



REVIEW ARTICLE

Mushroom: A source of nutrition and medicines

Pawan Kumar Kharwar, Vasundhara Singh, Salman Khan & Avinash Pratap Singh*

Department Of Botany, C.M.P Degree College, A constituent Postgraduate College of University of Allahabad, Prayagraj 211 002, India

*Email: avinashsinghau@gmail.com



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Abstract

Mushrooms are higher fungi with a delicious flavor and high nutritional value. They are a type of dietary element that can assist us in tackling problems with good nutrition, health and environmental sustainability. Nowadays mushrooms are an important source of food and medicine because they are low in calories, carbohydrates, fat, sodium and cholesterol. It has significant amounts of protein, fiber, vitamins, mineral nutrients and bioactive molecules. Fungi extracts are sources of medicinal compounds that have played a significant part in the preservation of human health ever since the dawn of time. In pharmaceutical industries drug research programmers heavily rely on natural products, which are the source of more than 50% of all contemporary clinical drugs. Mushrooms can be used as a source for biotherapeutics, which in turn can aid in the creation of new drugs, due to the presence of a significant number of secondary metabolites.

Keywords

biotherapeutics; carbohydrates; secondary metabolites; sodium

Introduction

Mushrooms are a very large group of fungi that belong to the class Agaricomycetes of phylum Basidiomycota (1). Mushrooms are abundant in dietary fiber and low in calories, fat and cholesterol (2, 3). Additionally, mushrooms have an average amount of saturated fatty acids and a high concentration of polyunsaturated and mono-unsaturated fatty acids. Mushrooms are a good supply of important fatty acids like linoleic and linolenic acids, which the human body cannot manufacture (4). It is estimated that between 1,50,000 and 1,60,000 different varieties of mushrooms will grow on Earth, with about 16,000 of those species having been described. (5). Approximately species around 7000 species are edible to varied degrees and over 3000 species from 31 genera are thought of as the best edible mushrooms (6). while approximately 200 wild kinds of mushrooms are used for therapeutic purposes (7). There are over 20 cultivated species of mushrooms, out of which 4-5 mushrooms including *Agaricus bisporus* (White Button mushroom) are being cultivated at commercial level (8). In overall production, different strains of *A. bisporus* occupy the dominating position followed by *Lentinula edodes* (Shiitake) and *Pleurotus spp.* (*Pleurotus ostreatus*, *P. flaeolatus*, *P. floridae*) *Volvariella volvacea*, *Calocybe indica*, *Flammulina velutipes*, *Lentinula edodes* and *Agaricus bisporus* are the most widely grown mushrooms in the world, (9). The moisture content of mushrooms is considerable and ranges between 80 and 95 g/100g, (10). *Auricularia*, *Pleurotus*, *Lentinula edodes*, *Agaricus spp.* *Tremella*, *Grifola*, *Flammulina*, *Hericium* and There are species of *Termitomyces*, *Laetiporus*, *Morchella*, *Tuber*, *Ramaria*, *Sparassis*, *Podaxis*, *Phellorinia*, etc which are edible and possess therapeutic potential (11). Dhamodharan and Mirunalini, 2010, reported that *Ganoderma*, *Cordyceps spp.*, *Phellinus* *Schizophyllum* and *Trametes* have therapeutic characteristics. Due to population expansion, urbanization and a corresponding decline in arable land, there will be an

imminent problem with food shortage and the deterioration of human health. One of the most commercially feasible and environmentally friendly biotechnological procedures to meet the world's protein demand is the production of protein-rich mushrooms from lingo-cellulosic agriculture and forest waste (12, 13). Throughout human history, using edible fungus to satisfy nutritional needs has been a frequent theme (14, 15). *Agaricus bisporus* is very rich in nutritional value and frequently grown in mushrooms around the globe except Antarctica (16, 17). *A. bisporus* is utilized as food and in food production because of its delicious flavor and higher nutritional content (17, 18). It is thought to have significant folkloric and ethnopharmacological importance in addition to high biological activity and minimal toxicity. In addition to food and beverage manufacturing, it plays a part in the pharmaceutical, cosmetic and fragrance industries (19). Customers were guided to native *A. bisporus* because of their flavor and texture (20). Numerous primary and secondary metabolites have been identified in mushrooms, having therapeutic activities that are helpful in the prevention and therapy of different diseases, including cancer, hyperlipidemia, microbiological illnesses, cardiovascular issues, liver diseases and immunological issues (21, 22). *A. bisporus* degrades trash and is typically found in humus-rich habitats. It is useful as a model organism and is widely produced for the food industry (23).

