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Pharmacognostic Study of Mushroom and Their Therapeutic Potential

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Abstract: *Medicinal mushrooms are higher fungi that have extra nutraceutical qualities, such as high fiber content, triterpenes, phenolic compounds, sterols, eritadenine, chitosan, and a trans-isomer of unsaturated fatty acids. They are regarded as the best supplier of nutritious foods and medications. They are classified as functional foods because of their exceptional nutritional content, appealing flavor, and aroma. This indicates that they are good for the body's overall health in addition to its nutritional needs. Numerous bioactive substances known as secondary metabolites are present in medicinal mushrooms and their extract.The presence of polysaccharide β-glucans or polysaccharide–protein complexes in mushroom extract has various therapeutic uses in human health because of its many qualities, including anti-aging, anti-diabetic, anti-cancerous, and anti-obesity. The thorough description of the therapeutic qualities of different medicinal mushrooms is the main subject of this review. Researchers will be better able to comprehend the metabolites and identify other compounds from the mushrooms that may be utilized in the possible creation of medications to treat a variety of serious illnesses.*

Keywords: Medicinal mushrooms, Bioactive compounds, Polysaccharides, Pharmacological activity

I. INTRODUCTION

Mushrooms are fruiting-bodied filamentous fungus that exhibit a vast array of pharmacological properties related to human health. Often produced all over the world, they are regarded as one of the most delicious delicacies. They have been utilized for ages as food and medicine, and they are a vital component of the human diet.They contain a wealth of nutrients and bioactive substances, including proteins, fibers, carbs, vitamins, and minerals. They also offer significant therapeutic benefits, including antiviral, antioxidant, antibacterial, anticancer, and hypocholesterolemic properties (Fig. 1), all of which are beneficial to human health.The mushrooms have a low fat content but a high protein and carbohydrate content. They include vital amino acids, which aid in supplying the body with the amino acids it requires. They are also abundant in a variety of vital unsaturated fatty acids, including oleic and linoleic acids, which are required for the body's healthy operation. In addition, they include a variety of vital minerals that are necessary for the healthy metabolism of numerous pathways. Mushrooms develop on decomposing organic debris that is rich in lignin, cellulose, and other essential carbohydrates because they lack chlorophyll, unlike plants.It is affordable, has many pharmacological qualities, is simple to grow, needs little space and resources, and can be cultivated anywhere in the world.

The number of mushrooms' nutritional, therapeutic, bioremediation, and biodegradation benefits is growing daily and has accelerated recently.

The presence of several secondary metabolites in mushrooms gives them therapeutic qualities. Although the fungus generally do not need these bioactive, low molecular weight secondary metabolites for regular growth and reproduction, they are created in response to stress and aid in survival through signaling and defense.Polysaccharides, which are members of the 1,3-β-glucans family and have anticancer properties that are accomplished by boosting and inhibiting the cellular immune system, are the most significant secondary metabolite found in medicinal mushrooms. High molecular weight glucans appear to be more efficient than low molecular weight glucans, and these polysaccharides have anticancer and immunostimulating qualities. The architectures of biologically active

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polysaccharides differ from species to species and strain to strain. In order to determine the pharmacological activity of these polysaccharides, medicinal mushrooms are often extracted using hot-water soluble fractions.

Additional secondary metabolites, such as lectins, lactones, terpenoids, alkaloids, antibiotics, and metal-chelating compounds, also provide distinct pharmacological effects.

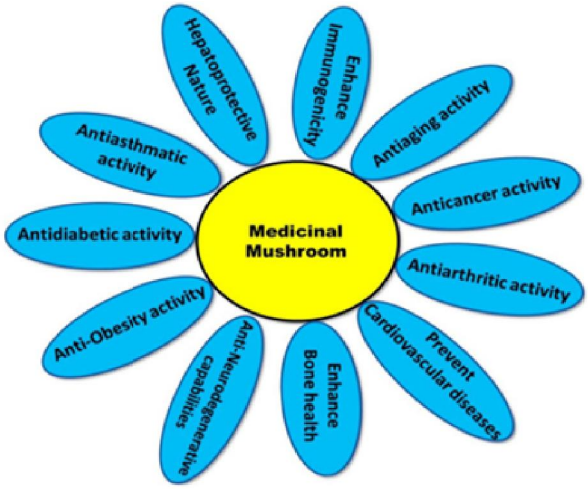

Fig. 1 Schematic illustration of therapeutic applications of edible mushroom

In addition to stimulating the immune system, these secondary metabolites have been shown in numerous studies to alter distinct cellular responses by disrupting specific transduction pathways. Pleurotus ostreatus is an edible fungus that, through up-regulating a cell cycle regulatory protein, can prevent the growth of breast and colon cancer cells. The extract from Pleurotuspulmonaris inhibits the PI3k/AKT signaling pathway, which prevents the development of liver cancer. According to Wachtel et al. (2011), extracted proteoglycans from Ganoderma lucidum exhibit a protective effect against liver damage. The antiproliferative and proapoptotic properties ofmethanolic extracts of the white button mushroom, Agaricusbisporus, suppress prostate cancer by controlling NF-kappa and extracellular regulated kinase (ERK/AKT). The fruiting bodies of G. lucidum contain a fucomannogalactan (FMG-Am) and a (1→3), (1→6)-linked d-glucan (GLC-Am) that activate humoral and cell immunity by upregulating the transcription of interferon-γ (INF-γ) and NK cells and triggering the production of nitrous oxide genes in macrophages. In collagen-induced arthritis, ethanol and proteoglycan extracts from Pleurotuslinteus demonstrate an anti-inflammatory activity.

