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Review Article

OYSTER MUSHROOM: ANSWER TO HUMAN AILMENTS

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ABSTRACT

Oyster mushroom is consumed all over the world due to its taste, flavor, high nutritional value, and some medicinal properties. Many species of this genus are rich in proteins with essential amino acids, polysaccharides, essential amino acids, dietary fibers, important minerals, and some vitamins. Because of this nutritional composition and presence of bioactive molecules, oyster mushroom has been reported to have anticancer, antihypertensive, antihypercholestromic, antidiabetic, antiobesity, antiaging, antimicrobial, and antioxidant activities. The high nutritional value and potent medicinal uses suggest that Pleurotus mushrooms are important functional foods or nutraceuticals.

Keywords: Oyster mushroom, *Pleurotus* species, Medicinal value, Human ailments, Antimicrobial activities.

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INTRODUCTION

Species of *Pleurotus,* commonly called oyster mushrooms, consist of gilled mushrooms that have an eccentric or lateral stem or are laterally or dorsally attached and sessile [1]. *Pleurotus* species are distributed throughout the temperate and tropical hardwood forests of the world [2]. Fungal populations are established and developed in nature through both sexual and asexual reproduction [3].

The genus *Pleurotus* is one of the most diverse groups of cultivated mushrooms that have important economic and medicinal value [3]. One of the reasons for their success is that oyster mushrooms are by far the easiest and least expensive to grow of all industrially cultivated edible mushrooms [2], and they grow on a number of different plant substrates. As food, the oyster mushrooms are a good source of non-starchy carbohydrates, have a high content of dietary fiber, and contain moderate quantities of good quality proteins and most of the essential amino acids, minerals, and vitamins [2].

MEDICINAL USES OF *PLEUROTUS*

A number of medicinal properties have been attributed to *Pleurotus* species. *Pleurotus* spp. have been shown to modulate the immune system, have hypoglycemic activity and antithrombotic effects, lower blood pressure, and blood lipid concentrations, and inhibit tumor growth, inflammation, and microbial activity [4-6]; Lectin and lovastatin are therapeutic compounds isolated from *Pleurotus* species. Lectins are carbohydrate-containing proteins of non-immune origin that agglutinate cells or precipitate polysaccharides or glycoconjugates [7]. Kaneko *et al.* examined hemaggutinating activity in crude extracts prepared from four fungal developmental stages; vegetative mycelium, primordium, immature fruit body, and mature fruit [8]. Lectin activity was not seen in vegetative mycelium but increased through the other three fungal developmental stages. In a study conducted by Sathyaprabha *et al*., [9] *Pleurotus platypus* and *Pleurotus eous* were extracted with pure ethanol and subjected to screening of bioactive compounds by gas chromatography-mass spectrum technique; according to their results, various active compounds are presented in *P. platypus* when compared with *P. eous.*

Lakshmanan and Radha produced lovastatin from *Pleurotus ostreatus* by high-performance liquid chromatography. Lovastatin is a potent hypocholesterolemic agent [10]. This low-molecular-weight substance is a competitive inhibitor of 3-hydroxy-3-methyl-glutaryl-coenzyme A reductase (HMG-CoA reductase), the key enzyme in cholesterol metabolism that catalyzes the reduction of HMG-CoA into mevalonate [10]. The best known organism for the potential production of lovastatin from edible higher basidiomycete mushrooms is species of the genus *Pleurotus* (*P. ostreatus*, *Pleurotus cornucopiae*, *Water-insoluble glucans*, and *Pleurotus sapidus*) [11]. The highest content of lovastatin was found in fruiting bodies of *P. ostreatus* [10]. Commercially, button mushroom ranks first followed by Shiitake and oyster mushroom occupies third position [12,13].

Though oyster mushroom is the third important mushroom of culinary value, there has been a upsurge in *Pleurotus* mushroom research activities in the last two decades not only for its nutritional and medicinal values but also many other biopotentialities of *Pleurotus* species such recycling of comprehensive account of nutritional with some medicinal agricultural residues [12,14], bioconversion of ligno-aspects of *Pleurotus* species [15,16], production or improved animal feed [17], bioremediation and biodegradation of xenobiotics [18,19], degradation of industrial dye [20,21], bioremediation [12,22], degradation of xenobiotics [23,24], bioconversion of lignocellulosic wastes [25], enzyme production [26,27], etc. Medicinal attributes of *Pleurotus* species are given below.