Medicinal Aspects of Mushrooms

The fungi have traditionally been used to treat heart disease, cancer and brain stroke. Additionally, it possesses anti-aging properties (24). They represent one of the biggest unexplored potential future food sources for flavourful and nourishing foods. Researchers have found that mushrooms are more helpful than other foods in preventing diabetes and lowering cholesterol, stress, asthma, allergies and cancer (24, 25). They can be utilized to close the gap in protein deficiency because of their high protein content. Mushrooms are beneficial for boosting immunity. As a result, it offers a nutritional supplement in the form of pills. In cardiovascular diseases and diabetics, they are beneficial because of the low content of starch and cholesterol (26). The mushrooms contain one-third of their iron in free form. Their polysaccharide content successfully fights HIV and is also used in anticancer medications (27). Biologically active compounds from mushrooms are used as nematocides and insecticides, antibacterial, antiviral and antifungal properties (28). Studies reveal that regular consumption of button mushrooms reduces the risk of breast cancer in women (29).

The mushrooms may prevent the creation of enzymes that alter the formation of estrogen, a hormone that promotes the development of cancer (30).

An edible basidiomycete fungus with a native range in the grasslands of North America and Europe is *A. bisporus* (14). Traditionally, the fungus was used to cure heart disease, cancer and brain stroke. Additionally, it possesses anti-aging properties (31). They stand for one of the largest untapped sources of nutrient and appetizing food in the future. Researchers have discovered that mushrooms are more helpful than other foods in preventing diabetes and

lowering cholesterol, stress, asthma, allergies and cancer (20). The protein malnutrition gap can be utilized should be closed due to a lot of protein found in mushrooms and it is also beneficial for immunity boosting. Consequently, it offers a nutritional supplement in the form of tablets (32). Their polysaccharide content successfully fights HIV and is used in anticancer medications (33). The mushrooms' biologically active chemicals have been employed as pesticides and nematocides as well as having antifungal, antibacterial, antioxidant and antiviral activities (34). β -glucans are the primary biologically active polysaccharides which is found in *Ganoderma* and its polysaccharides and triterpenoid components are what give it its anticancer and antimetastatic properties (35). These substances' immunostimulatory effects and antioxidant power may be related. Biologically active proteins and peptides, such as lectins, ribosome-inactivating proteins, antimicrobial proteins, ribonucleases and laccases, are also present in considerable amounts. These substances are essential for life activity and have immunomodulatory and anticancer properties (36-40).

Therapeutic Potential of Mushrooms

Chang and Buswell used the term "Mushroom Nutraceuticals" to characterize those substances that have great promise as dietary supplements intended to improve health and prevent a range of illnesses in humans (41). They have curative effects against many degenerative diseases without having any side effects; in contrast to those involved in the use of synthetic drugs. This is because of their immunomodulatory action, which enhances the activity of the immune system (42) by activating dendritic cells, NK cells, T-cells, macrophages and the production of cytokines (43). Research has revealed that consuming mushrooms regularly or their products can prevent different ailments (44). Studies on edible mushrooms and their constitutive active ingredients have shown that they can reduce blood sugar and cholesterol levels (4). Several mushrooms have significant levels of dietary fiber, antioxidants and vitamins C, B12 and D, as well as folate, ergothioneine and polyphenol (45), indicating that the mushrooms may have potential anti-inflammatory, hypoglycemic and hypocholesterolemic. The antifungal, anti-inflammatory, anticancer, antiviral, antibacterial, hepatoprotective, antidiabetic, hypolipidemic, antithrombotic and hypotensive properties of mushrooms are also well documented (46). Many bioactive substances were isolated from different mushrooms having different medicinal values and helpful for the treatment of cancer.

