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A Review on Nature's Hidden Wonders Mushrooms and It's Powerful Health Benefits

Gunda.Srija*, Vangala.Vimala[2]

[1]Assistant professor, Department of Pharmaceutical analysis and Quality Assurance, Sri Chaitanya institute of pharmaceutical sciences, Thimmapur, Karimnagar, Telangana, India.
[2]Assistant professor, Department of Pharmacology, CVM college of Pharmacy, Velchal, Karimnagar, Telagana, India.

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ABSTRACT :

In many areas of human life, including food, health, culture, and religion, mushrooms have had a significant impact. Most people eat mushrooms for their flavor and texture. Mushrooms are composed of 90% water and 10% dry material. Additionally, it has a physicochemical composition that is important for nutrition. The composition and nutritional benefits of edible mushrooms have been carefully investigated in this review. This review article may also help scientists, researchers, and medical professionals slow the advancement of some lifestyle diseases, neurological disorders, along autoimmune disorders.

Keywords : Mushroom, protein source, polyphenolic compounds, fungi, nutrient content, health benefits

INTRODUCTION :

Edible Mushrooms

Commercially important, edible mushrooms include portobellos (*Agaricus bisporus*), whose forms include button mushrooms, cremini , and baby bellas, and shiitake (*Lentinula edodes*). The morels (*Morchella*, *Verpa*) and false morels or lorchels (*Gyromitra*, *Helvella*) are popularly included with the true mushrooms because of their shape and fleshy structure; they resemble a deeply folded or pitted conelike sponge at the top of a hollow stem. Some are among the most highly prized edible fungi (e.g., *Morchella esculenta*). Edible truffles (various *Tuber* species), which hardly resemble mushrooms, are also popularly labeled as such. These and other edible mushrooms and fungi are free of cholesterol and contain small amounts of essential amino acids and B vitamins. However, their chief worth is as a specialty food of delicate, subtle flavour and agreeable texture. By fresh weight, the common commercially grown mushroom is more than 90 percent water, less than 3 percent protein, less than 5 percent carbohydrate, less than 1 percent fat, and about 1 percent mineral salts and vitamins.

The Cancer Thriver :

Health Benefits of Beta Glucans

The studies showed that beta glucan extracts were able to reduce inflammation as measured by TNF-alpha and a decrease in nitric oxide levels. This is good news for you as a cancer thriver, as inflammation is linked to cancer.

Seven different clinical trials were highlighted that showed beneficial effects of mushroom beta-glucan extracts given along with chemotherapy. The mushroom extract either improved survival, improved immune cell response or bone marrow recovery after chemotherapy. However, it was noted that overdoses are also possible.

Meta analyses of mushroom extract have also been done. A meta analysis is a study of studies. This is done by compiling the results of several studies so that the sample size becomes larger and it gives more statistical strength to the results. Professor Cunningham-Rundles highlighted this quote from one of the studies:

Bone Marrow Recovery

Myelodysplastic syndrome is a type of cancer in which blood cells do not mature properly and therefore do not become fully functioning red blood cells. Susanna Cunningham-Rundles set out to see if mushroom beta glucans could help in this disease. She

found that maitake mushroom beta-glucan did show an improvement in immune response in a group of patients with myelodysplastic syndrome (MDS). However, this study has been submitted for publication but is yet unpublished).

What do these studies mean for a cancer thriver?

Most of the studies that Dr. Cunningham-Rundles included in her presentation were performed either on cells in a petri dish or animals. We don't know for sure if the effect will be the same in our bodies, but I'm willing to add more mushrooms to my diet regardless. I don't see a downside to eating more mushrooms, especially since mushrooms have other proven health benefits such as improved microbiota (healthy gut bacteria) and better blood sugar control.

I am going to choose mushrooms that are readily available in my local market; white, brown, Portobello, shiitake and oyster mushrooms. I'm going to cook them because that's how I prefer to eat them. And when they are cooked I eat more because they shrink when they cook! So, I figure, even if an anti-inflammatory compound is lower after I cook it, I will eat more of them so that may just equalize the amount. When I see some other exotic ones like Maitake (ram's head, sheep's head or dancing mushrooms), I will give those a try too (although I have to admit they are kind of intimidating).