The crude extract of the mycelia and fruiting body of medicinal mushrooms contains a wide range of bioactive compounds with potential therapeutic uses, including α-unsaturated polysaccharides, glycoproteins, peptides, phenolic derivatives, hydrolytic, lipids, and oxidative enzymes.Medicinal mushrooms are frequently referred to as "mushroom nutraceuticals." As dietary supplements, this mushroom nutraceutical is taken as capsules or tablets and is made from the dried biomass or extract of the mycelium or fruiting body of a mushroom that may have therapeutic uses. The human body's immune response may be strengthened with consistent use of these nutraceuticals, which has been shown to increase resistance to illness and occasionally improve the state of the disease.The review provides a summary of the biologically active substances found in medicinal mushrooms, together with information on their structure, therapeutic uses, and pathways that demonstrate how they can prevent disease from developing. Several therapeutic qualities displayed by several mushrooms that have been previously investigated in vitro by various researchers.[1]

II. LIST OF SOME EDIBLE MUSHROOMS WITH THEIR MEDICINAL PROPERTIES[2]

S. No	Botanical Name	Common Name	Geography	Uses
1.	Agaricusbisporus	Button Mushroom	Europe and North America	Anti-tumor, Antioxidant, Antiviral, hypocholesterolemic, Hypoglycemic, Anti-bacterial, Anti-aromatase activity, Anti-proliferative activity.

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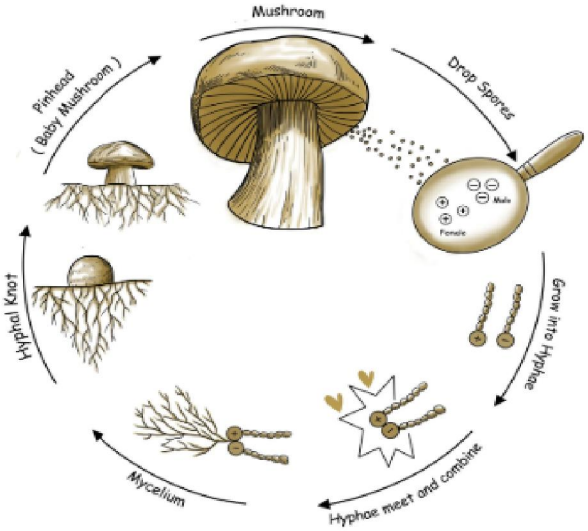
2.	Calocybeindica	Milky mushroom	India	Prebiotic Antiproliferative.
3.	Cotinariuscaperatus	Gypsy mushroom	Northen regions of Europe and north America	Antifungal, Antioxidant and Antiviral.
4.	Hypomyces Lactifluorum	Lobster mushroom	North America	Antioxidant
5.	Pleurotus ostratus/Pleurotus pulmonaris	Oyster mushroom	Worldwide	Immunomodulatory, Antitumor, Hyperglycaemia
6.	Lentinula edodes	Shiitake mushroom	Asia, Chinaand Japan	Antifungal, Antibacterial, Cytotoxicity assay
7.	SparassisCrispa	Cauliflower mushroom	Korea	Wound healing in Dibetiesmellitus, Anti -tumour activity
8.	Hydnumrepandum	Hegehog Mushroom or sweet Toth	Ireland, Europe, North America	Antimicrobial, Antitumor and cytotic,Anti-oxidant
9.	Hppsizygustessellatus	Beech Mushroom	Europe, North America and Australia	Anti-inflammatory, Antibacterial

III. THE LIFE CYCLE OF MUSHROOM



IV. NUTRITIONAL VALUE AND BIOACTIVE COMPONENTS:[3]

Medication mushrooms have fruiting bodies that are low in calories (50–70 kcal/100g) because of their high water content (approximately 80–90%). Their moisture content is between 3 and13% after drying.A table displaying the chemical makeup of therapeutic mushrooms is provided. The following nutrients may be found in these mushrooms: dietary fiber (16–53%d.b.), protein (3.87–37.4%d.b.), minerals (6.2–9.7%d.b.), lipids (1–5.62%d.b.), and carbs (65.6–87.13%d.b.).

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Bioactive Components:

