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Review Article

Edible Mushrooms and Their Holistic Approach on Health

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Abstract

During this period of time, mushroom experience changes in functional aspects and consumption areas. Due to its magnificent role in promoting health, it was considered one of the most healthy sources of food. *Agaricus* spp., *Marcrolepoita* spp., *Auricularia* spp, *Armillaria* spp, *Pholoita*, *Hericium*, *Grifola* spp, *Flammulina*, and *Hypsizygus* spp. are some most commonly consumed mushrooms in the world. They provide inexpensive means of nutritious and tasty food worldwide. However, ancient people are also very much aware of their holistic function towards health and that was why they used mushrooms for medicinal purposes in the past onwards. Mushroom plays an important role in the treatment of some lethal diseases like cancer, inflammation, autoimmune disorders, allergy, hypertension, arthritis, hyperglycemia, atherosclerosis, and many more. Meanwhile, researchers still focus on other functions of mushrooms in health science and also explore their anticancerous activity. However, many findings are left to be found in the future. This review paper throws light on the various important mushrooms and their functions related to human health, and also ongoing research towards treating some critical diseases.

More Information

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Introduction

The word Mushroom came from the Old French word Moisseron, which come across the in the 4th century. It was used to deliberate species of fungus which mainly belong to order Basidiomycetes or Ascomycetes. They are fleshy, spore-bearing fruiting bodies. In general, they are found in humus, moist wood, animal waste, soil rich in organic matter, and surface after heavy rainfall. Since, the 1980s, Medicinal properties and their promising regulating results in certain lethal diseases attract numerous scientists to research them respectively. There are about 70,000 species of fungi reported till now, out of them only 20,000 (31 genera) are edible. Moreover, about 10% of the 30 species are poisonous in nature and can be considered lethal. In the past, mushroom species are extensively used as food products but nowadays due to hot research topics clinical proficiencies are also a matter of concern. It performs as a storehouse of vitamins, minerals, essential proteins, essential lipids, and most crucial polysaccharides that may have key semblance in anti-inflammatory and anti-tumorous effects [1]. Some well-known edible genera of mushrooms are *Agaricus, Marcrolepoita, Auricularia, Armillaria, Pholoita, Hericium, Grifola, Flammulina, Hypsizygus,* etc [2]. These genera of mushrooms are not only delicious options for food but also have a holistic approach toward medicinal and therapeutic drugs.

Worldwide, people appreciate mushrooms both as food and for their therapeutic benefits. There have been over 130 documented health benefits associated with mushrooms, including anti-diabetic, antioxidant, antibacterial, anticancer, prebiotic, immunomodulating, anti-inflammatory, and cardiovascular improvements. Phase I, II, or III clinical trials have been conducted on a number of mushrooms for a range of illnesses, including cancer, as well as for improving immunity [3]. For millennia, many different cultures have enjoyed eating mushrooms. Because of their pleasing sensory qualities and alluring culinary qualities, edible mushrooms are regarded as a delicacy. *Agaricus bisporus* (Figure 1), *Pleurotus species*, and *Lentinula edodes* are the three mushrooms that are most commonly consumed worldwide. They are simple to grow, have a high nutritional

Figure 1: Agaricus bisporus commonly known as the White button mushroom found mainly in Asia, Europe, and North America. Most eaten mushroom in the world *(source:- https://elcfoodservice.com/products/button-mushroom).*

value, and have appealing culinary qualities [4]. Despite their high dietary fibre content and low calorie and fat content, mushrooms are excellent health foods from a nutritional standpoint. Additionally, they have a high protein content (20% - 30% of dry matter), which contains the majority of the essential amino acids, as well as mushrooms are a relatively good source of the nutrients like phosphorus, iron, and vitamins, including thiamine, riboflavin, ascorbic acid, ergosterol, and niacin [5]. Due to their potential to improve human health, mushrooms have recently gained popularity as functional foods [6]. They contain bioactive compounds with high medicinal value, such as lectins, polysaccharides, phenolics and polyphenolics, terpenoids, ergosterols, and volatile organic compounds, which are regarded to be responsible for their healthy activities, such as antitumors, immunomodulating, antioxidant, antithrombotic, radical scavenging, antihypercholesterolemia, antiviral, antibacterial, hepatoprotective, and antidiabetic effects [7]. Numerous studies have demonstrated that several mushroom species are effective in the prevention and treatment of a variety of chronic diseases, including cancer, cardiovascular disease, diabetes mellitus, and neurological diseases [8-10].

Antibacterial medicines may be found in mushrooms. It may also have antifungal activities. Mycochemicals are molecules that inhibit the action of free radicals, protecting the organism from oxidative damage. Free radicals are independent molecules with one or more unpaired electrons that cause biological injury and are involved in a number of non-communicable diseases, as well as helping to damage bacterial DNA and promote mutation. Mushrooms' high levels of vitamin C, polyphenols, and other substances provide a powerful antioxidant effect, reducing chronic diseases such as cancer, diabetes, and heart disease. Mushrooms contain a high concentration of non-nutrients (phenols) and micronutrients (vitamins), which provide antioxidant potential and may be beneficial as a dietary supplement for patients suffering from diseases such as atherosclerosis, hypertension, inflammatory conditions, ischaemia, obesity, parkinsonism, high risk of stroke, and Alzheimer's disease [11]. Besides being an ideal food source, mushrooms also have some drawbacks as they cause allergies in many individuals because they contain some essential phenols and polysaccharides that are not normally present in humans. However, out of these many appreciable qualities, this so-called flaw cannot affect its supreme nature as all medicine may have some drawbacks of its own.