In addition, I think people who have neutropenia, either from chemotherapy or myeloblastic syndrome, could consider using a beta glucan mushroom extract. However, before doing so, I would suggest you do further research and speak with your pharmacist at your cancer centre to consider the source of the mushroom beta glucan (i.e. which species of mushroom), the proper dose and duration, and any interactions it could have with your current medication.

Nutritional Potential of Mushroom

Mushrooms contain both primary and secondary metabolites. Primary metabolites are responsible for energy production, while secondary metabolites are responsible for medicinal properties . These macrofungi's organoleptic features and high nutritional content contribute to their growing popularity. Edible mushrooms are rich in proteins and account for 19–35% of the dry mass, while carbohydrates constitute 50–65% of the dry mass, rendering mushrooms an abundant source of high-quality dietary fiber. Furthermore, mushrooms exhibit a low lipid content, ranging from 2% to 6% of the dry mass, and are regarded as hypocaloric . These powerful compounds provide numerous health benefits including antimicrobial defense, protection against oxidative damage, and anti-inflammation properties. Moreover, mushrooms exhibit antidiabetic, anticancer, antiviral, and anti-immunomodulatory activities, making them valuable ingredients in the development of functional foods. Mushrooms also contain many bioactive compounds including alkaloids, ergosterols, polysaccharides, polyphenols, terpenoids, lectins, glycoproteins, sesquiterpenes, sterols, and lactones. The concentrations of these bioactive chemicals vary considerably based on several parameters, including culture, strain, storage conditions, substrate, and processing conditions . The nutritional compositions of some edible mushrooms are presented in.

Carbohydrates :

Mushrooms are low-calorie foods owing to low carbohydrate contents, minimal sugar levels (no glucose), and high fiber contents. They contain various carbohydrates including simple sugars like sucrose, xylose, glycogen, rhamnose, mannose, fructose, galactose, mannose, and xylose, and polysaccharides such as cellulose, glycoproteins, α-glucans, and β-glucans, glucan, mannoglucan, heteroglycan, galactomannan, and lentinan. Mushrooms are also high in dietary fibers, primarily non-starch polysaccharides, with 4 to 9% being soluble and 22 to 30% insoluble. They contain non-digestible carbohydrates, such as chitin and (1→3)-β-d-glucans, which promote intestinal health, and the main components of the cell wall are β-glucans and polysaccharides. Additionally, mushrooms contain non-digestible oligosaccharides (NDOs) consisting of carbohydrate molecules of fewer than 20 monosaccharide units joined by glycosidic linkages. These NDOs are resistant to hydrolysis by salivary and intestinal digestion enzymes associated with various beneficial advantages, including antipathogenic and prebiotic characteristics. Individuals can increase their intake of NDO through food sources, like mushrooms, and supplements derived from dried fruiting bodies or mycelium-based products from fungal species. Although mushrooms have less fiber than vegetables and fruits, they are still a nutritious, low-energy dietary option, particularly beneficial for type II diabetes and those seeking weight loss. Due to their low glycemic index (GI) and glycemic load (GL), they do not cause spikes in blood sugar levels. In *L. edodes*, key polysaccharides such as emitanin, lentinan (a β-(1,3)-D-glucan enhances the effectiveness of chemotherapeutic drugs), and KS-2 are found to benefit health.

