

# Therapeutic and nutraceutical potential of edible Mushrooms: an overview

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## ABSTRACT

In every country in the globe, mushrooms are valued for their therapeutic and dietary benefits. Because immunity and cellular protection are significant issues for health-conscious customers and for people who are coping with major health issues, and increasing vegetarians' interest in mushrooms has reached a height. Mushrooms typically belong to the Basidiomycetes family, which contains a wide variety of mushroom species and compounds with medicinal and nutritional value. According to reports, they are the most beneficial in people health and nutrition around the world. Around the world, studies on the medicinal and dietary benefits of mushrooms are in progress. Important information is being provided by researchers on the variety of bioactive substances present in these intriguing fungi. Mushrooms are now more widely accepted as a food and dietary supplement. Research on the bioactive metabolites/phytoconstituents of mushrooms is currently being actively conducted by numerous academic and research institutions. The current research intends to evaluate the variety of mushrooms and its benefits in the modern era, i.e., the types of metabolites/phytoconstituents present in these mushrooms, particularly those with medicinal and nutraceutical value, free radical scavenging activities and their function as bioactive agents.

## Introduction:

Since the beginning of recorded history, people have eaten mushrooms; the Greeks thought they gave warriors vigor in combat, and the Romans thought of them as "Food of the Gods." Mushrooms have long been revered in Chinese culture as a wholesome dish and a "elixir of life." They have been a part of human society for countless years, and because of their sensory qualities, they have attracted a great deal of interest in the most significant civilizations in history. Since they have been used for food and medicine for many years, mushrooms have become an integral element of the human diet. Due to their low-calorie content and inclusion of nutrients such as high-quality proteins, vitamins, minerals, unsaturated fatty acids, and dietary fibers, these compounds have a pleasing flavor, aroma, and nutritional value (Roncero-Ramos & Delgado-Andrade, 2017). Their worldwide production and consumption have significantly increased in recent years. The world's production of mushrooms and truffles climbed from 7.5 million tons in 2009 to 11.8 million tons in 2019 according to the FAOSTAT database (Bringye et al., 2021). Mushrooms are regarded as a functional food and a source of nutraceuticals due to the recognition of their positive effects on human health derived from their bioactive components and nutraceutical substances (Valverde et al., 2015). They are also known for having appetizing culinary qualities. Because they are minimal in calories, carbohydrates, fat, and sodium, as well as being cholesterol-free, mushrooms are a valuable food in today's society. In addition, mushrooms offer significant amounts of protein, fiber, selenium, potassium, riboflavin, and vitamin D. Mushrooms have a long history of use as food, but they are also valued for their therapeutic characteristics and use in traditional medicine. It has been claimed to have positive health effects and be effective in treating some ailments. Because they include necessary amino acids only found in animal proteins (Lesa et al., 2022) and are thought to be the only naturally occurring source of vitamin D<sub>2</sub> for vegetarians and vegans, they are also a desirable food for vegetarians. These factors have led to consumers including them more frequently in their diets, which has significantly increased both their production and consumption (Valverde et al., 2015). The number of mushrooms consumed per person has increased from 1 kg in 1997 to almost 4 kg in 2012. Due to their lack of a protective cuticle, rapid respiration, and high moisture content, mushrooms are extremely perishable (Castellanos-Reyes et al., 2021). They are consequently vulnerable to mechanical damage, microbiological attack, weight loss, and enzymatic browning, all of which cause a rapid postharvest loss of

quality. One to three days at room temperature (20 to 25<sup>0</sup> C) and five to seven days when refrigerated (4<sup>0</sup> C) are the maximum shelf lives for *Agaricus bisporus*, *Pleurotus ostreatus*, and *Lentinula edodes* mushrooms, respectively. The post-harvest shelf life of *Lentinula edodes* mushrooms is only three to five days (4<sup>0</sup> C) (Castellanos-Reyes et al., 2021). It's faster respiratory rate relative to other mushrooms is responsible for this increased perishability.

The capacity to treat or prevent diseases like Parkinson's, Alzheimer's, hypertension, and an increased risk of stroke is only one of the many nutritional advantages that mushrooms are reported to have. They are also utilized to minimize the possibility of cancer invasion and metastasis because of their antitumoral characteristics. In addition to having qualities that are antibacterial, immune system boosting, and cholesterol-lowering, mushrooms are important sources of bioactive compounds. Because of their abilities to support human health, several mushroom extracts are sold as nutritional supplements (Chugh et al., 2022; Venturella et al., 2021).