As a therapeutic agent, it can prevent diseases like hypertension, hypercholesterolemia, atherosclerosis, antidiabetic, anti-inflammatory, and anti-cancerous. They are most nutritive than any other crop [2].

Significantly, cancer or tumor is an uncontrollable division of cells. Every day millions of people suffer from this deadliest disease. There are numerous reasons for cancer in living cells, some of them may be exposure to carcinogenic compounds, random mutation in DNA, UV radiation, viral or bacterial infection, halt in some DNA repair system of cells, chronic inflammation, or others. It was reported that chronic inflammation due to infection or any kind of autoimmune disease may tend to predispose cancer development. Some examples are pancreatitis and pancreatic cancer, hepatitis B and C infection and hepatocellular carcinoma, atrophic gastritis and gastric cancer, Helicobacter infection and MALT lymphoma, inflammatory bowel disease, and colorectal cancer. Therefore, there may be some linkage between inflammation and tumorigenesis. Some species of mushrooms are known to manifest both anti-inflammatory, anti-tumor, and antiallergic properties. Worked by either direct attacking the tumor by apoptosis, metastasis suppression, necrosis, or indirectly by inhibiting neovascularization, increasing T_H1 cell subtype and Nk cell activation. Its anti-inflammatory mechanisms display a decrease in proinflammatory cytokines and reduce reactive oxygen species [12].

Anticarcinogenic effects

Cancer is a leading cause of death worldwide. A great number of research studies indicate that mushrooms, particularly their polysaccharides, may play a key role in the prevention and treatment of this condition [8].

Current anti-cancer medications available in the market have adverse effects and difficulties in the clinical care of many types of cancer, highlighting the critical need for innovative effective, and less-toxic therapeutic approaches. Some esteemed mushrooms with proven anti-cancer effects and active chemicals are of particular relevance in this regard. Several clinical trials have been done to evaluate the efficacy of commercial formulations incorporating medicinal mushroom extracts (β-glucans, phytophenol, omega-3 fatty acids, vital vitamins, and minerals) in cancer therapy.

Their standalone applications and as adjuncts to cancer therapeutics have evolved. Mushrooms are known to supplement chemotherapy and radiation therapy by alleviating cancer-related adverse effects such as nausea, bone marrow suppression, anaemia, and decreased resistance [13]. In this case, *Agaricus blazei* Murrill, *Grifola frondosa,* and *Hericium erinaceus* are potentially rich in β-glucans, which is a chain of D-glucose linked by β-(1-3) glycosidic bond and (1-6) linked side branches. β-glucans and other bioactive compounds present in some mushrooms are originally attributed to the immunomodulating and tumoricidal effects. Functioned by either direct attacking the tumor by apoptosis, metastasis suppression, necrosis, or indirectly by inhibiting neovascularization, increasing T_H1 cell subtype and natural killer cell activation [2].

Mushroom as antimicrobial agents

Some mushrooms synthesize specific vital secondary metabolites that are useful in inhibiting bacterial growth. Extracts from *G. lucidum and Osmoporus odoratus* produce petroleum ether, chloroform, acetone, and water extracts that are effective against six microbial species, namely *K. pneumoniae, E coli, S aureus, B subtilis, S typhi,* and *P aeruginosa.* Other antimicrobial mushroom species effective against *B. subtilis, S. aureus, E. coli, P. aeruginosa,* and *Candida albicans* are *L. perlatum, C. cibarius, C. vermiculris, R. formosa, M. oreades, P. pulmonarius* which are found near western Ghats of Karnataka, India (Figure 2) and have shown significant antimicrobial activity [2].

Role of mushroom in metabolic syndrome

Metabolic syndrome is a medical condition characterized by central obesity, hyperglycemia, hypercholesterolemia, and hypertension. Edible mushrooms, their extracts, polysaccharide fractions, and isolated compounds possess hypoglycemic, cholesterol, and triglyceride lowering ability, hypotensive effects, as well as weight managing activity [10]. The most active compounds are β-glucans as well as lectins and small compounds such as eritadenine, triterpenes, sterols, and phenolic compounds [9].

The secondary metabolites (acids, terpenoids, polyphenols, sesquiterpenes, alkaloids, lactones, sterols, metals, chelating agents, nucleotide analogs, and vitamins), glycoproteins, and polysaccharides, primarily β -glucans, are the different types of bioactive compounds found in mushrooms. These include lectins, proteases and protease inhibitors, ribosome-inactivating proteins, hydrophobins, and enzymes that break down lignocellulose. New proteins with biological functions have also been discovered that can be exploited in biotechnological processes and for the development of novel pharmaceuticals [14].