Numerous molecules have been discovered, including glucan, proteoglycan, lectin, phenolic compounds, flavonoids, volatile oils, tocopherols, flavonoids, carotenoids, folates, ascorbic acid enzymes and organic acids (36). Triterpenoids, dietary fiber, lentinan, schizophyllan, lovastatin, pleuran, steroids, glycopeptides, terpenes, saponins, xanthenes, coumarins, alkaloids, kalvasin, veryngeolysin, kinon, porisin, fenil, AHCC, ribonucleases, maitake D-fraction and propanoid, they have also shown effective against several disorders (23). In mushrooms, bioactive substances can be divided into three categories, Polysaccharides, glycoproteins and secondary

metabolites. Mushroom polysaccharides are the most well-known and effective compounds with immunomodulating and antitumor properties (47). The most adaptable bioactive molecules are beta-glucans (mushroom polysaccharide) because of their outstanding therapeutic potential (48).

Since humans do not amalgamate glucans, our immune systems identify these substances as non-self-molecules that cause both adaptive and innate immune responses (49).

Mineral and Nutrients in Mushrooms

For human health *A. bisporus* good for health because it contains high amounts of vitamins like Vitamin D2, thiamine, ascorbic acid and minerals like polyphenols, folates and ergothioneine as well as fiber and antioxidants are also found in high amounts that have a positive impact on cardiovascular diseases and diabetes. This implies that the mushroom might have hypoglycemic, hypocholesterolemic and anti-inflammatory properties (50-52). Fresh mushrooms have a 10 % dry matter composition, which is comparatively low fat and primarily composed of minerals, carbohydrates, proteins and fiber.

Carbohydrates

Energy is obtained from carbs present in food and mushrooms with digestible carbohydrates including mannitol (0.3-5.5 % dm) (53), glucose (0.5-3.6 % dm) (54) and glycogen (1.0-1.6 % dm) (55). Mushrooms contain an important amount of non-digestible carbohydrates, the majority of which are oligosaccharides and non-starch polysaccharides such as chitin, Beta-glucans and mannans (56). *Agaricus campestris* and *Armillaria mellea* (36) had carbohydrate contents as high as 70 % dm, whereas *Leccinum crocipodium* and *Russula virescens* had carbohydrate contents as low as 13 %. (Table 1). Beta-glucans make up around half of the bulk of the fungal cell wall, along with ergosterol, tocopherols, linoleic acid and lectins. Mushrooms also have a phenolic content of 1.6 mg/g of dried mass and flavonoid concentrations of 0.9 to 3.0 mg/g of dried material, including myricetin and catechin (9). The primary aromatic ingredient in mushrooms is agaritine, along with its derivatives, which are chemically hydrazine. Among mushrooms *A. contains*. Agaritine was discovered to aid in the creation of poisonous aryl diazonium ions. The main phenolic chemical found in mushrooms is gamma-glutaminy-4-hydroxybenzene (57, 58).

Proteins and Amino acids

Protein concentration in mushrooms varies according to species as well as environmental conditions and fruiting body maturity (27). The typical protein content of mushrooms is 12.0-29.3 % dm. However, certain authors claimed that *Cantharellus cibarius* and *Lepista nuda* had higher protein contents with 54 and 59 % dm, respectively (60). In certain types of mushrooms, the amino acid composition is on par with or superior to that of soy proteins and the composition can even be compared to that of hen's eggs. (61). Mushrooms can provide essential amino acids that humans are unable to synthesize. As a result, the proportion of essential amino acids to total amino acids provides insight into the nutrient value of proteins in diets.

Due to its excellent amino acid content, lucerne is regarded as having the highest nutritional value of all plants. The amino acid content of the mushrooms *C. ventricosum* and *Laccaria amethystine* is almost like alfalfa (62).

Lipids

In China, some species of mushroom typically have a low crude fat content, ranging from 1.0 % to 6.7 % (Table 2). Humans require linoleic and linolenic acids, which must be supplied through food, as essential fatty acids. Omega-6 fatty acids provide linoleic acid, while omega-3 fatty acids provide linolenic acid (63).

Minerals

The fruiting body of wild-grown mushrooms can retain significant amounts of both micro and macro elements that are vital to fungi and their consumers. In fruiting bodies, the two most abundant elements are Phosphorus (P) and Potassium (K). Calcium (Ca), Magnesium (Mg), Sodium (Na) and Iron (Fe) are next to Phosphorus (P) and Potassium (K) (68, 69).

Pharmacological Activity

Antioxidant Activity: Oxygen can be converted into reactive forms, such as hydroxyl radicals (OH), superoxide radicals ($O_2^{\cdot-}$) and H_2O_2 , which can damage DNA (71,72). Antioxidant compounds have been discovered in mushrooms that may stop an organism's harmful oxidative process. Some mushrooms are good sources of antioxidants like *Agaricus bisporus*. The *A. bisporus* extract, both boiled and raw, significantly reduced the oxidative crisis *in vitro* studies (73).