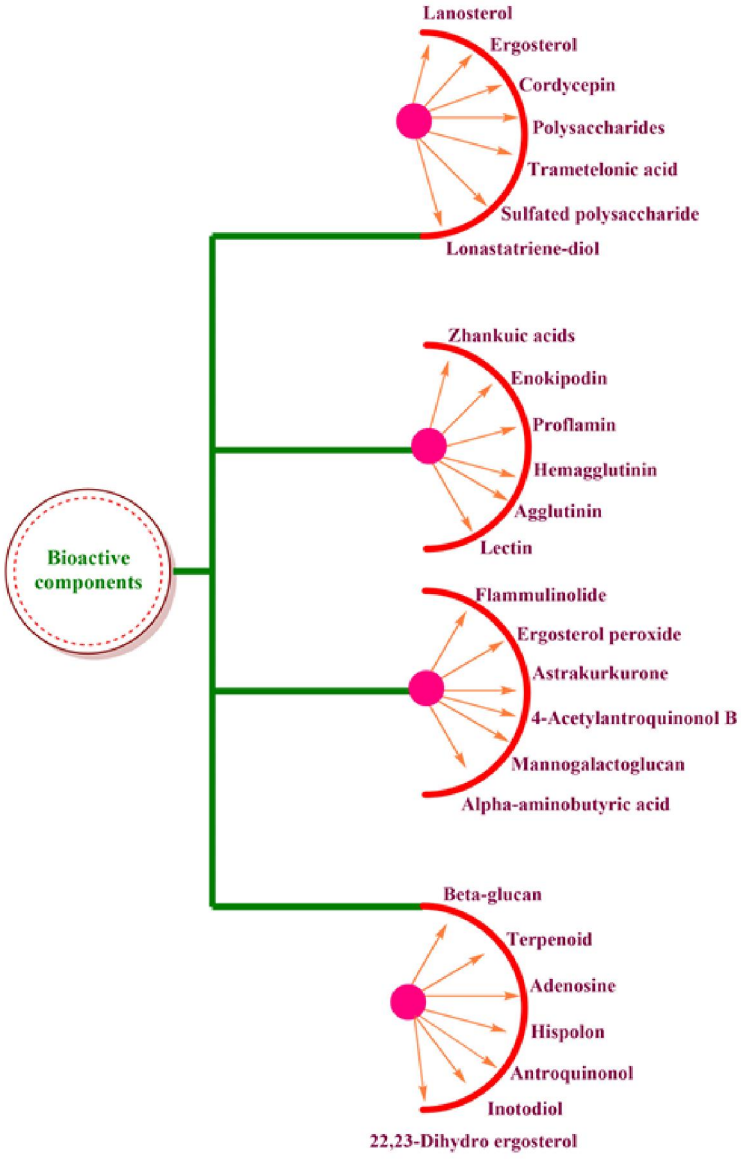

Figure. Important bioactive constituents in mushrooms[4]

Table. The chemical composition of medicinal mushrooms (g/100g dried mushrooms)

Common Name	Latin Name	Moisture	Protein	Carbohydrates	Lipids	Dietary Fibre	Ash
Reishi	Ganoderma lucidum (Curtis)P. Karst	7.5–12.99	13.3–23.6	42.8–82.3	3–5.8	14.81	4
Lion's Mane	Hericium erinaceus (Bull) Pers	7.03*	22.3	57.0	3.5	3.3–7.8	7.1
Chaga	Inonotus obliquus (Ach.exPers) Pilát	3.5	2.4	10.3	1.7	67.5	n.d.
Cordyces	Ophiocordyceps	3.5*	21.9–	24.2–49.3	5.5–	7.7	13.13

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	sinensis (Berk.) G.H.Sung,J.M.Sung, Hywel-Jones and Spataforaprior name Cordyceps sinensis		23.1		8.2		
Shiitake	Lentinula edodes (Berk)Pegler	7.14	17.2–27.09	38.1–66.0	1.26–2.95	46.19–49.09 (IDF: 40.7–44.2 and SDF: 1.95–8.4)	6.05-6.73
TurkeyTail Italso knownas:, Cloud mushroom,YunZhi, Kawaritake	TrametesVersicolor(L.) Lloyd	-	11.07	-	1.35	-	-

A. Polysaccharides:

Fungal carbohydrates are comprised of oligo saccharides (trehalose, malezitose), alcohol sugars (mannitol), monosaccharides (glucose, fructose, galactose), and polysaccharides, including homopolysaccharides (glucans, chitin, and glycogen) and heteropolysaccharides (xylomannan,-(1 6)-D-galactopyranosyl with branches at both (1 4) and (1 6)O-2 of galactose and O-6 of glucose are substituted with 6-O-galactopyranoses.3-O-D-mannopyranosyl-L-fucopyranosyl, D-mannopyranosyl, and L-fucopyranosyl in O-2-(1 3)-linked galactose, with -(1 4), -(1 6)-glucose and fucose branches, distinct mucilage made of galactose and glucose. Therefore, carbohydrates occur in complexes with other substances (like proteins) and can contain different sugar subunits.

The structure, bond type, and molecular weight of carbohydrates determine their functional characteristics.In fungi, chitin and D-glucans are the primary digestible polysaccharides. They are made up of units of sugar joined by glycosidic linkages. Glycosidic linkages 1-4 bind the monomer in chitin, glucosamine, whereas glucans are composed of glucopyranose molecules. Through the use of (1,3) and (1,4) glycosidic linkages, the molecules create linear segments to which side chains are affixed. These substances are categorized as dietary fibers.They serve a crucial function in the formation of cell walls and are present in both the vegetative and generative stages of fungal ontogenesis in both fruiting bodies and fungal cells. Complexes of D-glucans with proteins are thought to play a uniqe physiological role.

Their structure can be a random helix, triple helix, or single helix. The functional qualities of these compounds vary depending on their molecular weight, the kind of glycosidic linkages they contain, and the chain conformation.Triple-helix beta-glucans exhibit a higher capacity to suppress tumor growth than single-helix beta-glucans. According to Sletmoen and Stokke as well as Brown and Gordon, glucans with a low molecular weight and a short side chain are thought to be less active, whereas compounds with a higher molecular weight and reduced water solubility are more effective immunostimulators. However, Rop et al. discovered that water-soluble glucans were more effective at modulating the immune system than water-insoluble glucans. Macrophages are primarily antigen-presenting immune cells that boost the body's defenses against viruses and bacteria, which helps glucans have an immunomodulatory effect. Certain lymphocytes, known as NK cells, are stimulated by high molecular weight compounds and exhibit cytotoxic effects on tumor cells.