Protein :

Edible mushrooms are often high in protein, although the protein content varies widely depending on the mushroom's species, stage of growth, and growth medium. They contain essential amino acids such as lysine, valine, tryptophan, isoleucine, methionine, leucine, and threonine. Mushrooms also provide proteins such as lectins, laccases, histidine, phenylalanine, and cysteine . Notable

mushrooms of the *Pleurotus* species have high-quality protein due to the effective distribution of essential and non-essential amino acids such as gamma-aminobutyric acid (GABA), a critical neurotransmitter . When compared to other food sources, the protein content of edible mushrooms is quite competitive . Animal-based foods (dry weight) contain protein, which is present in proportions of at least 27% for milk, 37–83% for meat, 53% for eggs, and the highest 58–90% for fish and crustaceans . In contrast, plant-based sources such as legumes contain 22–40%, cereals 8–18%, nuts 4–20%, other seeds 18–32%, and tubers less than 10% . Certain species of edible fungi, *A. bisporus* 32.10%, *H. erinaceus* 22.30%, and *L. edodes* 22.80%, provide protein concentrations that are equal to or exceed those found in animal-derived sources such as dairy products, meat, eggs, and seafood . Consequently, these edible fungi represent an exceptional source of high-quality protein that is more accessible, cost-effective, and exhibits a reduced environmental footprint, and so, in the future, they will become a compelling alternative to both animal-derived and various plant-based protein options . Ergothioneine (EGT) is uniquely sulfur-containing and has excellent free radical scavenging activity. EGT is found in high concentrations in mushroom species like hen of the woods, shiitake, King Boletes, Enokitake, and oyster mushrooms . It has been correlated with several health benefits, including lower rates of dementia and cardiovascular disease and anti-inflammatory and cytoprotective effects, and it may even lead to a longer life expectancy. Mushrooms have much greater quantities of ergothioneine than cereals, vegetables, and meat . As such, edible mushrooms are appealing foods with significant nutritional benefits that contribute to overall health.

Fats :

Edible mushrooms represent a low-calorie aliment with a minimal fat content (4–6%). *A. bisporus,* also known as the button mushroom, has a total fat content ranging from 0.34 to 2.2 g per 100 g of dry weight . The three major fatty acids present in edible mushrooms are linoleic acid (C18:2), oleic acid (C18:1), and palmitic acid (C16:0). Linoleic acid is useful in reducing the amount of lipids in the blood and helping to alleviate arthritis symptoms . Additionally, these fungi are abundant in polyunsaturated fatty acids (PUFAs), particularly oleic (1.1–12.3 g/100 g fresh weight (FW)), stearic (1.6–3.1 g/100 g FW), palmitic (10.3–11.9 g/100 g FW), and linoleic acids. Ergosterol (ergosta-5,7,22-trien-3b-ol) is identified as the most prevalent sterol within edible mushrooms . Although mushrooms are characterized by low caloric and fat contents, they exhibit a markedly elevated ratio of polyunsaturated fatty acids in comparison to saturated fatty acids.

Micronutrients :

Mushrooms are rich in various vitamins such as vitamin B complex (B_1, B_2, B_3, B_9, and B_{12}), vitamin C, vitamin D_2, and vitamin E and minerals like calcium, cadmium, magnesium, phosphorus, iron, sodium, cobalt, zinc, potassium, copper, titanium, selenium, and molybdenum . Tocopherol (α, β, γ, and δ) is a vitamin present in various mushroom varieties . Mushrooms are known for their high potassium content and low sodium content, as potassium reduces tension in blood vessels and eventually helps in lowering blood pressure . *A. bisporus* is particularly high in Na, Li, and K, but poor in Cu, Mn, Cr, Co, Pb, Ni, and Zn . *H. erinaceus* contain high levels of K, P, and Mg followed by Na, Fe, Ca, Zn, Al, Cu, Li, Mn, and Ba. *G. lucidium* contains high levels of K, P, and Ca, followed by Mg, Na, Fe, Al, B, Zn, and Cu, and the least Mn.

