

MEDICINAL AND ANTIMICROBIAL PROPERTIES OF MUSHROOMS

Zakaria Ahmed*

ABSTRACT

Medicinal mushrooms or their extracts are used or studied for possible treatments of diseases. Some mushroom constituents including polysaccharides, glycoproteins and proteoglycans, modulate immune system responses and inhibit tumor growth. In preliminary research, whereas various other species of mushrooms produce antiviral, antimicrobial, anticancer, antihyperglycemic, cardioprotective, antidiabetic properties, as well as antiparasitic and anti-inflammatory compounds.

Keywords: Mushroom, Antimicrobial, Medicine.

1. INTRODUCTION

Mushrooms are unique within the fungal kingdom because they produce complex fruiting body. They are saprophytes. All of the mushrooms are placed in a division Eumycota meaning 'The True Fungi'. They are divided into other groups depending on the structure of their fruiting bodies and various other macro- and microscopic characteristics. The two major groups of Eumycota are Basidiomycetes and Ascomycetes. They include members of the Basidiomycota, within the class of Homobasidiomycetae.

Mushrooms have been a food supplement in various cultures and are cultivated and eaten for their edibility and delicacy. They fall between the best vegetables and animal protein source. Mushrooms are considered as source of proteins, vitamins, fats, carbohydrates, amino acids and minerals [1]. All essential amino acids as well as water-soluble vitamins and all the essential minerals are present in it [2]. Mushrooms are good sources of vitamins like riboflavin, biotin and thiamine.

Ogundana and Fagade [3] indicated that mushroom is about 16.5 % dry matter out of which 7.4 % is crude fiber, 14.6 % is crude protein and 4.48 % is fat and oil. Protein contents vary between 4 to 9 % in *Auricularia* species and between 24 to 44 % in *Agaricus* species. The protein value of mushrooms is twice as that of asparagus and potatoes, four times as that of tomatoes and carrots, and six times as that of oranges [1]. Their energy value also varies according to species, which is nearly equal to that of an apple. In recent times, mushrooms have assumed greater importance in the diets of both rural and urban dwellers. They are also relatively much cheaper than

beef, pork and chicken that contain similar nutrients. Many mushrooms have long been valued as tasty, nutritious food by different societies worldwide. Mushrooms are popular and valuable functional food, low in calories and high in minerals, essential amino acids, vitamins and fibers.

The results of proximate analysis by Adejumo and Awosanya of four edible species of mushroom collected from Nigeria [4] indicated that *Termitomyces mammiformis* was a very good source of crude protein, crude fiber, ash, calcium and manganese. *Russula vesca* was the richest in carbohydrate and magnesium, while *Lactarius trivialis* was found to be the richest in moisture content, iron and copper. It is also a good source of carbohydrate, calcium and manganese. *Lentinus tigrinus* is the richest in dry matter, and is also rich in carbohydrate, magnesium and copper. It was observed that lipids, sodium and phosphorus contents of the four species were generally very low. The results of mineral values [4] of the four edible species of mushrooms clearly indicate the potential for their use as sources of good quality food. It was observed that these four edible mushrooms hold tremendous promise in complementing the protein and mineral supply deficits prevalent in developing countries.

2. ANTIMICROBIAL PROPERTIES

Different types of mushrooms have different antimicrobial properties that are useful for human health. *Pleurotus tuber-regium* is useful in some combinations to cure headache, stomach ailments, cold and fever, asthma, smallpox and high blood pressure [5, 5a, 5b], while *Lentinus tuber-regium* and *L. tigrinus* are used for treating dysentery and blood cleansing, respectively. *Auricularia* species have been traditionally used for treating hemorrhoids and various stomach ailments [6]. *Boletus edulis* and *Lactarius* species are used for killing flies, while the puffballs are used for healing wounds [7-8]. They are also recommended to diabetic and anemic persons, owing to their low carbohydrate and high folic acid content. Some mushrooms are known for possessing anti-allergic, anticholesterol, anti-tumor and anti-cancer properties [1].