The oyster mushrooms, (*Pleurotus* spp.) are a widely cultivated edible fungi (74). Some *Pleurotus* species have been shown to have anti-inflammatory, antioxidant and anti-tumor properties (75,3). The methanolic extract is in the fruiting bodies of *P. floridae* extract of inhibit the lipid peroxidation and scavenging of OH radicals. Kalač, 2013, examined *in vitro*, different *Phellinus* spp. found that to scavenge oxygen-free, hydroxyl radical and nitric oxide free radicals. *Ganoderma* spp. was used as a tonic around 4000 years ago (76) and held a significant position in Chinese medicine due to its positive effects on all viscera and its nontoxic nature (77). *Ganoderma* contains phenolics and other phytoconstituents that effectively scavenge oxygen-free radicals. Hydroxyl free radicals are also neutralizing due chelating activity of phytoconstituent in *Ganoderma* sp. (78). (Table 1)

Antimicrobial Activity: There is evidence that the mycelia and fruiting body extracts of a wide variety of mushrooms exhibit antibacterial activity against a variety of pathogenic pathogens (79,80). It is feasible to separate several antimicrobial compounds from the mushrooms, which could have a variety of beneficial impacts on human health (60). *G. annulare* (Fr) showing antifungal effects and many other fungi (81). Due to the presence of oxalic acid, also has an antimicrobial effect on *Staphylococcus aureus* and other microorganisms. Additionally, *Lentinula edodes* mycelium ethanolic extract has antiprotozoal action against *Paramecium caudatum* (38).

Anticancerous Activity: The National Cancer Institute (NCI US) recently focused its search for new medication sources

Table 1. Active polysaccharides and their therapeutic properties of some mushrooms [59]

Mushroom Species	Active Compounds	Type of polysaccharides	Medicinal Uses	References
<i>Agaricus bisporus</i>	Lectins	Heteropolysaccharides	Enhance insulin secretion, anti-aging property.	[59]
<i>Auricularia auricula</i>	Acidic Polysaccharides	Homopolysaccharides	Anti-tumour activities, lowers cholesterol, triglycerides and lipid levels; decrease blood glucose, beneficial in coronary heart disease, immune tonic.	[59]
<i>Flammulina velutipes</i>	Polysaccharide, flammulin, FVP (Flammulina polysaccharide protein), peptide glycans, prolamin (active sugar protein), Proflamin (glycoprotein)	Heteropolysaccharides	Antioxidant, anti-cancer activity, anti-ageing property; immuno-modulatory, anti-viral action.	[98]
<i>Ganoderma lucidum</i>	Polysaccharides, triterpenoids, germanium, nucleotides and nucleosides, Ganoderic acid, Beta-glucan	Heteropolysaccharides	Augments immune system, liver protection, antibiotic properties, inhibits cholesterol synthesis; immunomodulatory, anticancerous properties	[59]
<i>Grifola frondosa</i>	Grifloan, Lectins	Heteropolysaccharides	Increases insulin secretion, decrease blood glucose, improves ovulation	[99]
<i>Lentinula edodes</i>	Eritadenine, Lentinan	Heteropolysaccharides	Lower cholesterol, anti-cancer agent.	[98]

Table 2. Proximate composition of some mushrooms (mean values; % of dry matter)

Mushroom species	Protein (%)	Carbohydrates (%)	Fat (%)	Ash (%)	Reference
<i>Agaricus bisporus</i>	23.9- 34.8	51.3-62.5	1.7-8.0	7.7-12.0	[65]
<i>Lentinula edodes</i>	13.4 -17.5	67.5-78.0	4.9-8.0	6.7	[66]
<i>Pleurotus ostreatus</i>	10.5- 30.4	57.6-81.8	1.6-2.2	7.7-12.0	[66]
<i>Pleurotus eryngii</i>	11.0	81.4	1.5	6.2	[64]
<i>Pleurotus sajor-caju</i>	37.4	55.3	1.0	6.3	[65]
<i>Flammulina velutipes</i>	3.87	85.99	2.89	7.2	[66]
<i>Hypsizygus marmoreus</i>	21.0	65.6	5.62	8.26	[67]
<i>Auricularia auricula-judae</i>	8.1	81.0	1.5	9.4	[67]
<i>Grifola frondosa</i>	21.1	58.8	3.1	7.0	[65]
<i>Tremella fuciformis</i>	4.6	94.8	0.2	0.4	[66]
<i>Tricholoma giganteum</i>	16.1	70.1	4.3	5.0	[67]
<i>Tuber melanosporum</i>	23.3	66.2	2.2	8.3	[23]
<i>Vovariella volvacea</i>	30.1	50.9	6.4	12.6	(23)