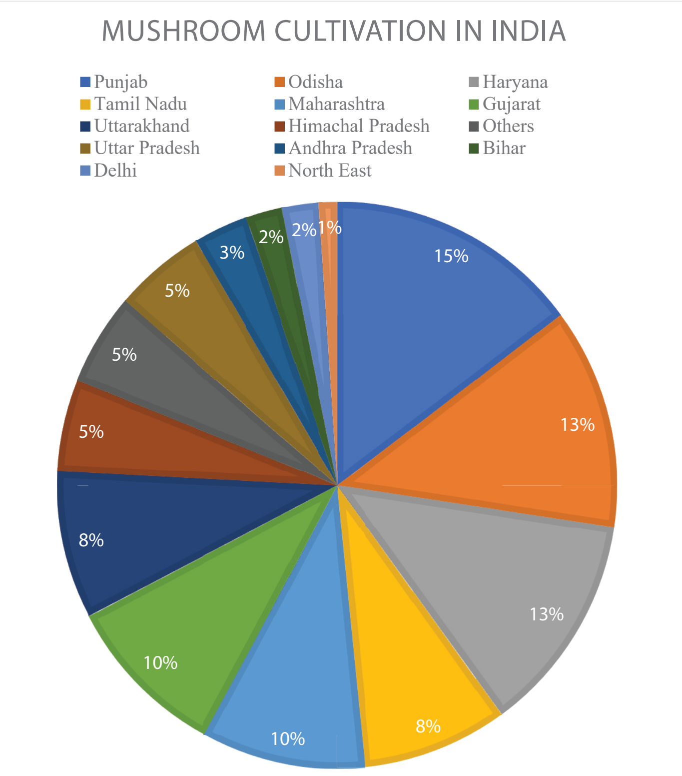

Figure 2: Mushroom cultivation in various states of India [57].

Mushroom as anti-inflammatory agent

Mycelia of *Agaricus blazei* Murrill, *Grifola frondosa, Hericium erinaceus*, and *M. esculants* synthesize bioactive compounds efficient in reducing inflammatory response in the body. It was documented that extracts from *A. blazei, H. erinaceus, and G.frondosa* can reduce the levels of proinflammatory cytokines like TNFα, IL-6, and IL-1β, and also beneficially regulate good gut microbiota. They reduce anaphylactic reactions in mice [12]. They are also found to prevent non-alcoholic steatosis by efficiently reducing hepatic stress in mice. The mycelia extract is proven to have higher anti-inflammatory activity than fruiting bodies [15]. Chronic inflammation due to infection or any kind of autoimmune disease may tend to predispose cancer development. Some examples are pancreatitis and pancreatic cancer, hepatitis B and C infection and hepatocellular carcinoma, atrophic gastritis and gastric cancer, *Helicobacter* infection and MALT lymphoma, inflammatory bowel disease, and colorectal cancer. Therefore, there may be a link between inflammation and tumorigenesis [12].

Mushrooms as hypocholesterolemic agents

Considering cardiovascular disease is related to atherosclerosis, LDL oxidation, and hypercholesterolemia, controlling cholesterol levels play an essential role in disease prevention and therapy. Because of their high fiber and low-fat content, edible mushrooms are an excellent food for the dietetic prevention of atherosclerosis. Indeed, in Oriental medicine, the incorporation of edible mushrooms in a natural hypocholesterolemic and antisclerotic diet is often recommended [16].

Consumption of *Termitomyces microcarpus* mushrooms may help to reduce the prevalence of diseases associated with high blood lipids, according to studies, and reductions in total serum cholesterol, LDL-cholesterol, and triglycerides may be attributed to the mushrooms' high fiber content [17].

Beneficial role of mushrooms in diabetes mellitus

Diabetes mellitus is a common metabolic and endocrine disorder that affects people all over the world and is a major health and financial concern. Diabetes medications, including synthetic antidiabetic medicines, are known to produce a number of side effects when administered by pharmacotherapy. Fortunately, numerous natural polysaccharides have anti-diabetic characteristics, and their usage as supplements to conventional medicine is becoming increasingly popular, particularly in developing countries. The significance of oxidative stress in the development of diabetic mellitus (DM) is crucial. on the antioxidant properties of mushroom polysaccharides used in the treatment of diabetic complications, and whether these antioxidant properties contribute to the deactivation of oxidative stress-related signaling pathways, as well as the improvement of β-cell dysfunction and insulin resistance. Approximately 104 distinct polysaccharides derived from mushrooms have been identified to have anti-diabetic properties. The effects of these polysaccharides on hyperglycemia and other alternative antioxidant therapy for diabetic complications, as well as their uses and limitations, are being studied in order to acquire a better knowledge of how they might be utilized to treat DM. Preclinical and phytochemical studies have revealed that the majority of active polysaccharides derived from mushrooms have antioxidant activity, which reduces oxidative stress and prevents the development of diabetes. More research is needed to confirm whether mushroom polysaccharides can effectively alleviate hyperglycemia, the mechanisms by which they do so, and to determine whether these polysaccharides could be used as complementary therapy for the prevention and management of diabetes in the future [18].

Mushroom as prebiotics

Prebiotics such as oligosaccharides and polysaccharides (inulin) have sparked considerable attention as functional food ingredients due to their ability to modify the composition of colonic microbiota in the human gut by inhibiting exogenous pathogens, hence boosting host health). Mushroom appears to be a promising prebiotic candidate since it contains carbohydrates such as chitin, hemicellulose, glucans, mannans, xylans, and galactans.

