and therapeutic agents. Botanically, mushrooms are the fruiting bodies of macroscopic filamentous saprophytic fungi, traditionally valued across ancient civilisations, including Greek, Egyptian, Roman, and Chinese cultures for their beneficial effects on human health. Out of an estimated 1.5 million fungal species, around 14,000 are known to produce fruiting bodies large enough to be classified as mushrooms, and at least 2,000 of these are suitable for consumption or medicinal use, though only around 35 species are cultivated commercially (Das et al., 2021; Assemie and Abaya, 2022). Edible mushrooms are considered functional foods due to their impressive nutritional profile and bioactive constituents (Kumar et al., 2021). Edible mushrooms play a valuable role in human nutrition due to their rich nutritional composition. They are naturally low in calories and fat, while providing a high content of dietary fibre. Moreover, they are a notable source of protein, making up between 19% and 37% of their dry weight and contain all essential amino acids in proportions that generally meet the dietary needs of adults (González et al., 2020). Furthermore, they contain minerals such as iron and phosphorus, and vitamins including thiamine, riboflavin, niacin, ergosterol, and ascorbic acid (Kumar et al.,2021). Owing to their umami flavour, fibrous texture and rich nutritional composition, mushrooms are increasingly recognised as a functional ingredient for enhancing the health and sustainability profile of protein-rich foods (Das et al., 2021). Beyond their nutritional attributes, mushrooms are a remarkable source of bioactive compounds such as polysaccharides (notably β-glucans and glycoproteins), terpenoids, alkaloids, polyphenols, sterols, lactones, sesquiterpenes, nucleotide analogues, and metal-chelating agents (Kumar et al., 2021). These compounds are responsible for a wide range of pharmacological effects. Numerous studies have confirmed the therapeutic potential of mushrooms, highlighting properties such as antioxidant, antimicrobial, antitumor, antiviral, anti-inflammatory, hepatoprotective, hypocholesterolaemic, immunomodulatory, antithrombotic, and antidiabetic activities (El-Ramady et al., 2022). Consequently, mushrooms are increasingly used in the development of nutraceuticals and pharmaceutical products aimed at preventing or treating various human ailments.

Medicinal mushrooms, in particular, have drawn significant scientific interest due to their role in modulating immune responses and managing chronic diseases (Zhao et al., 2020). They are valued for their ability to support the immune system, balance metabolic processes and help in disease prevention. Their richness in polysaccharides, polyphenols, amino acids, and vitamins makes them an important natural source of health-promoting bioactive compounds (Łysakowska et al., 2023). Certain medicinal mushrooms like *Ganoderma lucidum* and *Hericium erinaceous* have shown immunomodulatory effects, including activation of immune-related pathways and cytokine expression (Zhao et al., 2020). This review focuses on the nutritional composition and bioactive constituents of selected edible and medicinal mushrooms, with emphasis on their health-promoting properties and potential applications in functional foods and nutraceutical development.

Overview of classification and use of mushrooms

Mushrooms, classified as macrofungi, are increasingly recognised for both their culinary appeal and bioactive properties (Singh, 2025). They are widely distributed across the globe and belong primarily to the classes Basidiomycetes and Ascomycetes. These macrofungi are characterised by the development of a clearly visible fruiting body, which makes them easy to spot and harvest by hand. Most commonly, mushrooms are part of the *Agaricacea*e family and exhibit remarkable diversity in colour, shape, surface texture, and biological activity. They typically thrive on soil or decaying organic matter, such as wood and are especially abundant in damp and cool environments (Mwangi et al., 2022; Assemie and Abaya, 2022). Medicinal mushrooms include all types of macroscopic fungi whose extracts or powder forms, obtained at any stage of their growth, have demonstrated proven health-promoting effects (Zhao, 2020). Although most edible mushrooms possess medicinal properties, many species with medicinal effects are also edible, which makes the distinction between medicinal and edible mushrooms challenging (Mwangi et al., 2022). While a wide variety of mushrooms are consumed worldwide, only a small proportion is cultivated commercially, and the majority are still harvested from the wild (Katoch et al., 2023). Scientific advances have enabled the cultivation of certain species, but this represents only a fraction of their potential biodiversity. The conservation of mushroom biodiversity is essential for developing new cultivars and improving existing ones to increase productivity. Understanding taxonomy, habitat requirements and regional diversity lays the foundation for the sustainable use of key mushroom species (Katoch et al., 2023). The use of mushrooms for health purposes has a long-standing tradition in Asian cultures and is becoming increasingly popular in the West. However, mushrooms from European ethnomedical traditions remain underexplored, despite their promising pharmacological potential. Some species have been consistently used and documented in old herbal texts, and studies have confirmed their anti-tumour, anti-inflammatory, antioxidant and antibacterial effects. Nevertheless, modern scientific research on these species remains limited (Gründemann et al., 2020). Mushrooms are among the oldest foods and medicinal resources known to humans, valued both for their nutritional richness and therapeutic properties. In particular, their high content of edible and digestible protein contributes to their dietary importance, while their bioactive compounds play a role in disease prevention and management (Shirur et al., 2021). Macroscopic fungi, or mushrooms, have also been significantly less studied as potential pharmacological agents compared to plants in Europe. However, their prominent role in Traditional Chinese Medicine, along with recent pharmacological and chemical studies on specific mushroom species and their known bioactive compounds, suggests that mushrooms traditionally used in European folk medicine may also hold considerable potential, either as therapeutic agents themselves or as sources of isolated bioactive substances (Gründemann et al., 2020). In order to support the continued exploration and utilisation of medicinal mushrooms, there is a growing need for production systems that are both environmentally sound and economically viable, particularly if they are to serve as sustainable sources of nutritionally and pharmacologically valuable foods (Shirur et al., 2021).