Bioactive Compounds :

Mushrooms encompass a diverse array of bioactive constituents, which include phenolic acids, glycosides, volatile substances, alkaloids, flavonoids, organic acids, and a variety of biological catalysts such as amylases, cellulases, laccases, lipases, pectinases, proteases, phytases, and xylanases. The phenolic constituents identified within mushrooms comprise gallic acid, p-coumaric acid, caffeic acid, p-hydroxybenzoic acid, protocatechuic acid, and pyrogallol . The majority of phenolic acids in mushrooms are hydroxybenzoic acids (HBAs) and hydroxycinnamic acids (HCAs). HBAs may be found in complex compounds such as tannins, lignin, and organic acids, whereas HCAs are attached to cell wall components such as lignin, cellulose, and protein. The most prevalent HCAs encountered in mushrooms include ferulic, sinapic, caffeic, and p-/o-coumaric acids, which play critical roles in lignin biosynthesis, disease resistance, and growth regulation . Mild alkaline hydrolysis is the most effective for extracting them. In mushrooms, mainly quinic acid esters, and also gallic, gentisic, homogentisic, p-hydroxybenzoic, protocatechuic, 5-sulphosalicylic, syringic, vanillic, and veratric, are the most often observed HBA derivatives. Anthocyanidins, biochanin, flavanols, flavones, isoflavones, flavanones, catechin, chrysin, myricetin, hesperetin, naringenin, naringin, formometin, resveratrol, quercetin, pyrogallol, rutin, and kaempferol are among the flavonoids present in mushrooms . The structures of active compounds in mushrooms are presented in . The quantity of these bioactive chemical compounds in mushrooms depends on the substrate, culturing conditions, storage conditions, and cooking procedures . *G. lucidum* produces several terpene derivatives, including ganoderal, ganoderic acids, lucidone, ganodermanondiol, ganodermic, and ganodermanontriol . *H. erinaceus* is known for hericenones (A-J, I, L, and K), erinacines (A-K, P-V, Z1, and Z2) , and *L. edodes* contains a polysaccharide known as lentinan.

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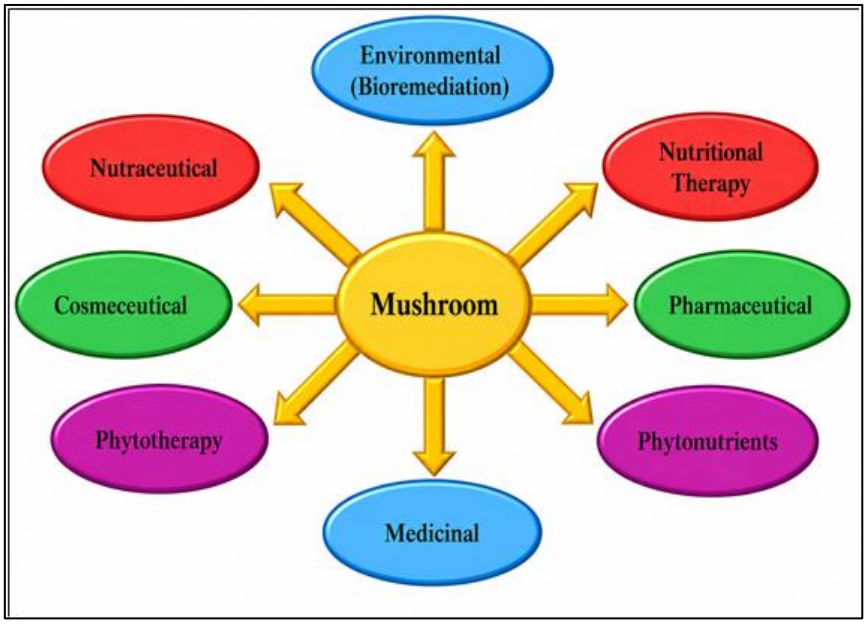


Figure:1 Representing the wide applications of mushrooms

Mushroom based non-alcoholic Beverages:

The resurgence of interest in medicinal mushrooms has led to the development of a wide array of mushroom-infused drinks, ranging from teas and coffees to more complex formulations such as smoothies and energy drinks. For example, mushroom coffee blends have gained significant popularity due to their ability to combine the energy-boosting effects of caffeine with the adaptogenic properties of mushrooms (Roupas et al., 2012). The production of mushroom drinks involves sophisticated extraction and formulation techniques to ensure the bioavailability and stability of the active compounds, which can be sensitive to heat and other environmental factors. Advances in biotechnology have enabled the development of extraction methods that maximize the retention of these bioactive compounds, ensuring that the final products deliver the intended health benefits (Firenzuoli et al., 2008).