Additionally, they increase the expression of cytokines linked to immune response, such as interferon, TNF, IFN-g, IL-1, and IL-12, which prevent tumor cell growth and trigger their death, thereby having antiviral, antibacterial, and antitumor effects.These substances are frequently used to conventional cancer chemotherapy as adjuvants. Glucan concentration in mushrooms ranges from 3.79% d.b. for Cordyceps (Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora) to 60.79% d.b. for Turkey Tail (Trametes versicolor (L.) Lloyd). Generally speaking, edodes are a more effective supplier of these substances than caps. Glucans are abundant in the shiitake (Lentinula edodes (Berk.) Pegler) mushroom. Its-glucan lentinan, which triggers immune cells to target cancer cells, is the source of its unique name. Lentinan can strengthen the antiviral treatment of AIDS by increasing the production of

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T cells and AZT (3-Azido 3-deoxythymidine). Its benefits in treating conditions including glioma (human astrocytoma U251 cells), breast cancer, and liver cancer have been demonstrated. On the other hand, the Turkey Tail (Trametes versicolor (L.) Lloyd) has distinctive proteoglucans. Polysaccharide K (PSK), another name for crestin, is one of them; it makes up roughly 25–38% of the protein in the molecule. Treatment for cancers such as stomach, oesophageal, colon, rectal, and lung cancers is successful when using this proteoglucan.

Table. Beta-glucan content of different medicinal mushrooms: [5,6]

Common Name	Latin Name	Content of-Glucans (g/100 g d.b.)
Reishi	Ganoderma lucidum (Curtis) P. Karst.	4.3–23.6
Lion's Mane	Hericium erinaceus (Bull.) Pers.	35.3
Chaga	Inonotus obliquus (Ach. ex Pers.) Pilát	8.5
Shiitake cap/steam	Lentinula edodes (Berk.) Pegler	20.0/25.3
Turkey tail	Trametes versicolor (L.) Lloyd	60.79

Another kind of glucan, known as PSP (Poly Saccharo Peptide), complexes with the protein found in Turkey Tail (Trametes versicolor (L.) Lloyd) mushrooms. It stimulates immune cells by boosting the synthesis of prostagladin E, histamine, cytokines, and chemokines. By easing nausea, vomiting, dry mouth, exhaustion, and other associated discomforts, it lessens the negative effects of chemotherapy. The biological activity of poly- and monosaccharides that exist in complexes with other substances has also been linked to glucans. Ophiocordyceps sinensis (Berk.) cordyceps (G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora) contains cordycepin, which serves as an example. Its chemical structure is similar to that of the nucleoside adenosine (ribose + adenine sugar); however, the ribose moiety's five-membered ring at position three is missing one hydroxyl group. Cellular production of DNA and/or RNA depends on adenosine. By interfering with the manufacture and alteration of nucleic acids, cordycepin can inhibit the growth of bacteria and viruses by integrating into their RNA and DNA structures, which is similar to how adenosine works. Through a decrease in the expression of pro-inflammatory cytokines and chemokines, it exerts anti-inflammatory actions and boosts T and B lymphocyte proliferation and secretion. It also exhibits suppressive qualities against tumor cells and prevents platelet aggregation. The benefits of polysaccharides and other phytochemicals found in mushrooms are displayed in the table.

Table: Bioactive components in medicinal mushrooms and their health-promoting effects.[7,8]

Common Name	Latin Name	Compounds with Bioactive Potential	Health-Promoting Effect
Lion's Mane	Hericium erinaceus (Bull.) Pers	Hericerins, Erinacins, Glycoprotein, Polysaccharide Beta-glucans, Sterols, Lactone, Fatty acids, Volatile compounds (e.g. hexadecanoic acid, linoleicacid, phenylacetaldehyde, benzaldehyde)	Anticancer, Antioxidant, Antiageing. Neurotonic, Anti-asmatic, Hypoglycemiceffects Hypocholesterolemic effects
Shiitake	Lentinula edodes (Berk.) Pegler	Polysaccharides, Beta-glucans (lentinan),Glycoproteins, Phenols, Steroids, Terpenoids, Nucleotides	Immune-enhancing effects,Antitumor, Antioxidant, Antiaging activity, Antimicrobial activity.[9,10,11] Hypocholesterolemic effect, Reduction in blood pressure

B. Proteins:

In addition to carbohydrates, mushrooms also contain significant bioactive components such proteins and peptides. They vary greatly in content, ranging from 4.6 to 56.3 g/100 g, and are mostly influenced by the type of mushroom. The highest protein concentration (over 20%) is found in the following mushrooms: Shiitake (Lentinula edodes (Berk.) Pegler), Lion's Mane (Hericium erinaceus (Bull.) Pers.), and Cordyceps (Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora). The length of the polypeptide chain, the makeup and sequencing of the amino