It was observed that *Fomes lignosus* possess some curative effects against some bacterial infections and intestinal disorders [9, 5a, 5b]. Jonathan, et al, [9] also reported the antagonistic effect of extracts of some

* Department of Microbiology, Primeasia University, 9 Banani, HBR Tower, Dhaka-1213, Bangladesh, Email: zakariaahmed70@gmail.com.

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Nigerian higher fungi against selected pathogenic microorganisms. Olawuyi, et al., [10] reported the antibacterial activities of the distilled water, ethanolic and chloroform extracts of *Fomes lignosus* against three Gram-negative bacteria (*Escherichia coli*, *Proteus mirabilis* and *Pseudomonas aeruginosa*) and two Gram-positive bacteria (*Bacillus cereus* and *Staphylococcus aureus*) where the antibacterial activities of the tested mushroom vary and are target microbes specific. The activity of *F. lignosus* extract of chloroform and ethanol against *S. aureus* was significantly higher. According to Olawuyi, et al. [10], Gram-negative bacteria are more sensitive to fresh *F. lignosus* than Gram-positive bacteria.

3. MEDICINAL USES

Recently, the demand for more effective and safer therapeutic agents for the chemoprevention of human cancer has increased. Natural products produced by plants and their synthetic derivatives are expected to play an important role in the development of innovative agents to inhibit the onset of cancer [11]. Macro fungi, such as mushrooms and entomopathogenic fungi, are good sources of natural medicines that exert antitumor activity. Polysaccharides are the best known and most potent mushroom-derived substances because they inhibit the growth of many types of tumors [12-13]. Natural antitumor polysaccharides isolated from mushrooms include, acidic and neutral compounds with different types of glycosidic linkages, as well as some that are bound to protein or peptide residues such as polysaccharide protein complexes [12-14].

Animal studies show mushrooms have anti-inflammatory activity. Inotilone, quercinol, antcin A, and benzocamphorin F, are anti-inflammatory compounds isolated from mushrooms. *Pholiota squarrosa* contains xanthine oxidase inhibitors. *Coprinopsis atramentaria* contains coprine, which metabolizes to 1-aminocyclopropanol, an inhibitor of acetaldehyde dehydrogenase. A number of mushrooms inhibit 5- α reductase and/or aromatase in vitro. In Southeast Asia, especially in China and Japan, mushrooms have long been acknowledged for their medicinal and analeptic qualities in addition to their desirable flavors and nutritional value. Several mushroom species display anti-oxidant power [15-16], and mushroom-derived polysaccharoproteins are reported to scavenge active oxygen species [17].

The medicinal properties of mushrooms have long been recognized, especially in Oriental cultures, and modern techniques have identified numerous

bioactive mushroom components, which are variously reported to exhibit anti-cancer, anti-tumor, anti-viral, immunomodulatory, hypocholesterolaemic and hepatoprotective activities [6]. More recently, it has been shown that fruit bodies of *A. bisporus* and *G. lucidum* contained bioactive compounds that prevented H₂O₂-induced oxidative damage to cellular DNA [18]. Although the medicinal effects of *G. lucidum* products are well documented [19], there are few reports attributing medicinal properties to *A. bisporus* even though it is the most widely cultivated and consumed edible mushroom [20]. Quinoid compounds obtained from this mushroom have been reported to suppress the propagation of mouse ascites tumor [21], and a lectin from this species also reversibly inhibited the proliferation of human colon carcinoma cells [22]. Both cellular components and secondary metabolites of a large number of mushrooms have been shown to affect the immune system of the host, and therefore could be used to treat diseases of clinical importance [5a].

It is well known that mushroom polysaccharides primarily exert their antitumor activity via activation of the immune response of the host organism (immunoenhancing activity) [23]. This indicates that mushroom polysaccharides do not directly kill tumor cells. Rather, they help the host to adapt to various biological stresses and exert a nonspecific action on the host, supporting some or all of the major systems. Because mushroom polysaccharides cause no harm and place no additional stress on the body, they are regarded as biological response modifiers. Immunoenhancing activity has been observed in many mushroom polysaccharides [24].