on natural materials, including plants, marine animals and microorganisms. Natural plant compounds and their derivatives are the only sources of currently available and therapeutically effective anticancer medications. They are an endless source of polysaccharides with anti-cancer and immune-boosting qualities (82). Because *A. bisporus* lowers estrogen production and the activity of the aromatase enzyme, it is advantageous in cases of breast cancer (83). Polysaccharides, (84), acidic proteo-heteroglycans with mixed, linkage and a (60) branching type (85) glycan were shown to be the biologically active components of *P. linetus*. Numerous mushroom species have been shown to contain these complex polysaccharides, which have been connected to immunostimulatory and anticancer properties (86) (Fig. 1).

The isolated chemicals form different mushrooms' antihypertensive and antihypercholesteremic properties (87). A methanolic extract of *Pleurotus florida* fruiting bodies was found to effectively inhibit the solid tumor model formed in mice by the Ehrlich's ascites carcinoma (EAC) cell line (75). Lentinan is a polysaccharide obtained from the *Lentinus edodes*. It was first discovered with more potent anticancer and antiproliferative properties than other mushroom polysaccharides such as lentinan (55). Lentinan's cytostatic action is primarily caused by the stimulation of the host immune system (88). The lentinan, a pure polysaccharide

made exclusively of carbon, oxygen and hydrogen atoms, has also demonstrated anticancer efficacy in xenograft models (56).

Immunomodulating Activity: The derivatives of Proteins, peptides, lipopolysaccharides, glycoproteins and lipids are examples of substances that have been categorized as compounds with strong immune-system-influencing properties. Polysaccharides are T-lymphocyte-dependent antigens that do not cause a cell-mediated immune response. Some natural polymeric polysaccharides have been cited as effective immunomodulatory substances (88, 89). When combined with protein, these bioactive polysaccharides have the power to influence immune cells (89). Lentinan also acts as an immunomodulator due to the action of NK (natural killer) cells, after *in vitro* clinical lentinan treatment (48). Due to the immunomodulating properties *Ganoderma lucidum*, sometimes also called the 'Mushrooms of immortality' (90).

About 2000 years ago, China and other Asian countries made considerable use of *Ganoderma lucidum* contains substances with powerful immunomodulating properties, because of the existence of polysaccharides (particularly -D-glucan), proteins and triterpenoids (91). It has been demonstrated that these antigen-presenting macrophages express more MHC class II molecules when treated with *Ganoderma* and GLB (27).