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acids, and the compounds' particular biological activity can all be determined. They are most frequently attributed to antibacterial, anticancer, antioxidant, hypotensive, angiotensin-converting enzyme (ACE) inhibition, and antiviral properties. The most significant bioactive fungal proteins are immunomodulatory proteins, lectins (glycoproteins), and proteins having enzymatic activity, such as laccase, ribonucleases, nucleases, and ergotionein. Lectins help to reduce blood sugar levels by increasing the release of insulin. Furthermore, they trigger the immune system and exhibit chemopreventive properties against a range of cancer forms, including hepatocellular carcinoma. These substances can be found in reishi (Ganoderma lucidum), for example. From the fungus Trametes versicolor, Li et al. also identified this kind of protein, which they called TVC. The authors have shown that TVC causes the enhanced necrosis of alpha tumor cells generated by mice macrophages and promotes the proliferation of human peripheral blood lymphocytes.Cordyceps (Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora) contain a distinctive low molecular weight peptide called cordymin. Research has indicated that this substance protects rats with alloxan-induced hyperglycemia by reducing blood glucose levels.[12] Five weeks following the research, a decrease in aglycated hemoglobin (HbA11C) levels was also observed in rats given a dose of 50–100 mg/kg of body weight. The animal's body weight dropped along with the oxidative damage brought on by high sugar levels. Numerous investigations have demonstrated the full amino acid composition of protein produced from mushrooms. Its nutritional worth surpasses that of proteins found in milk, meat, or eggs, as Thatoi and Singdevsachan have pointed out. The protein found in mushrooms is distinguished by its high concentration of glutamic acid, aspartic acid, or arginine, as well as important amino acids. Aspartic acid, threonine, serine, glutamic acid, glycine, alanine, valine, and leucine were among the eighteen different types of amino acids found in tramates versicolor, according to Pop et al. Additionally, research has verified the presence of the non-protein neurotransmitter aminobutyric acid (GABA) and ornithine, which is recognized for its unique physiological action.[13]

C. Lipids:

Depending on the species, mushrooms can have a fat content of 0.1 to 5.9 g/100 g. Shiitake (Lentinula edodes (Berk.) Pegler) and Cordyceps (Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora) are the two most fat-containing medicinal mushrooms. Oleic (C18:1) and linoleic (C18:2) acids are examples of unsaturated fatty acids (UFAs), which make up between 52 and 87% of total fat.In Cordyceps (Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones, and Spatafora), for instance, these acids are predominant.[14] This mushroom's minor fatty acid content is made up of saturated fatty acids, such as stearic (C18:0) and palmitic (C16:0) acids. The fatty acid composition of cordyceps (Ophiocordyceps sinensis (Berk.) Studies by Guo et al. comparing wild and indoor-cultivated Ophiocordyceps sinensis (Berk.) showed that the wild mushrooms had a higher content of polyunsaturated fatty acids (PUFAs) than the indoor-cultivated mushrooms. In Shiitake (Lentinula edodes (Berk.) Pegler) mushrooms, fatty acids such as oleic acid, hydroxydocosanoic acid, hydroxytricosanoic acid, hydroxytetracosanoic acid, and hydroxypentacosanoic acid are predominant. Smaller levels of stearic acid, hydroxyhexacosanoic acid, linoleic acid, palmitic acid, hydroxyarachidic acid, hydroxyheneicosanoic acid, and hydroxy-tricosenoic acid are found.

Since linoleic acid is a naturally occurring supply of this acid, medicinal mushrooms also have anticancer benefits on prostate, colon, and breast cancer.Unsaturated fatty acids are also helpful in preventing excessive blood clotting and can be utilized in the synthesis of tissue hormones.

D. Sterols:

Sterols are bioactive substances that can also be found in mushrooms. Of these, ergosterol is the most prevalent. When exposed to UV light, this molecule photolyzes to produce vitamin D2. Ergosterol shown cytotoxicity towards liver cancer cells and acute promyelocytic leukemia cancer cells, according to a study by Zhengetal. Meanwhile, moderate antibacterial activity against specific bacteria and fungi was observed by the authors. From Cordyceps, a distinctive sterol known as H1-A was extracted. It shares structural similarities with testosterone and dehydroepiandrosterone. This substance may be useful in treating a few autoimmune illnesses, according to in vivo research conducted on mice.

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E. Terpenes and Terpenoids:

Terpenes are a different class of chemicals with the general formula C5H8) n, and terpenoids have extra functional groups (-OH,-CHO, =CO,-COOH,-O-O-). The primary physiologically active metabolites of terpenoid nature are triterpenes, which are produced by Inonotus obliquus (Ach. ex Pers.) Pilát and Ganoderma lucidum (Curtis) P. Karst. Research in the literature has shown that reishi (Ganoderma lucidum (Curtis) P. Karst.) and chaga (Inonotus obliquus (Ach. ex Pers.) Pilát) have high concentrations of these chemicals. Terpenes mostly have anti-inflammatory properties. Triterpenes extracted from Inonotus obliquus (Ach. ex Pers.) and Ganoderma lucidum (Curtis) P. Karst. Pilát decreased the release of inflammatory mediators such as prostaglandin E2 (PGE2) and nitric oxide (NO) as well as pro-inflammatory cytokines like TNF-, IL-1, and IL-6 in macrophages. According to Akihisa et al., the lanostane-type triterpene acids found in Ganoderma lucidum (Curtis) P. Karst. demonstrated anti-inflammatory qualities by preventing the inflammatory process that was produced in mice macrophages. The positive benefits of mushroom terpenes have been documented in antimalarial, antiviral, anticancer, and anticholinesterase activity treatments. Triterpenoids' pharmacological action has been used to treat neurodegenerative illnesses, such as Alzheimer's disease.