Ganoderma lucidum has been widely used in China and Japan for thousands of years for the treatment of various diseases, including cancers, confirming its possibility of revitalization and curing of different illnesses. It acts as antitumour, anti-inflammatory, antiviral (e.g. anti-HIV), antibacterial, antiparasitic, immunomodulating and hepatoprotective. It has a role in blood pressure regulation, against cardiovascular disorders and chronic bronchitis, like kidney tonic and nerve tonic [25a]. Pharmacologically, a number of the water-soluble polysaccharides have demonstrated antitumour and immunostimulating activities. *Karst* is one of the most often used mushrooms in traditional medicine of Far Eastern people. Because of its bitter taste and wooden built it is not suitable for nutrition, but the bioactive substances extracted from this mushroom possess very important medicinal characteristics.

Polysaccharides, β -glucans, obtained through the processes of hot water extraction, alcohol precipitation and dialyses refining had influence on the reduction of B cells (a human B cell line transformed by Epstein-Barr virus) and T cells (an immortalized line of human T lymphocyte cells). Among all tested concentrations of mushroom extract, the most intensive influence showed concentration of one mg/ml, which reduced the number of B cells by 61.46%, while in the case of T cells their number were reduced by 57.14% [26]. Edible mushrooms have beneficial effects on health and in the treatment of disease through their immunomodulatory, anti-neoplastic and lipid-reducing properties [25b, 26]. The Shiitake mushroom (*Lentinus edodes*), for example, has served as a model for investigating functional mushrooms and isolating pure compounds for pharmaceutical use [27]. Water extracts of the Shiitake fruiting bodies have been shown to prevent tumor growth in mice [6, 28-29]. Mushroom's polysaccharides, especially the high-molecular-weight β -D-glucan have been considered to have anti-cancer activity [30]. Iris, et al., [31] stated that *P. ostreatus* has anti-proliferative and pro-apoptotic activities where they described a newly identified low-molecular-weight α -glucan with promising anti-tumorigenic properties and demonstrated its direct effect on colon cancer cell proliferation via induction of programmed cell death.

A major strategy for colon cancer chemoprevention is the search for nutritional components directed at inducing apoptosis of cancer cells. Edible mushrooms have beneficial effects on health and in the treatment of disease through their immunomodulatory, anti-neoplastic, and lipid-reducing properties [32-34]. *Inonotus obliquus* has been used as a folk medicine due to its antitumor properties against several types of cancer cells [11, 35-36]. In some cases, the therapeutic efficiency of *I. obliquus* has been demonstrated clinically. For example, a decoction of fungal sclerotia did not show toxic effects and has been used in the treatment of cancers and digestive system diseases [37, 39]. Recently, in addition to polysaccharides, many polyphenolic compounds such as triterpenoids, steroids and ergosterol peroxides from *I. obliquus* have been found to possess biological activities, including antioxidant, antibacterial, hepatoprotective, platelet aggregation inhibitory and antitumor effects [35, 38, 40-47].

Sung, et al., [48] reported that the hot water extract of *Inonotus obliquus* exerts inhibitory activity against the proliferation of human colon cancer cells (HT-29) and

their results suggested that this mushroom would be useful as an antitumor agent via the induction of apoptosis and inhibition of the growth of cancer cells through up-regulation of the expression of proapoptotic proteins and down-regulation of antiapoptotic proteins [48]. Mizuno reported that polysaccharides from fungal sclerotia, which are known to include hetero-polysaccharide and homoglycan, showed strong antitumor effects, while polysaccharides from cultured mycelia did not (49-50). However, Kim, et al. [51, 23] reported that the polysaccharides extracted from cultivated mycelia (termed endo-polysaccharides) also have anticancer activity. *Agaricus bisporus* extracts demonstrated immunomodulatory activities *in vivo* [52-53] and activity against several cancer cell lines [22]. *Agaricus subrufescens* (*Agaricus blazei/brasiliensis/sylvaticus*) is another medicinal mushroom associated with Brazil and Japan. There was an evidence for using *Agaricus subrufescens* extracts for certain cancers [54-56] whereas *Agrocybe aegerita* has anticancer activity *in vivo* [57].