Chitin, a water-insoluble polysaccharide, is indigestible in the human digestive system and hence serves as a dietary fibre. Keeping in mind the concept of a prebiotic, the unique quality of mushroom carbohydrates to be non-digestible improves its likelihood of being a prospective prebiotic. However, much research is required to support such a claim, because not all dietary carbs are prebiotics [19]. The species which could be widely used for the prebiotics purpose are *Agaricus bisporus, Agaricus bitorquis, Agaricus blazei, Auricularia auricular-judae, Boletus erythropus, Calocybe indica, Flammulin avelutipes, Ganoderma Lucidium, Geastrums accatum, Hericium erianaceus, Lentinus edodes, Phellinus linteus, Pleurotus eryngii, Pleurotus florida* and *Pleurotus ostreatus* [20].

Nutritive values of mushroom

Mushroom has tremendous nutritive value. It has low-calorie content and is rich in essential amino acids, minerals, vitamins, and lipids. It has low-fat content and promising amounts of antimicrobial phenols (Tables 1-3).

The carbohydrate content of mushrooms on the basis of dry weight is 11% to 65%. Fresh mushroom contains 0.91%

Table 1: Proximate composition of mushrooms shown in percentage [43].

Species	Protein	Carbohydrate	Lipids/fats	ASH	Fiber
Agaricus arvensis	32.87	32.91	-	0.18	0.14
Agaricus bisporus	41.06	28.38	2.12	7.01	18.23
Agaricus bisporus	33.48	46.17	3.1	5.7	20.9
Agaricus heterocystis	32.23	48.55	2.9	11.42	19.7
Agaricus langei	35.14	34.83	-	14.1	3.28
Auricularia auricula	4.2	82.8	8.3	4.7	19.8
Auricularia auricula	36.3	33.23	1.63	7.07	8.4
Auricularia auricula-judae	36.3	33.23	-	7.07	2.81
Auricularia polytricha	37 .0	38.48	0.74	6.87	21.97
Boletus aestivalis	32.76	52.07	-	14.97	12.13
Calocybe indica	17.69	64.26	4.1	7.43	3.4
Calocybe indica	21.6	49.2	4.96	12.8	13.2
Calvatia gigantea	27.3	-	1	6.3	22
Cantharellus cibarius	21.1	-	1.6	13.2	12.8
Cantharellus cibarius	34.17	47	-	7.78	1.4
Clavulina cinerea	27.5	-	2.5	13.9	8.4
Clitocybe sp.	24.8	42	1.24	15.73	13.04
Cookeina sulcipes	28.93	50.2	-	6.55	0.16
Flammulina velutipes	17.6	73.1	1.9	7.4	3.7
Gomphus floccosus	21.2	-	5.3	8	9.2
Grifola frondosa	31.47	40.77	1.49	5.13	7
Hypsizygus tessulatus	37.8	51.2	-	9.09	12.9
Lactarius hygrophoroides	44.93	42	-	2	10.58
Lactarius quieticolor	19	-	2.6	6.6	14.4
Lentinus edodes	32.93	47.6	3.73	5.2	28.8
Lentinus edodes	22.8	64.4	2.1	6	-
Lentinus sajor-caju	28.36	68.24	2.42	4.88	-
Lentinus squarrosulus	37.13	47.83	2.58	8.33	11.33
Lentinus tigrinus	18.07	60	2.25	5.14	14.69
Lentinus torulosus	27.31	64.95	1.36	13.16	-
Lentinus tuber-regium	28.93	50.2	2.17	6.56	12.17
Lepiota lilacea	28.12	49.33	-	8.09	11.98
Lepiota magnispora	27.55	35	-	3.05	5.2
Lepista irina	26.12	50.2	-	3.16	6.08
Lyophyllum decastes	18.31	34.36	2.14	14.2	29.02
Macrolepiota rhacodes	34.31	48	2.25	11.8	4.78
Melanoleuca grammopodia	36.27	33.04	-	4.13	8.12
Panus fulvus	27.06	33.04	-	3.11	6.08
Pleurotus florida	27.83	32.08	1.54	9.41	23.18
Pleurotus ostreatus	30.4	57.6	2.2	9.8	8.7
Pleurotus ostreatus	37.63	43.4	2.47	10.17	4.2
Pleurotus pulmonarius	37.63	43.4	-	10.17	4.12
Pleurotus roseus	30.27	42.97	2.02	5.57	4.2
Pleurotus sajor-caju	39.1	38.57	1.17	5.73	4.9
Pleurotus sajor-caju	19.23	63.4	2.7	6.32	48.6
Ramaria brevispora	24.1	-	1.3	10.9	8.8
Russula delica	26.25	34.88	5.38	17.92	15.42
Russula integra	21.1	-	4.5	11.5	6.4
Schizophyllum commune	15.9	68	2	8	-
Schizophyllum commune	22.5	32.43	-	10.1	6.5
Termitomyces heimii	34.2	39.03	2.11	16.8	9.73
Termitomyces microcarpus	29.4	46.53	2.33	11.2	11.5
Volvariella bombycina (Fruit body)	28.3	38.9	2.72	10.9	24.6
Volvariella bombycina (Mycellia)	25.5	34.75	1.15	9.03	31.8
Volvariella volvacea	37.5	54.8	2.6	1.1	5.5
Volvariella volvacea	30.57	43.53	2.04	10.37	9.67

Table 2: Essential amino acid in 100 gm dry mushroom [44].