Bioactive components of mushrooms and their biological effect

Mushrooms are recognised for their qualities in both nutrition and medicine. They offer a unique flavour, appealing aroma and significant nutritional value, making them a type of functional food that supports overall health. Additionally, mushrooms have been extensively used in therapeutic applications due to their rich content of various secondary metabolites, which are bioactive compounds with health-promoting effects (Ha et al., 2020). As summarised in Table 1, the principal bioactive constituents of edible mushrooms include polysaccharides, terpenes and terpenoids, proteins, sterols, and lipids. These compounds contribute to antioxidant, immunomodulatory, anticancer, antidiabetic, and anti-inflammatory effects demonstrated in numerous in vitro and in vivo studies (Kumar et al., 2021). Edible mushrooms are a rich source of essential nutrients, including vitamins, minerals, dietary fibre, and proteins, as well as a wide range of bioactive compounds with medicinal potential, such as polysaccharides, terpenoids, phenolic compounds, flavonoids, carotenoids, sterols, alkaloids, glycosides, tocopherols, folates, ascorbic acid, enzymes, and organic acids, among which polysaccharides and terpenoids are particularly notable due to their strong bioactive properties (Rangsinth et al., 2023; Seo and Choi, 2021; Pathak et al., 2022). Polysaccharides are the primary bioactive compounds in medicinal mushrooms, known for their wide range of health benefits, including antioxidant, anticancer, antidiabetic, anti-inflammatory, antimicrobial and immunomodulatory properties. Among them, glucan polysaccharides, especially β-glucan, stand out for their ability to lower blood sugar levels, combat microbial infections, and enhance immune function by activating macrophages (Elkhateeb et al., 2019). Polysaccharides are the main contributors to the immune-regulating properties of medicinal mushrooms, as they can bind to specific receptors on immune cell walls and activate targeted immune responses (Venturella et al., 2021). Polysaccharides from edible fungi have immunomodulatory effects by activating signalling pathways through membrane receptors and influencing the gut microbiota and immune organs. They enhance immune responses, promote cancer cell death, reduce metastasis, relieve chemotherapy side effects, and enhance immune cell infiltration into tumours. Additionally, some polysaccharide complexes can restore macrophage function and exhibit strong antitumor effects (Zhao et al., 2020; Yin et al., 2021). Terpenes are known for their wide range of biological activities, particularly their antioxidant, anticancer, antitumor and anti-inflammatory effects. Structurally, terpenes are composed of five-carbon isoprene units, whereas terpenoids are modified terpenes that contain additional functional groups and/or rearranged carbon skeletons Terpenes and terpenoids also play a significant role in modulating the immune system by enhancing the expression of genes involved in immune responses (Venturella et al., 2021; Elkhateeb, 2020). Terpenes, especially triterpenes found in mushrooms like Ganoderma lucidum and Inonotus obliquus, primarily exhibit anti-inflammatory effects by reducing the secretion of pro-inflammatory cytokines and mediators in immune cells. In addition to their anti-inflammatory properties, these compounds have demonstrated potential benefits in anticancer, antiviral, antimalarial treatments, and neurodegenerative diseases such as Alzheimer's (Łysakowska et al., 2023). Mushrooms are a valuable source of proteins with notable biological activities, including cytotoxic, anticancer, antioxidant, antiviral, antibacterial, and antihypertensive effects, which contribute to their therapeutic potential. In addition to these effects, mushroom-derived proteins exhibit immunomodulatory activity. Similar to polysaccharide-based compounds, these protein-derived bioactives can be classified into two main categories: fungal immunomodulatory proteins (FIPs) and lectins. FIPs are non-glycosylated proteins, whereas lectins are carbohydrate-binding proteins containing specific glycan moieties attached to a polypeptide chain. These compounds participate in various biological processes, including innate immunity and cell–cell interactions (Venturella et al., 2021; Zhao et al., 2020). Lectins have been reported to stimulate insulin secretion and modulate immune responses, while bioactive peptides such as cordymin contribute to the reduction of blood glucose levels and oxidative stress (Łysakowska et al., 2023). Ergosterol is one of the principal sterols naturally present in edible mushrooms, contributing significantly to their nutritional and pharmacological value. As a provitamin, ergosterol serves as the biological precursor of vitamin D. Because of this, edible mushrooms represent an excellent natural source of vitamin D_2. In addition to its nutritional role, ergosterol has been shown to possess various pharmacological properties, including antimicrobial, antioxidant, anticancer, antidiabetic and neuroprotective effects (Rangsinth et al., 2023). Edible mushrooms are low-calorie foods with minimal fat content, yet they are rich in lipids such as polyunsaturated fatty acids (PUFAs), including linoleic, oleic and palmitic acids. These fatty acids contribute to lowering blood lipid levels and relieving arthritis symptoms. Despite their low-fat content, mushrooms have a high PUFA-to-saturated fat ratio and also contain significant amounts of ergosterol, a major fungal sterol (Singh et al., 2025).