V. NUTRITION IN MUSHROOMS

Since ancient times, edible mushrooms have been used extensively as food by humans and valued for their flavor, texture, and therapeutic and tonic qualities. Generally speaking, mushrooms are 90% water and 10% dry substance. From a nutritional perspective, their chemical makeup is appealing. Because they are low in fat and high in fiber, protein, and minerals, mushrooms constitute a significant nutritional component.[15] All nine of the necessary amino acids needed by humans are present in mushroom protein. Mushrooms' excellent digestion makes them a viable alternative to muscle protein. In addition, mushrooms are a strong source of iron, phosphorus, and vitamins like thiamine, riboflavin, ascorbic acid, ergosterol, and niacin. They are also a lot of vitamin B1, B2, B12, C, D, and E. Additionally, mushrooms are a great source of vitamin D, which is otherwise unavailable in other dietary supplements.[12]

Mushrooms have very little sodium, no fat, cholesterol, or calories, and no gluten. Fruit bodies contain a lot of minerals, including potassium, iron, copper, zinc, and manganese. Tocopherols, phenolic chemicals, flavonoids, carotenoids, organic acids, ash, glycosides, volatile oils, and folates are also present.In addition, mushrooms are significant from a nutraceutical perspective because they contain a variety of chemicals, including carotenoids, tocopherols, phenolic compounds, unsaturated fatty acids, and ascorbic acid. Edible mushrooms are a health food because of their nutritional qualities and the positive health impacts of the bioactive substances they contain. Food bioactives that benefit people by promoting health and lowering the risk of disease have recently attracted a lot of consumer interest.It is possible to think of mushrooms as a functional food that offers both nutritional value and health advantages. Following nutrients, the idea of "functional foods" was initially proposed as a component in food analysis. [11]. The most common nutrients of mushrooms are discussed as follows:

A. Proteins and Amino Acids:

The amount of crude protein in edible mushrooms varies widely and is typically high, depending on the species and stage of growth. Mushrooms' primary flavor attributes are influenced by their generally low free amino acid content, which ranges from 7.14 to 12.3 mg/g in dry edible mushrooms. The proteins in mushrooms lack sulfur-containing amino acids like cysteine and methionine, according to their essential amino acid profiles. These edible mushrooms do, however, contain quite high levels of valine and threonine.[16]

B. Vitamins:

Riboflavin, niacin, and folates are among the vitamins that are abundant in cultivated mushrooms. Mushrooms contain a larger amount of vitamin B2 than other foods. The bioavailability of folates in mushrooms is comparable to that of folic acids, and their concentration is moderately high. Apart from riboflavin, niacin, and folates, cultivated mushrooms also have tiny levels of B12 and D2 and minor amounts of vitamin C and B1.

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C. Carbohydrates:

The amount of total soluble sugars in edible mushrooms is minimal, whereas the amount of oligosaccharides is considerable. The range of carbohydrates in edible mushrooms is between 35% and 70% DW, depending on the species.[17,18]

D. Fatty Acids:

Fatty acid content in mushrooms is typically low, ranging from 2 to 8% of distilled water. More than seventy-five percent of total fatty acids are polyunsaturated fatty acids, of which oleic and linoleic acids are the most important. Palmitic acid is the primary saturated fatty acid.[19]

VI. THERAPEUTIC POTENTIAL OF MUSHROOMS

antibacterial, antifungal, and hypoglycemia are only a few of the documented medicinal benefits of mushrooms.[20] The polysaccharide–protein complex (PSPC) The main characteristics of mushrooms are their bioactive substances and therapeutic qualities.

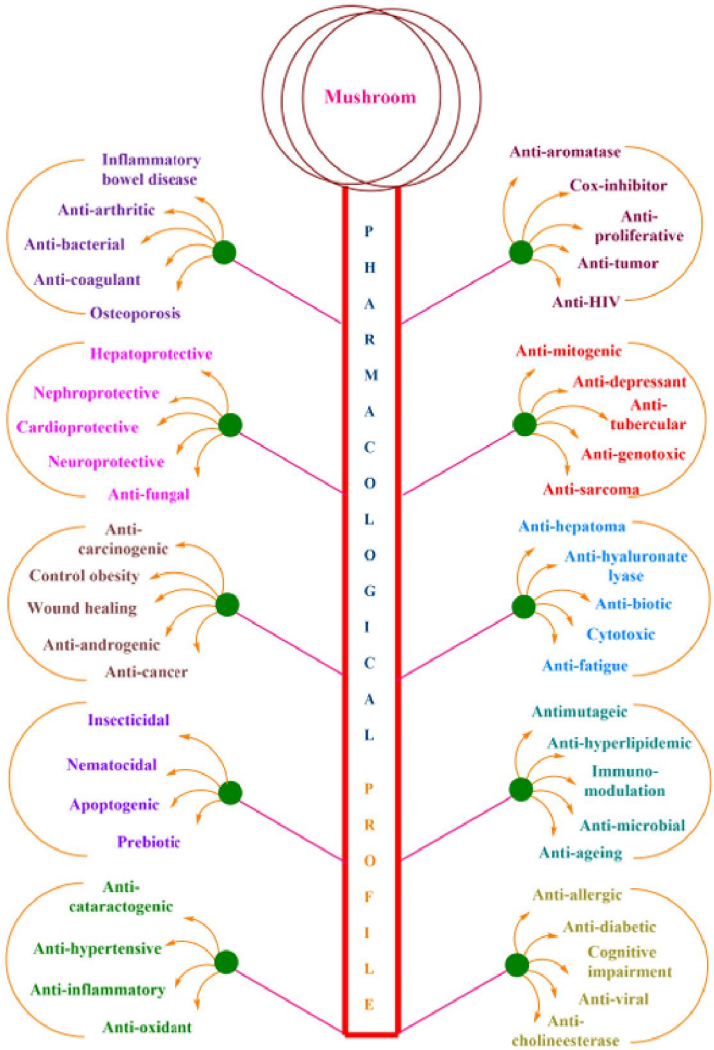

Figure. Pharmacological profile of mushrooms as a therapeutic agent.[4]