Antimicrobial activity

Pleurotus species have been found to combat simple and multiple drug-resistant isolates of *Escherichia coli, Staphylococcus epidermidis*, and *Staphylococcus aureus* [28] and species of *Candida* [29], *Streptococcus*, and *Enterococcus* [30-33]. Methanolic extracts of *Pleurotus* species demonstrated an inhibition in growth of *Bacillus megaterium*, *S. aureus*, *E. coli*, *Klebsiella pneumoniae*, *Candida albicans*, *Candida glabrata*, species of *Trichophyton* and *Epidermophyton* to different degrees that were lower with respect to two antifungal agents: Streptomycin and nystatin [28]. The petroleum ether extract of the *P. eous* possessed strong antibacterial activity against both Gram-positive and Gram-negative bacteria, and the growth of foodborne pathogens can be inhibited when *P. eous* is added as an extra nutrient in food products [34]. Mustafa *et al*. [32] reported that liquid filtrate of *Pleurotus salmoneostramineus* showed maximum inhibition against *Pseudomonas aeruginosa* ATCC 27853 and *Candida parapsilosis* ATCC 2201 and

mycelia of *P. cornucopiae* showed 5.21% and 29.19% inhibition against *Enterococcus faecalis* ATCC 29212 and yeast *C. parapsilosis* ATCC 22019.

Antiviral activity

Pleurotus mushroom contains substances exert direct or indirect antiviral effects as a result of the stimulatory activity [35]. Ubiquitin, an antiviral protein, was isolated and identified from fruiting body of oyster mushroom [36]. Water-insoluble Water-insoluble glucans isolated from sclerotia of *Pleurotus tuber-regium* and their corresponding water-soluble sulfated derivatives were active against type-1 and type-2 [20,37]. Antiviral activity was due to binding of $-glucans to viral particles, thereby preventing them from infecting the host cells [20]. Not only intracellular proteins of *P. ostreatus* but its extracellular extract also contains polysaccharides that have T immunomodulating effects.

Antihuman immunodeficiency virus (HIV) activity

A lung ribonucleases (RNases: mol. wt. 10.7 kDa) have isolated and characterized from the *P. ostreatus* [38] that has the potentiality to neutralize HIV through degradation of viral genetic material. On the other hand, RNases (mol. wt. 14.5 kDa) were isolated and characterized from sclerotia of *P. tuber-regium*, exhibited very stable nuclease activity at 100°C for 30 minutes. On the other hand, RNases (mol. wt. 14.5 kDa) were isolated and characterized from sclerotia of *P. tuber-regium*, exhibited very stable nuclease activity at 100°C for 30 minutes with a higher ribonucleolytic activity toward poly-G [39,40,41]. Another ribonuclease, pleuturegin, was also isolated from both fresh and dried sclerotia of *P. tuber-regium* [17]. Later, in [19] the fruiting bodies of oyster mushroom, they observed a novel-like protein having HIV-1 reverse transcriptase reported inhibitory activity [18]. Similarly, hot water extracts of *P. sajor-caju* and *P. pulmonarius* inhibit *HIV*-1 reverse transcriptase activity by SU2 molecule having 4.5 kDa mol. wt. [61].

Pleurotus sajor-caju and *Pleurotus pulmonarius* inhibit HIV-1 reverse transcriptase activity by SU2 molecule having 4.5 kDa mol. wt. [42]. A lectin isolated from fresh fruiting bodies of *Pleurotus citrinopileatus* also inhibited HIV-1 reverse transcriptase [19].