Essential amino acid	*Agaricus bisporus*	*Agaricus edodes*	*Pleurotus florida*	*Pleurotus ostreatus*	*Pleurotus sajorcaju*	*Volvereilla volvacea*
Leucine	7.5	7.9	7.5	6.8	7.0	4.5
Isoleucine	4.5	4.9	5.2	4.2	4.4	3.4
Valine	2.5	3.7	6.9	5.1	5.3	5.4
Tryptophan	2.0	-	1.1	1.3	1.2	1.5
Lysine	9.1	3.9	9.9	4.5	5.7	7.1
Threonine	5.5	5.9	6.1	4.6	5.0	3.5
Phenylalanine	4.2	5.9	3.5	3.7	5.0	2.6
Methionine	0.9	1.9	3.0	1.5	1.8	1.1
Histidine	2.7	1.9	2.8	1.7	2.2	3.8

Table 3: Major vitamins and mineralS (on dry basis) [44].

Major vitamins and minerals	Daily requirement (mg)	Mushroom content (mg)
Thiamine (B1)	1.4	4.8 - 8.9
Riboflavin (B-2)	1.5	3.7 - 4.7
Niacin	18.2	42 - 108
Phosphorus	450	708 - 1348
Iron	9	15 - 17
Calcium	450	33 - 199
copper	2	12 - 22

hemicellulose, 0.28% reducing sugars, 0.59% glycogen, 0.9% mannitol, and a satisfactory quantity of β-glucan. However, the most commonly consumed mushroom in India is the white button mushroom, also called *Agaricus bisporus*. It is rich in sucrose, glucose, raffinose, fructose and xylose.

Mushrooms usually contain all essential amino acids required by the human body for its proper metabolism. *Agaricus bisporus* contain 32% to 42% of the protein in dry weight [2]. It is an abundant source of essential amino acids like histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine [21]. Meanwhile, the protein content of a mushroom also depends upon the species of the mushroom, the composition of the soil or substratum, and the size of the pileus [22].

Some essential lipids are the main constituent of mushroom fruiting bodies and mycelia. Mushroom is a source of polyunsaturated fatty acids like linolenic acid (omega-3 fat). It contains about 2% - 4% fat in dry weight.

Mushroom is known to be a vital source of vitamins and minerals, like vitamin D2, B complex and Vitamin C. Major minerals found in mushroom are Potassium, Phosphorus, Sodium, Calcium, Magnesium, and trace elements like Copper, Zinc, Ferrous, Molybdenum, and Cadmium. Also, it has the property to accumulate heavy metals in soil [2,22].

Edible mushrooms have been widely used as human food for ages and are valued for their texture, flavour, and medicinal and tonic properties [23]. Mushrooms, on average, contain 90% water and 10% dry matter [24]. They have a chemical composition that is appealing from a nutritional standpoint [25]. Mushrooms are nutritious because they are high in protein, fibre, and minerals while being low in fat. The mushroom protein provides all nine essential amino acids that humans require. Because of their great digestion, mushrooms are being examined as a potential alternative for muscle protein [26]. Aside from that, mushrooms are an excellent source of vitamins B1, B2, B12, C, D and E as well as a good supply of phosphorus, iron, and vitamins such as thiamine, riboflavin, ascorbic acid, ergosterol, and niacin [27-29]. Mushrooms are also a good source of vitamin D, which is not found in other food supplements [30].

Mushrooms have limited calories, no fat, no cholesterol, no gluten, and very little sodium. Fruit bodies are high in minerals like potassium, iron, copper, zinc, and manganese. They also contain ash, glycosides, volatile oils, tocopherols, phenolic compounds, flavonoids, carotenoids, folates, organic acids, and other components [31]. Mushrooms are also beneficial in terms of nutraceuticals because they include a variety of substances such as unsaturated fatty acids, phenolic compounds, tocopherols, ascorbic acid, and carotenoids. Mushrooms are considered a healthy food due to their nutritional properties and the health-promoting benefits of the bioactive substances they contain [32-34].

Consumers are increasingly interested in food bio-actives that benefit people in terms of health promotion and disease risk reduction. Mushrooms are a type of functional food that has health benefits in addition to nutritional value [35]. After nutrients, the concept of "functional foods" was first introduced as a consideration in food analysis [36].

The following are the most frequent nutrients found in mushrooms:

Proteins and amino acids: The crude protein content of edible mushrooms is typically high, although it varies substantially depending on factors such as species and stage of growth [37]. Mushroom-free amino acid levels are typically low, ranging from 7.14 to 12.3 mg/g in dry edible mushrooms, and contribute to the principal taste qualities of mushrooms [38]. Mushroom essential amino acid profiles show that the proteins are low in sulfur-containing amino acids such as methionine and cysteine. However, these edible mushrooms are high in threonine and valine.

Vitamins: Several vitamins, including riboflavin, niacin, and folates, are found in cultivated mushrooms. Mushrooms have a higher vitamin B2 concentration than vegetables in general [28]. Mushrooms have moderately high levels of folates, and their bioavailability is comparable to that of folic acids [39]. In addition to riboflavin, niacin, and folates, cultivated mushrooms contain trace levels of vitamin C, vitamin B1, and vitamin D2 [28].

Carbohydrates: Edible mushrooms have a high oligosaccharide content but a low total soluble sugar content [40]. The carbohydrate content of edible mushrooms varies according to species, ranging from 35% to 70% DW [40].

Fatty acids: Fatty acid levels in mushrooms are typically low, ranging between 2% - 8% of distilled water. The proportion of polyunsaturated fatty acids to saturated fatty acids is quite high, accounting for more than 75% of total fatty acids, with oleic and linoleic acids being the most important, and palmitic acid being the principal saturated fatty acid [41] Figure 3.