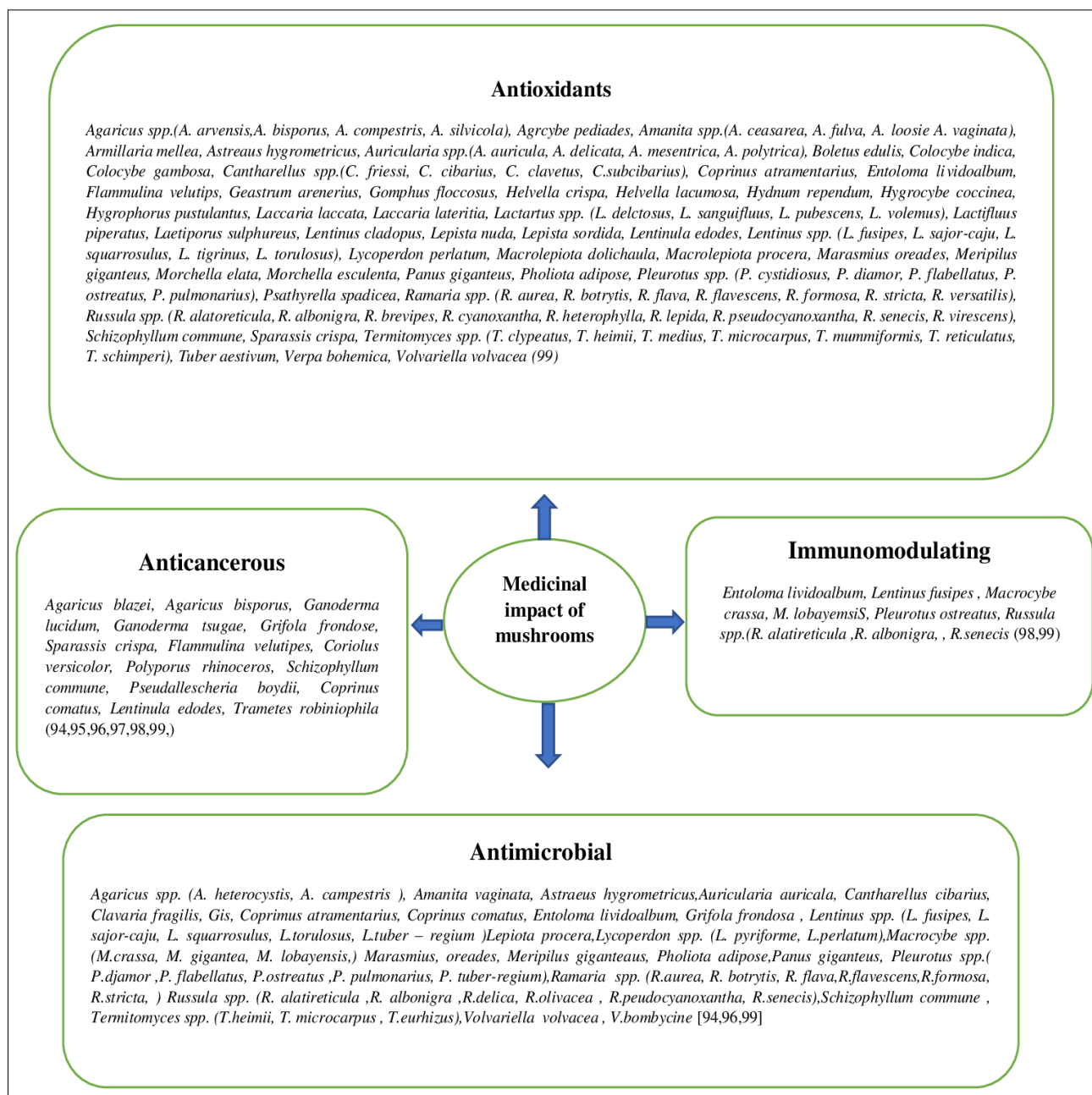


Fig. 1. Medicinal impact of mushrooms.

Conclusion

The fact that mushrooms include all the nutrients, minerals, vitamins and fiber in large quantities makes them a popular food source all over the world. We can say that edible Mushrooms can be utilized as a complete diet. Mushrooms are sources of different bioactive compounds, rich in nutritional value, having therapeutic properties and immunomodulators with antioxidant and anticancerous properties. Several bioactive chemicals found in mushrooms provide them with anti-inflammatory, antiviral, antimalarial, anticholinesterase and anticancer properties. Different phenolic compounds were also obtained from different species of mushrooms having therapeutic properties, particularly for the cure of cardiovascular, diabetes, cancer, Alzheimer's and Parkinson's diseases, etc. The steroids of the mushrooms have anticomplement, antimicrobial, cytotoxic activity, antitubercular and antiviral activities. Mushrooms are also a fabulous inception of antioxidants, so helpful in reducing oxidative stress. Medicinal mushrooms may help

avoid certain diseases, control metabolism and boost immunity. In addition to being a valuable source of physiologically active chemicals, medicinal mushrooms are abundant in polysaccharides, polyphenols, amino acids, vitamins and other nutrients that support the body's health and well-being. More research is required to validate these advantages and create best practices for incorporating medicinal mushrooms into meals. According to studies, edible mushrooms and their by-products may offer highly palatable, nutritious and healthy food besides their medicinal and pharmacological benefits.

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Authors' contributions

PKK and APS conceptualized the review article. PKK conducted the review and wrote the manuscript. VS and SK gave valuable suggestions for the review article. APS suggested the topic of review and directed me in refining and finalizing the overall manuscript.

Compliance with ethical standards

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