The microbiological, chemical, and sensory properties of food must be taken into account while evaluating stability. In order to accomplish these goals, adequate preservation procedures must be adopted to the point when microorganism activities are defeated. The most conventional and processed foods' microbiological stability and safety are based on a concoction of many preservation elements (referred to as hurdles), which the microorganisms found in food are unable to overcome. Physical, physicochemical, or microbiologic hurdles can be used in food (Lorenzo et al., 2018). Although food preservation is the primary goal of hurdle technology, numerous hurdles have also reportedly been used to enhance sensory qualities (Singh & Shalini, 2016). Numerous studies have shown that using a combination of preservatives at lower concentrations than using a single preservative at a higher dosage inhibits microbial activities more effectively (Herman et al., 2013). This review provided a comprehensive overview of hurdle technology as well as the theoretical underpinnings of food deterioration and preservation. A review of the principles, applications, benefits, and consequences of hurdles on food quality was also done. The contributions of other researchers who focused on the use and efficiency of hurdle technology in maintaining the microbiological, chemical, sensory, and physical properties of processed foods received special attention.

## Phyto-constituents present in different edible mushrooms

According to the dietary categories of the United States Department of Agriculture, mushrooms are categorized as vegetables and have many nutritional qualities similar to meals derived from plants. They do, however, not belong to an animal or plant species but rather to the kingdom of fungi (Feeney et al., 2014). Phytochemicals are significant bioactive components that support and advance wellbeing and are found in a variety of foods, including mushrooms and therapeutic plants (Samtiya et al., 2021). Anthocyanidins, phytoestrogens, carotenoids, terpenoids, phytosterols, limonoids, polyphenols, glucosinolates, isoflavonoids, and flavonoids are examples of phytochemicals in general (Upadhyay & Dixit, 2015). Due to the advantages, they offer, including the prevention, management, and treatment of illnesses and various physiological problems, they have a great impact on the medical profession. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are terms used to describe how free radicals primarily come from oxygen and nitrogen (RNS). Radicals are produced by a variety of endogenous systems in the human body, as well as when tissues are subjected to diverse pathophysiological situations or physicochemical circumstances. These radicals\* are linked to early ageing and a number of disorders that impact the human body and can adversely change DNA, proteins, and lipids (Pham-Huy et al., 2008; Pizzino et al., 2017; Sharifi-Rad et al., 2020).

## Nutraceutical and therapeutic metabolites of Mushrooms

Because of its flavor and/or nutritional worth, people eat mushrooms. Color, texture, smell, and taste can all be used to evaluate how appetizing something is, but nutritional value must be determined scientifically. It entails proximate composition analysis as well as a spectrum examination of amino acids, fatty acids, vitamins, minerals, nucleic acids, and other compounds. It should be emphasized that a species' genetic diversity, which results in strain variations, and environmental factors, such the kind of substrate, both have an impact on the species' composition. All of the essential amino acids for humans, including lysine and methionine, which are frequently low in plants, are present in mushrooms, which also have a pleasant flavor and texture (Byrne, 2020). Eating mushrooms has a nutritional value that is almost on par with milk and meat. They are rich in proteins, carbs, vitamins, unsaturated fatty acids, fiber, minerals, and important amino acids (lysine, valine, and leucine). Mushrooms have extremely little sodium, fat, or calories. Additionally, mushrooms have no cholesterol.

The average mushroom has a high protein content of 20 to 30% by dry weight. Anyone who wants to boost the amount of protein in their diet, including vegetarians, can benefit from this. Fiber is crucial for the digestive system and lowers cholesterol. Numerous edible mushrooms contain niacin and other vital B vitamins. This can be another beneficial supplement for vegetarians because some B vitamins can only be found in animal tissue and not in plant tissue (Kennedy, 2016). Additionally, there is vitamin D, which is necessary for calcium absorption. On a dry weight basis, fruiting bodies typically comprise around 55% carbohydrates, 32% proteins, and 2% fat, with the remaining material being mineral-containing ash (Cardwell et al., 2018; Rahi & Malik, 2016). As a result, these mushrooms are being grown commercially at an increasing rate for the benefit of human health. Additionally, a range of hydrolyzing and oxidizing enzymes are present in mushrooms (Martinez-Medina et al., 2021).

Nature's most skilled chemists are fungi. Their creations span from primary metabolites, which are simple, common chemicals like gluconic and citric acid, to secondary metabolites, which are more complicated, uncommon substances like aflatoxin and ergot alkaloids. Numerous ailments have been effectively treated with the help of the bioactive compounds found in hundreds of therapeutic mushrooms (Meyer et al., 2020). The industrial and medical uses of these mushrooms are widely known, and several studies have been conducted and published on these topics. Because of its unique climatic conditions, India is home to a wide variety of mushroom flora and their metabolites (A. Ajith & K. Janardhanan, 2007). Berkeley brought up the medicinal usage of mushrooms. Due to their anesthetic properties, he also mentioned using *Calvatia gigantea* (giant puffball) and *C. caelata* in burn cases (Eroğlu et al., 2016).