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Mushrooms' pharmacological qualities include boosting immunity, preserving homeostasis, controlling biorhythm, and—above all—curing and preventing a number of serious illnesses, including cancer, stroke, and heart conditions. Hepatoprotective, antidiabetic, anti-angiogenic, immunomodulatory, anti-inflammatory, antioxidative, anticarcinogenic, antiviral, derived from mycelial cultures of mushrooms has been thoroughly investigated for its immunomodulatory and anticancer properties.[21] The following are some examples of mushrooms' pharmacological potential:

1. Anticancer activity
2. Antiviral activity
3. Anti-neurodegenerative – neuroprotective activity
4. Anti-diabetic activity
5. Anti-inflammatory activity
6. Anti-tumour activity
7. Antiallergic activity

1.Mushrooms as Antitumor Agents:

In Eastern Asia, Cordyceps militaris has long been utilized as a nutraceutical and as a cancer cure in traditional Chinese medicine.[22] Research is now being done on the problem of finding new antitumor drugs, including mushrooms. According to reports, Pleurotus florida, Phellinus rimosus, Ganoderma lucidum, and Pleurotus pulmonarius have strong anticancer and antioxidant properties. [23] The Sarcoma 180 line in mice was used to investigate the anticancer properties of the higher basidiomycetes extracts of Boletus edulis fruiting bodies and other Homobasidiomycetes, and the results showed substantial activity.Calvacin, which was extracted from the giant puffball (Calvatia gigantea), was found to be effective against a variety of experimental malignancies, such as HeLa cell lines, Sarcoma 180, mammary adenocarcinoma 755, and leukemia L-1210. According to research, there are about 650 species of higher basidiomycetes with notable anticancer activity**.**

2. Antiasthmatic properties of mushrooms:

Adults and children can both suffer from asthma, a respiratory condition. Asthma symptoms are triggered and exacerbated by allergen exposure. FIP-fve is a fungus immunomodulatory protein found in the extract of the medicinal mushroom Flam mulina velutipes. oral treatment of the mouse asthma model to prevent chronic airway inflammation caused by isolated FIP-fve inhibitory allergen (OVA). The balance of type 1 T helper cells (Th1) and type 2 T helper cells (Th2) is essential for this allergy. It is known to distort the reaction to the generation of Th1 cytokines. As shown by bronchoalveolar lavage fluid (BALF) analysis and ELISA assay, the rate of inflammation and hyperresponsiveness increased following intranasal delivery of OVA (Lee et al. 2013). On OVA-induced airway inflammations, oral FIP-fve demonstrated an anti-inflammatory impact and may have the ability to treat an allergic reaction in the body. To evaluate the effects of anti-asthmatic activity on lung cells of ovalbumin-induced asthmatic mice, mycelia of Cordyceps sphecocephala extract was injected. The findings showed that asthmatic mice showed decreased immune responses by inhibiting the expression of cytokines, and that rising levels of IL-4, IL-13, and IL-25 expression were controlled (Heo et al. 2010).

3. Anti-ageing property of mushroom:

According to recent research, the medicinal mushroom Tricholo malobayense has a variety of bioactive substances that have anti-aging properties. When measured in a model of old mice produced by d-galactose, the extracted polysaccharide TLH-3 from the fresh fruiting body of Tricholo malobayense exhibits anti-aging properties. By controlling the expression of UTH1 oxidative stress-responsive genes, the two novel anti-aging ergosterols, ganodermasidase A and B, found in the isolated methanol extract of medicinal mushroom, Ganoderma lucidum (Krupodorova et al. 2015), prolong the replicative life span of Saccharomyces cerevisiae. Polysaccharides, polyphenolics, phenolics, terpenoids, selenium, vitamins, and volatile organic compounds are just a few of the isolated chemicals from the medicinal mushroom's fruiting body that exhibit remarkable antioxidant, anti-aging, anti-wrinkle, skin-whitening, and moisturizing properties. In elderly mice given d-galactose, a water-soluble polysaccharide (AAP I-a) derived from Auricularia auricular inhibits oxidative damage. The industry produces antiaging lotions and creams as well as other skin-related cosmetics using a paste of polysaccharides. The functional enzymes that cause skin aging,

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including elastase, tyrosinase, hyaluronidase, and MMP-1 enzymes, are inhibited by these polysaccharides (AAP I-a), which can postpone the aging process. Additionally, by promoting the expression of collagen synthesis and restoring skin suppleness, these polysaccharides aid.

4. Cardiovascular Disease:

Polysaccharides derived from fungi may help prevent cardiovascular illnesses and their aftereffects. Because of their high fiber and low fat content, edible mushrooms are excellent choices to be a part of a balanced diet in order to prevent atherosclerosis. Low levels of total triglycerides and lipids are the outcome of the mechanisms of action, which include anticoagulation and antiaggregation activity in the blood platelets. Moreover, the antioxidant action may be linked to the hypocholesterolemic impact. When black fungus polysaccharides were administered to high-fat mice, the antioxidant enzyme activities in the heart and blood were markedly increased, and the levels of lipid peroxidation were decreased. Human studies have shown that meals high in β-glucans reduce serum levels of LDL and total cholesterol, as well as the visceral fat area and waist circumference in hypercholesterolemic patients. At the intestinal level, β-glucans decreased the absorption of long-chain fatty acids and cholesterol. These polysaccharides also downregulated the genes related to lipid transport and lipogenesis.