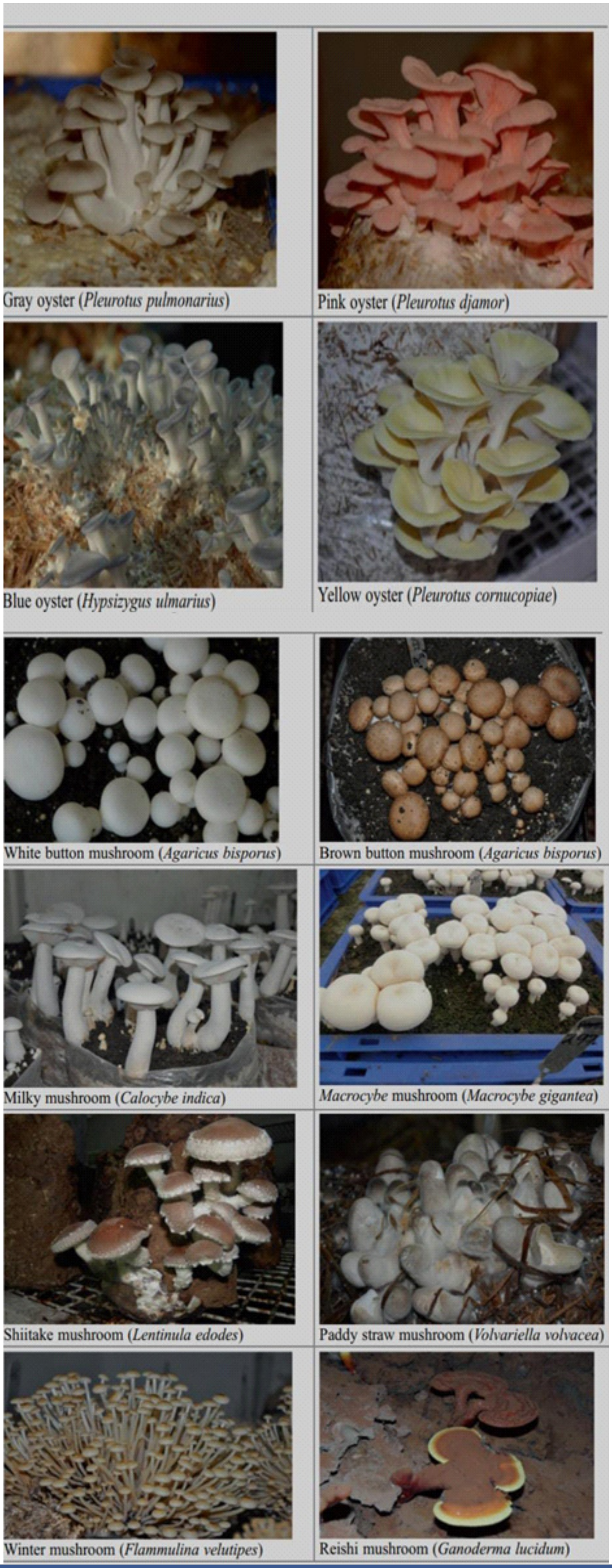

Figure 3: Different Types of Mushrooms [57].

Mushroom as antioxidant

Reactive oxygen species(ROS) are incriminated in many diseases like cancer, rheumatoid arthritis, atherosclerosis as well as aging, and mutation (DNA alterations). ROS are very harmful to cells. It damages DNA and thus ultimately results in the apoptosis of cells. *G. lucidum* extract contains ethyl acetate, methanol, etc. which is known to highly constrain O_2 and OH radicals and also has high antiperoxidative activity. Consuming mushrooms for many years may limit aging speed and tumorous consequences [2].

Mushrooms as antiviral agents

Since ordinary antibiotics cannot treat viral illnesses, specific medications are desperately needed. The antiviral properties of mushrooms are characterized not only for entire extracts but also for individual components. They can directly inhibit viral enzymes, synthesis of viral nucleic acids, or virus adsorption and uptake into mammalian cells. Smaller compounds, in particular, demonstrate direct antiviral actions. The immune-stimulating activity of polysaccharides or other complex compounds results in indirect antiviral effects [45]. Several triterpenes from Ganoderma lucidum (i.e., ganoderiol F, ganodermanon triol, ganoderic acid B) have antiviral activity against human immunodeficiency virus type 1 (HIV-1) [46].

Mushrooms as antiallergic agents

Although several mushroom extracts have been shown to activate the immune system, some have also been shown to decrease immunological responses. This feature may be useful in the treatment of allergic illnesses, which are becoming more common around the world. In mice, ethanolic extracts of the edible Japanese basidiomycetes *H. marmoreus, F. velutipes, Pholiota nameko*, and *Pleurotus eryngii* had strong antiallergic benefits [47]. Ganoderic acids C and D from *G. lucidum* have been found to suppress histamine production from rat mast cells [48,49]. Eating *Tricholoma populinum* resulted in the resolution of severe allergic symptoms in two patients, one with thromboangiitis obliterans and the other with urticaria [50]. Isolated from the fruit bodies of *Inonotus hispidus*, hispolon, and hispidin have been shown to inhibit the chemiluminescence response of human mononuclear blood cells as well as the mitogen-induced proliferation of mouse spleen lymphocytes [51].