Table 1. Main groups of bioactive compounds in mushrooms and their biological activities

Group of compounds	Main representatives	Biological activities	Source
Polysaccharides (β-glucans, glycoproteins)	e.g. lentinan	immunomodulatory, antitumor, antioxidant	Assemie and Abaya, 2022; Singh et al., 2025
Terpenes/ triterpenoids	e.g. ganoderic acid, erinacines, hericenones	anticancer, anti-inflammatory, neuroprotective	Singh et al., 2025
Phenolic compounds Sterols	e.g. flavonoids, gallic acid	antioxidant, antimicrobial, anticancer	Singh et al., 2025; Pashaei et al., 2024
	e.g. ergosterol	antimicrobial, antioxidant, anticancer, antidiabetic, anti-neurodegenerative, Precursor of vitamin D_2	Rangsinth et al., 2023

Key mushroom species and their active compounds

Different medicinal mushrooms contain unique bioactive compounds that can influence various immune pathways with differing effectiveness (Zhao et al., 2020). *Hericium erinaceus* (Figure 1) contains erinacines and hericenones, compounds that stimulate nerve growth factor (NGF) synthesis, thereby promoting neuronal growth and repair. Erinacines, particularly Erinacine A, enhance NGF synthesis and phosphorylation of its receptor TrkA, suggesting potential in the treatment of neurodegenerative diseases. These compounds also possess antioxidant properties, helping to mitigate oxidative stress and inflammation. Additionally, Erinacine S promotes neurite outgrowth and axonal regeneration in the peripheral nervous system (Szućko-Kociuba et al., 2023; Tsai et al., 2019; Lin et al., 2023).

Figure 1. *Hericium erinaceus. Source: author.*

Another mushroom species is *Ganoderma lucidum* (Figure 2), which is rich in polysaccharides, especially GLP-1, which exhibit immunomodulatory and antitumor effects. The administration of GLP-1 in mouse models increases the differentiation of myeloid-derived suppressor cells (MDSCs), enhances antitumor immunity and modulates gut microbiota composition. GLP-1 has also demostrated potential to improve the efficacy of immune checkpoint inhibitors, such as anti-PD-1 monoclonal antibodies (Li et al., 2024; Wang et al., 2020; Gao and Homayoonfal, 2023).

Lentinula edodes (Figure 3), commonly known as shiitake, contains lentinan, a β-glucan with potent immunomodulatory and antitumor properties. Lentinan inhibits tumour progression by modulating immune responses, enhancing natural killer (NK) cell activity, and inducing apoptosis in tumour cells. It also exhibits antioxidant and anti-inflammatory effects and has been reported to improve quality of life and enhance the efficacy of chemotherapy and radiotherapy in cancer patients (Zhou et al., 2024; Wang et al., 2016; Deng et al., 2018).

Figure 2. *Ganoderma lucidum*. Source: Pinterest (https://i.pinimg.com/1200x/ab/47/a0/ab47a026ad85c363c3b299ecdbce5136.jpg), accessed November 27, 2025.

Figure 3. *Lentinula* edodes. Source: Pinterest (https://i.pinimg.com/1200x/ff/56/57/ff56577c2ec6ec5449e6653886acffe5.jpg), accessed November 27, 2025.