Coffee:

Mushroom coffee represents a fusion of traditional coffee with the therapeutic properties of medicinal mushrooms. Typically, this involves blending coffee with mushroom extracts in a 1:1 ratio, such as *G. lucidum*, *H. erinaceus*, and *I. obliquus*, which are known for their cognitive and immune-enhancing effects (Hobbs, 2017; Smith, 2021). The process typically involves extracting bioactive compounds from mushrooms, which are then combined with ground coffee beans or instant coffee, resulting in a beverage that retains the familiar taste of coffee while offering additional health benefits (Wani et al., 2010; Kała et al., 2024).

Teas:

Mushroom teas have a rich history in traditional medicine, particularly in Asia, where they have been consumed for centuries as therapeutic beverages. Traditional formulations often involve the use of dried or powdered mushrooms, such as *G. lucidum*, *T. versicolor*, and *I. obliquus*, brewed with hot water to extract their bioactive compounds. These mushrooms are revered for their potential to enhance immunity, reduce inflammation, and combat fatigue (Zhao et al., 2020). Standardized hot-water extraction protocols for *G. lucidum* teas could increase bioactive yield by 30%–40% while reducing production time, based on recent ultrasonic-assisted extraction trials (Zhang et al., 2024b). In modern formulations, mushroom teas have evolved to include blends with various herbs, spices, and even other teas, such as green or black tea, catering to diverse consumer preferences while enhancing overall health benefits.

Herbal drinks and tinctures :

Various fungal species from different families are utilized in the food and beverage industry for their bioactive compounds.

Smoothies and energy drinks :

Smoothies and energy drinks (Mushroom powders blended with fruits, seeds, and plant proteins), supplements and powders(Concentrated mushroom extracts; fortified dairy and non-dairy drink powders), Soups (Dried or powdered mushrooms combined with protein sources, vegetables, or dairy), Sparkling and elixir drinks (Low-calorie mushroom waters or functional shots with herbs, vitamins, probiotics).

Therapeutic Efficacy:

1.	**Anticancer Properties**	Polysaccharides derived from mushrooms can inhibit tumor progression by enhancing the immune response, particularly through their impact on natural killer (NK) cells and macrophages via T-cell activation and cytokine secretion. Polysaccharides from mushrooms can impede tumor progression by augmenting the immune response through their influence on natural killer cells and macrophages mediated by T-cell activation and cytokine secretion. Mushrooms are rich in various anticancer components such as antroquinonol, krestin, cordycepin, lectin, sulfated polysaccharide hispolon, lentinan, and maitake D fraction.
2.	**Antioxidant Properties**	Polysaccharopeptides found in mushrooms can improve overall fitness by triggering enzymes that remove free radicals and reduce oxidative stress . Mushrooms contain a variety of antioxidant compounds including ergothioneine, ergosterol, carotenoids, phenolics, tocopherols (vitamin E), ascorbic acid (vitamin C), polysaccharides (acidic polysaccharides), and amino acids [hydrophobic amino acids (HAAs) like leucine, isoleucine, valine methionine, proline, alanine, etc.] . For example, *P. ostreatus* extract has been demonstrated to increase catalase gene expression and diminish free radical-induced protein oxidation in adult rats, protecting against age-related illnesses. The ethanolic extract of dietary *P. ostreatus* mushrooms inhibits lipid peroxidation, chelates ferrous ions, reduces ferric ions, and quenches 2,3-diazabicyclo.
3.	**Antidiabetic Properties**	Antidiabetic compounds in various mushroom species typically exhibit the following effects: (1) prevention of β cells' apoptosis and promotion of their regeneration; (2) regulation of glucose metabolism; (3) inhibition of inflammation and oxidation; and (4) enhancement of gut microbiota. A study on the polysaccharide compounds of *G. lucidum* demonstrated that these compounds reduce insulin resistance without damaging pancreatic islet cells and successfully reverse the process of diabetes . Mushroom extracts from *A. bisporus*, *G. frondosa*, *H. erinaceus*, *G. lucidum*, and *Pleurotus* species reduce blood glucose levels in the liver and muscle by controlling the expression of glycogen synthase kinase (GSK-3β), glycogen synthase (GS), and glucose transporter 4 (GLUT4). As a result, GSK-3β may be identified as a negative regulator that is modulated by insulin-mediated, GS-regulated activity.
4.	**Antimicrobial Property**	The mushroom species *P. ostreatus* is considered a medicinal mushroom due to its antimicrobial properties because of β-D glucan's presence. It includes several antibacterial agents, such as phenolic compounds, phenolic acids, and flavonoids, which are beneficial in this variety and others . Ethanol extracts from two grown mushroom kinds, *L. edodes* and *A. bisporus,* were tested for antibacterial activity against *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Enterococcus faecalis*, and *Acinetobacter baumannii*. Upon exposure to extracts derived from *L. edodes* and *A. bisporus*, bacterial cell death was observed, attributable to the elevation of protein and DNA levels within the surrounding milieu, indicative of bacterial cell deformation in response to the extracts above. Developing various extracts to combat