Mushrooms as hepatoprotective agents

Ganoderic acids R and S, as well as ganosporeric acid A, derived from *G. lucidum*, showed in vitro antihepatotoxic action in the galactosamine-induced cytotoxic test using primary cultured rat hepatocytes [52]. The *in vivo* studies of two fractions of *G. lucidum* total triterpenoids extract protected mice from hepatic necrosis induced by chloroform and D-galactosamine, and these hepatoprotective effects were possibly related to the ability to promote the activity of scavenging enzymes for hepatic-free radicals in mice and thus to raise the ability of anti-oxidation in mice [53].

Bioactive compounds in mushrooms

Mushrooms are commonly used as a functional food due to their great nutritional value. They are also highly valued for their medical and therapeutic applications [54]. Interestingly, mushrooms are a rich source of biologically active substances that provide medical or therapeutic benefits to people, such as illness prevention and therapy [35]. Polysaccharides, proteoglycans, terpenoids, phenolic compounds, steroids, and lectins are only a few of the bioactive substances produced by edible mushrooms. These chemicals have numerous therapeutic benefits, including immunomodulatory, anticarcinogenic, antiviral, antioxidant, and anti-inflammatory properties [55].

Mushroom bioactive chemicals are responsible for boosting human health in a variety of ways. Mushrooms include bioactive chemicals as well as cell wall components such as polysaccharides (-glucans) and proteins, as well as secondary metabolites such as phenolic compounds, terpenes, and steroids. The concentration and activity of bioactive chemicals vary according to mushroom type, substrate, fruiting conditions, stage of development, mushroom age, storage conditions, and, of course, cooking processes [56].

Future aspects

Mushrooms can contribute significantly to the livelihoods of rural and semiurban people by providing food security and money production, and they can also provide a useful dietary complement due to their protein and vitamin content, as well as their therapeutic characteristics. Its cultivation is highly compatible with a wide range of other traditional agricultural and domestic activities, and it can make a significant contribution to the livelihoods of the disabled, women, and landless poor, who can increase their independence and self-esteem with appropriate training and access to inputs. The high cost-benefit ratio, easily available and inexpensive agricultural wastes, and favorable meteorological conditions make mushroom growing a profitable method of societal development. Mushroom gardening can be a profitable small-scale business venture. The FAO (Food and agricultural organization) has been aggressively supporting mushroom production in underdeveloped countries for rural development and food security. India has enormous mushroom production potential, and all commercial culinary and medicinal mushrooms can be easily cultivated here. Although India is not a large producer of any of the mushroom kinds, due to its different climatic circumstances, it does farm all edible and medicinal mushrooms in one or more parts. Mushroom production is based on the recycling of agricultural leftovers, which are abundant in every part of the country. At the moment, places in India with a rice-wheat cropping system are confronting a difficult issue in dealing with crop wastes. Mushroom farming can successfully use these agricultural residues to produce protein-rich food and plays an important role in agricultural residue management. The supply and demand imbalance in the global mushroom trade, as well as the contraction of output in Western countries due to high labour costs, have resulted in higher market prices for Indian mushroom farmers. The knowledge and adoption gap in technology must be closed by providing farmers with training on many elements of mushroom cultivation.

Mushrooms are a functional food with biologically useful components that have considerable therapeutic potential for the prevention and control of a variety of ailments. More research and clinical studies are needed to confirm that mushrooms are a source of bioactive compounds with therapeutic potential. They can be utilized directly in the diet to boost health by utilizing the additive and synergistic effects of the bioactive substances found in them. More research is needed to understand the various roles of many active chemicals and the routes involved. The therapeutic implications of mushrooms are enormous, but detailed mechanisms of the various health benefits of mushrooms to humans still require intensive investigation, particularly with the emergence of new evidence of their health benefit effects such as antidiabetic, anticarcinogenic, antiinflammatory, antiallergic, antihepatoprotective agent, and so on. Exploration of newly produced mushrooms and separation of their active components with mechanism-based potential therapeutic benefits remains a challenge, and mushrooms will continue to be the primary focus of study in the foreseeable future. Mushrooms that have medicinal properties Cultivation, Bioactive Molecules, and Health Benefits of Edible Mushrooms Because of the abundance of relevant bioactive chemicals, 25 forms a rising component of today's pharmaceutical industry. The conservation and cloning of therapeutic mushrooms is required for long-term development. Isolation, purification, and structural investigation of novel anticancer and immune-stimulator chemicals should be prioritized.

Discussion

This paper provides an insightful view of the vital holistic approaches of mushrooms and their potent roles in medical science to foster the overall health and fitness of humankind. Mushrooms include a variety of components that have exceptional properties for preventing or treating various ailments (Table 4). Mushrooms can be utilized in low-calorie diets due to their low-fat content. The mushroom protein provides all nine essential amino acids that humans require. Furthermore, they are a good source of nutrients such as phosphorus, iron, and vitamins such as thiamine, riboflavin, ascorbic acid, ergosterol, and niacin. Mushrooms have also been reported as therapeutic foods

Table 4: List of mushrooms and their effect on human health.