Auricularia auricula extracts demonstrated hypoglycemic *in vivo* and anticancer, anticoagulant, and anticholesterol activities *in vitro* [58-59]. An *Auricularia polytricha* isolate inhibited sarcoma *in vivo* [60]. A *Boletus edulis* isolate inhibited several cancer cell lines and was found to bind a cell-specific T-antigen disaccharide [61]. A *Coprinus comatus* extract inhibited adenocarcinoma *in vitro* [62]. *Dictyophora indusiata* creates dictyophorines, dictyokinazols, and tyrosinase inhibitors [63]. Epidemiological studies in Japan have associated *Flammulina velutipes* consumption with lower cancer rates [64]. Proflamin, an isolate of *Flammulina velutipes*, has anticancer activity *in vivo* [65]. FIP-5 is an immunomodulatory protein isolated from *Flammulina velutipes*. Many *Grifola frondosa* studies indicate potential anticancer and antihyperglycemic activities. Antiatherosclerotic, antifungal and immunomodulatory compounds have been isolated from *Hypsizygus tessellatus*.

Lentinan is an isolate of *Lentinula edodes* mycelia. In Japan and China, lentinan is an adjuvant for gastric cancer [66]. AHCC is an extract derived from fermented *Lentinula edodes* mycelia. The *Lentinula edodes* isolate eritadenine, is an inhibitor of S-adenosyl-L-homocysteine hydrolase, and has hypocholesterolemic activity. *Lignosus rhinocerus* is a medicinal mushroom associated with Malaysia [67]. A *Morchella esculenta* isolate demonstrated immunomodulatory activity *in vitro* [68]. *Phallus impudicus* extracts have been clinically researched in

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relation to venous thrombosis [69]. *Pholiota nameko* creates compounds with antiinflammatory, immunomodulatory, and hypolipidemic activities [70-72]. A *Pleurotus djamor* isolate demonstrated anticancer activity *in vitro* [73]. *Pleurotus eryngii* extracts have immunomodulatory activities *in vitro* [Nozaki, et al. 2008].

A number of studies indicate *Pleurotus ostreatus* consumption lowers cholesterol levels *in vivo*. Research with *Pleurotus ostreatus* extracts indicates potential anticancer and immunomodulatory activities [34, 74-75]. *Sparassis crispa* has anticancer and immunomodulating activity *in vivo* [76-77a,b, 78-79]. A *Tremella fuciformis* isolate protected against effects of radiation *in vivo*. *Tremella mesenterica* has potential anticancer and immunomodulating activities [80a, 80b, 81]. *Tricholoma matsutake* isolates may have anticancer and immunomodulating activities [82-88]. *Volvariella volvacea*, a mushroom associated with Thailand and Vietnam, has anticancer activity *in vitro* [73].

4. CONCLUSION

It has been known for many years that selected mushrooms of higher Basidiomycetes origin are effective against cancer. There are approximately 650 species of higher Basidiomycetes that have been found to possess antitumor activity. Searching for new antitumor and other medicinal substances from mushrooms and studying the medicinal value of these mushrooms has become a matter of great significance. Some countries classify mushroom isolates as antineoplastic compounds. Mushrooms and other forms of fungi create antimicrobial and antiviral compounds. Now-a-days consumption of medicinal mushrooms is increasing strongly. Therefore, this review gives room for improvement of technological knowledge in the determination of antimicrobial and medicinal substances from selected mushrooms, which will be useful in production of valuable antibiotic drugs in pharmaceutical industries.

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