		antibiotic-resistant bacteria is crucial as resistance is anticipated to become one of the most serious health issues in the future.
5.	**Anti inflammation property**	Mushrooms possess properties that allow them to act directly on inflammation. Their lipids, rich in unsaturated fatty acids, exhibit anti-inflammatory qualities as these fatty acids are precursors of eicosanoids involved in balancing inflammatory and anti-inflammatory processes . Mushroom taxa such as *Agaricus* sp., *Pleurotus* sp., and *Termitomyces* sp. exhibit a high abundance of polysaccharides and synthesize biomolecules that play a pivotal role in the protection of joints against inflammatory mechanisms.
6.	**Healing Property**	The extract and metabolites from varieties like *G. lucidum* and *A. blazei* (polysaccharides) showed wound-treating properties, including different mechanisms such as epithelial cell stimulation, cytokines, and growth factor release . Chitinous polymers were extracted from the common *A. bisporus* mushrooms by employing straightforward methodologies and subsequently transformed into continuous fibers utilizing a specially designed laboratory-scale fiber-spinning apparatus. The resultant spun fibers consist of **an array of chitin fibrils** embedded within a glucan matrix, with their fiber dimensions meticulously governed by the specifications associated with needle gauges. After 30 s of contact with a small amount of water (<10 μL), all mushroom chitin fibers demonstrated self-healing characteristics. A microblade may successfully restore macroscopically injured mushroom chitin strands' natural form and tensile characteristics, as indicated by the enhanced self-healing capability for tensile strength (reaching 119%) and breaking strain (attaining 132%).
7.	**Enhancing gut microflora**	Mushrooms are valuable sources of prebiotics including polyphenols, oligosaccharides, and fibers, which enhance the metabolic activity of beneficial members of gut microflora . A mushroom *G. lucidum* contains polysaccharides and peptides that are non-digestible by pathogens, preventing their multiplication and thereby altering the gut microbiota . These indigestible polysaccharides derived from mushrooms serve a prebiotic role, suppressing the proliferation of pathogenic bacteria within the gastrointestinal tract while enhancing the growth of beneficial probiotic bacteria. *G. lucidum*, *H. erinaceus*, *L. edodes*, and *G. frondose* are among the most frequently reported edible mushrooms known to modulate gut flora . β-glucan, a type of polysaccharide found in mushrooms, can be fermented by gut bacteria, leading to beneficial changes in the host's microbiome.

Conclusion :

The consumption and production of highly functional foods, such as mushrooms rich in nutrients and bioactive compounds and offering protection against various diseases, is a step toward address these food issues, as they offer protective and therapeutic benefits against many diseases. The bioactive compounds in mushrooms make them highly suitable for consumption through different sources like food, nutraceuticals, and medicine. Adding mushrooms to our daily diet boosts our nutrient intake by providing essential macro- and micronutrients, and bioactive compounds that are lacking in regular meals.

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