They are also employed to halt wound bleeding. The well-known medicinal mushrooms *Agaricus subrufescens*, *Ganoderma lucidum*, and *Ophiocordyceps sinensis* are among those with a long history of use. These fungi produce chemicals that have been found to have biological inhibitory actions against viruses and cancer cells. Clinical medicine frequently makes use of certain metabolites, including polysaccharide-K, ergotamine, and beta-lactam antibiotics (Chugh et al., 2022; Sanchez & Demain, 2017). Lentinan, a therapeutic medication licensed for use in the treatment of cancer in numerous nations, is found in the shiitake mushroom. Polysaccharide-K (trade name: Krestin), a substance produced from *Trametes versicolor*, is a recognized adjuvant for the treatment of cancer in Europe and Japan (Ina et al., 2013). For instance, the wood-rotting fungus *Ganoderma lucidum* is being grown

for its purported therapeutic properties. Nucleosides, proteins, amino acids, vitamins, polysaccharides, and triterpenoids are examples of metabolites that have been found to exhibit anticancer, antiallergic, antiviral, anti-inflammatory, anti-aging, hepatoprotective, hypoglycemic, and cardiovascular effects. They are applied to the management of persistent hepatitis (Cör Andrejč et al., 2022). They are helpful for boosting vitality, sharpening the mind, and avoiding amnesia. *G. lucidum*-derived extracts and powders are sold as medicines for a variety of illnesses in the form of capsules or sugar-coated tablets (G. Wang et al., 2018). *Lentinus edodes* contains polysaccharides, proteins, lipids, enzymes, vitamins, and minerals that are used as a health tonic and to alleviate headaches and vertigo. Anti-tumor efficacy is shown in lentinan isolated from *Lentinus edodes*. Immune-stimulating polysaccharides are thought to be the active components, bolstering immunity and overall health (Rahman et al., 2018). 2,2-diphenyl-1-picryl-hydrazylhydrate (DPPH) radical scavenging and overall antioxidant capability of *Agaricus bisporus* have been described (Clarke et al., 2013). Additionally, the hypocholesterolemic, hypoglycemic, and hypolipidemic qualities of *Pleurotus ostreatus* have been documented. Mushrooms have powerful pharmacological effects or physiological characteristics, including bioregulation (immunological enhancement), maintenance of homeostasis, regulation of biorhythm, treatment of a number of diseases, prevention and improvement of life-threatening illnesses like cancer, cerebral stroke, heart diseases, and immune deficiency diseases (including AIDS), or generation of immunosuppression during therapy (Alam et al., 2011).

### Nutritional and medicinal aspects

Mushrooms have been used as a food source for thousands of years, due to their chemical makeup, which makes them appealing from a nutritional standpoint. They are currently in high demand in part due to their low calorie, carbohydrate, fat, salt, and cholesterol content. The growth stage and conditions following harvest can have an impact on the chemical makeup and nutritional value of mushrooms, and these characteristics can vary substantially between species. The median amounts of crude protein, lipids, ash, and carbohydrates in various cultivated mushroom species, according to Kalac's review, are 208, 22, 70, and 682 mg/kg dry matter and 419 kcal/kg fresh matter, respectively (Castellanos-Reyes et al., 2021; Das et al., 2021). Due mostly to the high-water content of newly grown mushrooms, mushrooms have a very low dry matter content of 80-140 g/kg. One of the main causes of the limited shelf life of fresh mushrooms is this final ailment. Due to their high protein content (15 to 35% of dry weight), which reflects the idea that mushrooms are a good alternative to

meat and have comparable nutritional value to many plant species, mushrooms are regarded as a valuable source of protein from a dietary perspective. They contain more protein than other foods, particularly dairy products, despite having lower protein contents than animal meat. Mushroom proteins are more nutrient-dense than other vegetable proteins, because they contain all nine necessary amino acids. Due to the fact that they include necessary amino acids found in animal proteins, mushrooms are also regarded as a tasty snack for vegetarians (Päivärinta et al., 2020).