5. Antioxidant Activity:

A large number of prevalent disorders are associated with oxidative damage. Thus, compounds that have antioxidant properties typically stop some diseases from developing.

Various mushrooms' polysaccharides shown reducing qualities, lipid peroxidation inhibition, oxidative stress and proliferation suppression, free and superoxide radical scavenging action, and more.In addition to the fungus species, the activity was also influenced by the active polysaccharide's chemical makeup and arrangement.The strong antioxidant action of polysaccharide–peptide complexes and other mixed carbohydrates has also been demonstrated**.**

6. Anti-obesity activity:

Numerous disorders, including diabetes, hyperlipidemia, and atherosclerosis, have been linked to obesity, which is a serious global health issue. When given to rats on a high-cholesterol diet, extracts from Pleurotus Florida showed encouraging results against obesity. They prevented the rats from gaining weight, decreased total cholesterol, LDL, and triglycerides, and also decreased the amount of fat that was deposited on the mice's bodies. The β-glucan included in Pleurotus sajor-caju extract prevents obesity in obese mice fed a high-fat diet.Eight distinct edible mushrooms are compared for their anti-obesity and hypolipidemic effects in mice fed maize oil. Pleurotus eryngii (PEE) water extract lowers pancreatic lipids, while Gifola frondosa suppresses pancreatic lipase by preventing the hydrolysis of 4-methylumbelliferyl (4-MUO) and trioleoylglycerol emulsified with lecithin, according to an in vitro investigation.

7. Antiviral properties of mushrooms:

The hallmark of poliomyelitis, which is brought on by poliovirus, is flaccid paralysis. Developing nations like those in Asia and Africa are susceptible to poliomyelitis. Polysaccharide extracts from the fruiting body of the sun fungus Agaricus brasiliensis, both in aqueous and ethanol form, have antiviral activity against poliovirus type 1 in HEp-2 cells. Fresh mushroom fruiting bodies include proteins, peptides, and polysaccharide polypeptides that have been shown to inhibit the enzyme reverse transcriptase, which is essential to the HIV-1 virus' life cycle. The lectin that was extracted from Pleurotus citrinopileatus exhibits antiviral properties against HIV-1. A protein (glycoprotein) rich in carbohydrates and containing a ubiquitin-like N-terminal sequence was found in the extract of the fruiting bodies of the edible oyster mushroom Pleurotus ostreatus. This protein demonstrated properties like cleaving transfer RNA, inhibiting the reverse transcription of the human immunodeficiency virus-1, and inhibiting translation in rabbit reticulocyte lysate. A medicinal plant with a wide range of biological activities is Phyllanthus urineri. The anti-HSV-1 and HSV-2 properties of several solvents isolated from P. urinaria were examined in vitro using the plaque reduction test. Herpes simplex virus-2 (HSV-2) was suppressed by P. urinaria extracts in acetone, ethanol, and methanol. Grifola frondosa fruiting bodies were extracted to produce an antiviral protein that has anti-HSV-1 properties.

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7. Status of Mushroom Cultivation in India:[24]

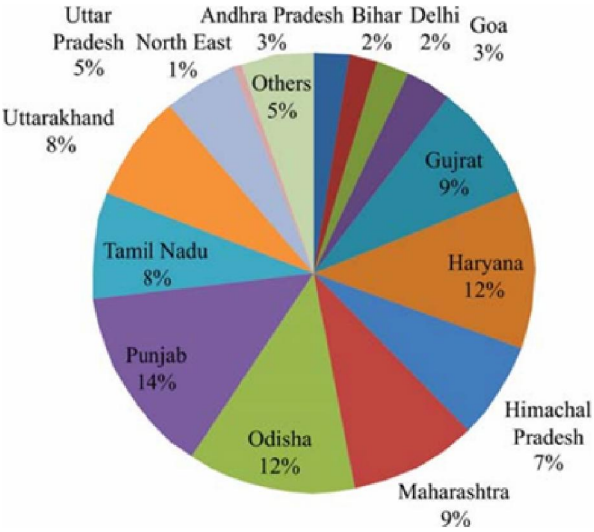

Fig. Major mushroom producing state of India, 2016

VIII. CONCLUSION

A medicinal mushroom extract can be administered to patients to help treat them or shield them against a wide range of illnesses. The mushroom extract can be added to the diet as a dietary supplement. The therapeutic mushroom's fruiting bodies and mycelial extract both contain bioactive chemicals that have a good impact on human health. For the creation of effective biotechnological techniques, the production of mushrooms and the extraction of their bioactive metabolites are essential components. Isolated chemically defined compounds from medicinal mushrooms have the potential to become novel medicines and useful foods. These days, industries in many nations use mushroom mycelial as a medical ingredient to make tonics that cure illnesses. Mushroom extracts, which come from the higher class of fungi known as Basidiomycetes, are used in biotechnological procedures to create new pharmacological compounds that combat a range of illnesses.[22] Additional research, such as clinical trials of bioactive substances, can be applied to treat infections and other illnesses. We believe that our review will lead to a greater use of mushrooms in medical research, with the ultimate goal of creating effective treatments for a number of illnesses.

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