Mushroom	Role in human health	Immunoresponse
Agaricus bisporus	Beneficial in cancer, type 2 DM, high cholesterol, atherosclerosis, and various liver and digestive diseases.	Activation on macrophages
Agaricus blazei	Highly effective in preventing tumors and cancer, antiallergic, anti-inflammatory, and immunomodulatory.	Activation of t-lymphocyte and natural killer cells.
Auricularia auricula-judae	Powerful antioxidant, immune boosting agent, rich in vit B complex, improves heart function and digestive health.	Antiviral activity
Boletus erythropus	Anti-inflammatory, bactericidal,	Antimicrobial activity
Calocybe indica	Abundant in protein and vitamins.	Down-regulate lipogenesis genes.
Ganoderma lucidum	Immune boosting agent, relieve cough, asthma, dizziness, insomnia, palpitation, and antiallergic.	Induction of apoptosis.
Geastrum saccatum	Use as prebiotics, anti-inflammatory, and antioxidant.	Treatment for stomach cancer
Grifola frondosa	Anticarcinogenic, antioxidant, antiallergic, anti-inflammatory.	Activation of t-lymphocyte and natural killer cells.
Lentinus edodes	Reduce cholesterol and atherosclerosis, rich in beta-glucan	Activation of t-lymphocyte and natural killer cells.
Phellinus linteus	Alleviate sickness in humans by consolidating a channel for hemostasis, removing blood-arthralgia consumption, relieving abdominal pain, and treating chronic diarrhoea	Increased production of interleukin
Pleurotus eryngii	Antimicrobial, antiviral, hormonal support, anti-diabetic	Antiproliferative effect
Pleurotus florida	Antioxidant, anticarcinogenic effect	Inhibit tumoral cell-to-cell adhesion.
Pleurotus ostreatus	Antioxidant, anticarcinogenic effect, antidiabetic, immune supportive.	Increase gastrointestinal motility.
Schizophyllum commune	Antibacterial, antifungal, antioxidant, anticarcinogenic	Activation of t-lymphocyte and natural killer cells.
Sparassis crispa	Antioxidant, anticarcinogenic	Lipid peroxidation inhibition.
Termitomyces eurhizus	Hyperlipidemia, fight against gastroduodenal disease, Alzheimer's disease.	Anti-aging effect
Hericium erinaceus	Antidiabetic, use as prebiotics, inhibit nerve damage, antioxidant	Activate innate immune
Osmoporous odoratus	Antimicrobial, antiviral,	Activate macrophages and the innate immune system.

that can help prevent diseases like hypertension, diabetes, hypercholesterolemia, and cancer. The inclusion of dietary fibre, bioactive components, antioxidants, lectins, and antimicrobial agents contributes to these functional qualities. As a health-promoting food supplement (nutraceutical), mushrooms with immune-modulating polysaccharides are employed. The mechanism of action of numerous secondary metabolites identified from medicinal and wild edible mushrooms is unknown. Because of their great nutritional and therapeutic potential, mushrooms can be used in a variety of ways, such as functional foods or as a source of nutraceuticals for the maintenance and enhancement of health and life quality. Because of the abundance of beneficial bioactive chemicals, medicinal mushrooms are a rising component of today's pharmaceutical industry. While they have a long history of use across many cultures, they are now supported by strong scientific research. Mycologists all around the world are certain that a better understanding of mushrooms can help several types of cancer at various stages. Exploration of unexplored wilderness species with therapeutic qualities is necessary. The conservation and cloning of therapeutic mushrooms is required for long-term development. A dedicated study should be conducted to identify, purify, and investigate the structural properties of innovative anti-cancer and immune-stimulator chemicals. From ancient times mushrooms are consumed and are supposed to be a good source of proteinaceous and tasty food but due to extensive research going on mushroom classes other beneficial and crucial roles are illuminated and yet many advantageous roles still remain to know. Mushrooms contain a high concentration of non-nutrients (phenols) and micronutrients (vitamins), which provide antioxidant potential and may be beneficial as a dietary supplement for patients suffering from diseases such as atherosclerosis, hypertension, Cancer, inflammatory conditions, ischaemia, obesity, parkinsonism, a high risk of stroke, and Alzheimer's disease, autoimmune disease, and many more. Its bioactive products can be extracted and used as drugs Its essential genes may be used to produce a large number of essential secondary metabolites by recombinant DNA technology and produce large quantities of drugs for humankind industrially. More research is awaited in this area.

Conclusion

This article concludes that mushrooms are employed not only as a source of nutrition but also as medicinal resources. Polysaccharides from mushrooms have been found to have immunomodulatory, antitumor, antioxidant, antibacterial, and prebiotic activity due to their greater structural variety when compared to other biologically active compounds. Mushrooms are generally affordable because they may be cultivated on a variety of inexpensive agricultural or forest wastes such as rice straw, maize cobs, and sawdust. In the search for cost-effective and environmentally friendly techniques of environmental rehabilitation, the utilization of mushrooms is an excellent approach and answer. Despite numerous advantages, there are certain limits in mushroom cultivation, including input constraints, technology constraints, general constraints, socio-cultural constraints, and crop management constraints. Management from 'waste to wealth' is critical for more sustainable farming around the world, and boosting mushroom production in India appears to be a practical and appealing solution. Increasing the commercial value of items, whether fresh or processed, may raise demand concentration and encourage market orientation.

The most essential potential of mushrooms is that they are a nutritious, high-quality food that has medicinal capabilities that help humans stay healthy. Based on the information presented above, edible mushrooms are high in bioactive substances, primary and secondary metabolites. As a result, including it in the diet can help to improve human health and reduce the rate of malnutrition in underdeveloped nations.

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