### **Vitamin D-enriched Mushrooms**

Vitamin D increases the synthesis of the calcium transport proteins in the small intestine, improving dietary calcium absorption and lowering the incidence of rickets in children and osteomalacia in adults (Khazai et al., 2008). A sufficient intake of vitamin D is necessary for healthy muscle function and lowering the risk of falls in the elderly. It may also help prevent certain cancers, pediatric respiratory diseases, cardiovascular diseases, neurodegenerative diseases, and type 1 and type 2 diabetes, though the evidence for these benefits outside of the skeletal system is still inconclusive (H. Wang et al., 2017). Despite being categorized as a vitamin, vitamin D can be sufficiently synthesized by the body when the skin is exposed to ultraviolet (UV) radiation from the sun. Dietary sources of vitamin D are necessary to maintain appropriate circulation 25-hydroxyvitamin D (25(OH)D) concentrations if sunshine exposure is restricted. One billion people are thought to be vitamin D deficient worldwide (25(OH)D concentrations 50 nmol/L), while population-based studies frequently claim prevalence rates of over 50% (Wacker & Holick, 2013).

Vitamin D<sub>2</sub>, found in fungus and yeast, and vitamin D<sub>3</sub>, found in animals, are the two primary dietary forms of vitamin D; smaller levels of D<sub>3</sub> and D<sub>4</sub> are also present in fungi (Cardwell et al., 2018). The finest naturally occurring dietary supply of vitamin D is oily fish, which is uncommon in the Western diet. Some nations have lax policies regarding fortification, and products like milk, margarine, breakfast cereals, and drinks are fortified with vitamin D (G & Gupta, 2014). Mushrooms that have been sun-dried and exposed to UV radiation may be a significant dietary source of vitamin D (as vitamin D<sub>2</sub>). The only non-animal food product with significant amounts of bioavailable vitamin D is vitamin D-enhanced mushrooms, which have the potential to be a main source of dietary vitamin D for vegans and vegetarians (Rahi & Malik, 2016).

Worldwide, vitamin D insufficiency is very common, especially in India. In this context, shiitake (*Lentinula edodes*), button (*Agaricus bisporus*), and oyster (*Pleurotus ostreatus*) mushrooms are known for their bioactive properties. Mushrooms are significant nutritional foods. It is commonly known that ultraviolet (UV) radiation can be used to produce significant amounts of vitamin D<sub>2</sub>. After consuming UVB-irradiated mushrooms for 4 weeks, vitamin D-deficient rats with low serum levels of 25-hydroxy vitamin D (25-OHD), parathyroid hormone (PTH), calcium, phosphorus, and alkaline phosphatase (ALP) had a significant (p 0.05) improvement. Additionally, microscopic findings show that the osteoid area and trabecular separation of the femur bone have improved. Additionally, the degree of gene expression for the vitamin D receptor (VDR) and genes involved in its metabolism was investigated. In the groups who consumed mushrooms and received vitamin D supplements, it was shown that CYP2R1 and VDR were upregulated while CYP27B1 was downregulated in the liver. Additionally, in kidney tissue, CYP27B1 and VDR were elevated whereas CYP2R1 was downregulated (Malik et al., 2022).

### Biological properties

Tyrosinase, a dinuclear copper enzyme from mushrooms (*Agaricus bisporus*), is well known for its ability to oxidize catechols to ortho-quinones as part of the melanin production process. The enzyme can also work as an external monooxygenase for the asymmetric oxidation of sulphides in the presence of catechol, which regenerates the oxy-form of the enzyme required for the sulfoxidation pathway. Thioanisole was converted to (S)-sulfoxide at an 85% rate despite the low yield. The addition of ascorbate might increase the yield (Pillaiyar et al., 2017; Zaidi et al., 2014).

The virus infects the common cultivated button mushroom (*Agaricus bisporus*). It has been discovered that the field mushroom *A. campestris* contains bacilliform particles that morphologically resemble MBV. Mycelium and maybe basidiospores are used for horizontal transmission. The virus has been found in most of the world's major mushroom-producing nations, and its spread coincides with the commercial production of *A. bisporus*. MBV can replicate on its own, but it usually co-infects with a dsRNA virus in La France disease-affected mushrooms (the La France isometric virus, or LFIV). It is unclear if MBV is a secondary, less serious cause of LaFrance disease, the etiologic agent of an unidentified pathology, or benign. MBV is not required for the LFIV pathophysiology (Eastwood et al., 2015).



## Conclusion:

In order to preserve or restore a healthy defensive mechanism, researchers are hunting for fungi, particularly mushrooms that contain naturally health-supporting properties. For a very long time, people have been searching for unique substances that can effectively and constantly increase biological processes. The development of medicinal procedures in the future will mainly rely on dietary supplements. There is evidence to support the use of nutraceuticals, or dietary supplements, to treat some illnesses. These products are created from biologically active food ingredients. The mushroom family in particular has the potential to enhance immune performance. There are populations of both cultivated and wild mushrooms in many parts of the world. In addition to being a fantastic food source, mushrooms have long been used medicinally. While the nutritional value and culinary uses of mushrooms are well established, the therapeutic benefits of the fungi are still not widely recognized.

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