Applications in the food and pharmaceutical industry

Edible and medicinal mushrooms have gained increasing recognition in both the food and pharmaceutical sectors due to their extensive bioactive profiles and multifunctional properties. These fungi, rich in compounds such as β-glucans, polysaccharopeptides, triterpenoids, phenolics and sterols, serve as important, agents in developing health-oriented solutions. The combination of nutritional value and therapeutic potential makes mushrooms particularly valuable in promoting human health through functional food products, dietary supplements and potential pharmaceutical agents (Łysakowska et al., 2023). In recent years, mushrooms have been widely incorporated in the formulation of functional food products designed not only to provide nutrition but also to confer health benefits that may prevent or manage chronic conditions. Species like *Lentinula edodes*, *Pleurotus ostreatus*, *Ganoderma lucidum* and *Trametes versicolor* are frequently used in value-added foods such as fortified bakery items, soups, plant-based meat analogues, and beverages. Their inclusion enhances not only the protein, fibre, and mineral content of foods but also contributes antioxidant, immunomodulatory, and metabolic benefits. For example, *Boletus edulis* has been incorporated into breads and burgers for its fibre and antioxidant properties, while *Agaricus bisporus* has been used to extend shelf life and nutritional value in meat products (Bains et al., 2021; Zhang et al., 2021). Beyond food formulations, mushrooms also play a significant role in the dietary supplement market. Extracts from *Trametes versicolor* (particularly PSP and PSK), *Ganoderma lucidum* and *Hericium erinaceus* are widely commercialised in capsule, powder, or syrup forms to support immune health, manage metabolic conditions and combat oxidative stress. These supplements are especially valued for their ability to regulate gut microbiota, improve glycaemic and lipid profiles and reduce systemic inflammation. Mushroom polysaccharides such as β-glucans act as prebiotics, promoting short-chain fatty acid production and supporting gut health, as evidenced by early human trials, particularly with *Pleurotus ostreatus* (Cerletti et al., 2021; Das et al., 2021). Moreover, innovations in food technology have led to the use of mushroom-derived protein hydrolysates (MPHs) as natural antioxidants and antimicrobial agents that can extend food shelf life and enhance sensory attributes. These hydrolysates, rich in bioactive peptides, are now common in functional food design aimed at cardiovascular and metabolic wellness (Ketemepi et al., 2024). Additionally, umami-rich peptides and kokumi compounds from mushrooms improve flavour profiles while allowing food producers to reduce sodium and fat content, an important advancement in the development of healthier and more sustainable food options. Notably, functional and nutraceutical applications of mushrooms are not limited to physical well-being but also extend into cognitive health. Compounds from *Hericium erinaceus* have shown neurotrophic effects, indicating their potential for supporting brain health and addressing neurodegenerative conditions such as Alzheimer's and depression. These findings highlight mushrooms as promising tools in preventative health and wellness strategies (Thatoi and Singdevsachan, 2014; Feng et al., 2019). While their applications in food and supplements dominate current usage, the pharmaceutical potential of mushrooms is increasingly being realised. Numerous bioactive molecules extracted from fungi exhibit therapeutic effects that are being explored for drug development. Lentinan, a β-glucan derived from *Lentinula edodes*, has been successfully used as an adjuvant in cancer therapies in Japan, where it improves patient outcomes by enhancing innate immunity and complementing chemotherapy (Cerletti et al., 2021). Similarly, PSK, commercially known as Krestin, has demonstrated the ability to stimulate immune pathways via Toll-like receptors, contributing to its use in managing advanced cancers (Bains et al., 2021). Other promising compounds include triterpenoids from *Ganoderma lucidum* and hericenones from *Hericium erinaceus*, which have demonstrated hepatoprotective, anti-inflammatory and anticancer properties in preclinical studies. These substances are being studied for their efficacy in managing chronic diseases, including cancer, diabetes, and neurodegenerative disorders. The pharmacological relevance of mushrooms is further underscored by their diverse enzymatic systems and secondary metabolites, which show antimicrobial, antiviral, and immunostimulatory potential, making them ideal candidates for future drug formulations (Zhang et al., 2021; Ketemepi et al., 2024).

Summary

In summary, edible and medicinal mushrooms represent a valuable nexus of nutrition and medicine. Their application in the food industry, particularly in functional foods and dietary supplements, provides a natural and accessible route to preventive healthcare. Simultaneously, their rich biochemical diversity and therapeutic promise are driving their inclusion in pharmaceutical research and innovation. With growing scientific validation and global interest in plant-based wellness, mushrooms are poised to play an increasingly vital role in advancing human health.

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