Antioxidant Activity

Fruiting bodies of *Pleurotus* possessed higher concentration of antioxidants than other commercial mushrooms [43-45]. The crude polysaccharide of *P. ostreatus* had a good antioxidant property and nitric oxide synthase activation power [46]. *P. ostreatus* increased the activities of important antioxidant enzymes (*viz.* superoxide dismutase, catalase, and peroxidase), thereby reducing oxidative damage in humans [44,47]. Oyster mushrooms are now widely used as ingredients in dietary supplements in the hope of maintaining health and preventing diseases [48] due to their higher free radical scavenging activities. The antioxidant activity of cultured mycelia of ten species of the oyster mushroom, *Pleurotus* species, namely, *P. ostreatus, Pleurotus flabellatus, P. sapidus, P. citrinopileatus, Pleurotus roseus, P. sajor-caju, Pleurotus florida, Pleurotus cystidiosus, Pleurotus fossulatus,* and *Pleurotus Eryngii,* was studied by Nitha *et al*. [49] and found that out of the ten species studied all except *P. roseus* scavenged hydroxyl radicals, and the maximum activity was showed by *P. sajor-caju* (76.17%). These free radical scavenging activities of oyster mushrooms depend on the color of fruiting bodies as per Yang *et al.* [44]. Fruiting bodies of oyster mushroom have higher phenol concentration when compared with mycelium and fermentation broth filtrate of *P. citrinopileatus* [50,51]. Salima *et al*. [52] showed that reducing power, chelating activity on Fe^{2+}, and total phenol content were higher in *P. florida* than in *P. pulmonarius* and *P. citrinopileatus*. *P. florida* had highest peroxidase and superoxide dismutase activity as compared to *P. pulmonarius*. Methanolic extract of *P. florida* has significant antioxidant activity and serves as easily accessible antioxidant rich food for enhancing immune system against oxidative stress [48].

Antilipidemic activity

Hyperlipidemia is the leading risk factor for atherosclerosis. Feeding of mushroom powder increases the excretion of total lipids and cholesterol through fecal matter. Mevinolin (a statin: Present in fruiting bodies of *P. ostreatus* and *P. citrinopileatus*) exhibited antihypocholesterolemic activities [54,55]. *P. pulmonarius* exhibited potent. Synergistic antihyperglycemic effect when used in combination with glyburide [56]. Recent report produced by Alam *et al.* [57] reported that when fruiting bodies of *Pleurotus ferulae* reduced the total cholesterol in plasma, triglyceride, low-density lipoprotein, total lipid, phospholipids, etc., whereas 5% mushroom powder of *P. salmoneostramineus* reduced total lipid, phospholipids, and low-density lipoprotein (LDL)/high-density lipoprotein (HDL) ratio by 29.67, 16.61, and 65.31%, respectively [53].

Anti-inflammatory activity

Pleuran isolated from fruiting bodies of oyster mushroom possesses anti-inflammatory activity [46]. Extracts of many of them, for example, *P. florida* and *P. pulmonarius*. Give a lowering response in both acute as well as in chronic inflammation [45,46] and when oral or percutaneous administration of extract of *P. eryngii* was done, it suppresses the inflammation in delayed type (type IV hypersensitive) allergy response in mice [58, 59].

Hepatoprotective activity

Pleurotus species contain some active compounds such as $-glucan, phenol, and vitamin C that increase the activity of antioxidant enzymes, namely, catalase and superoxide dismutase; these enzymes are responsible for reduction of hepatic cell necrosis [60,61]. Hepatoprotective activity of this mushroom is exerted through increased levels of serum aminotransferase enzymes in animals [50,62]. Recently, Chen *et al.* [63] observed that water-soluble polysaccharides extracted from *P. eryngii* remove the free radicals and also increase the activities of antioxidant enzymes in liver injury mouse model.

Hypocholesterolemic activity

Preliminary reports indicated that diet containing 4-10% dried fruiting body of *Pleurotus* leukocyte show more reduction in the arterial pressure. Recently, a blood cholesterol level when compared to normal diet by Chen *et al.* In rabbits and rats [64-66], lovastatin, a drug, used in the lowering blood cholesterol level, produced by *P. ostreatus* was approved by FDA in 1987. When dried mushroom mixed in the diet of experimental animal acted as accelerator of HDL reduced production of very LDL through LDL, cholesterol, reduced cholesterol absorption, and reduced HMG-CoA reductase activity in the liver [67].

Antiaging activity

Extracts of *Pleurotus abalonus* elevated levels of vitamin C and E, increased activities of catalase, superoxide dismutase, and glutathione peroxidase in aged rats [68]. Similar results were obtained with the extracts of *P. ostreatus* [69]. These enzymes are known potent antioxidant enzymes [46,47]. The levels of malondialdehyde, a polyunsaturated lipid, and an electrophilic mutagen were lowered on the administration of mushroom extract to aged rats [70] that reacted with deoxyadenosine and deoxyguanosine in DNA, forming a DNA adduct.

Antitumor activity

Hot water extract showed a remarkable host. The mediated antitumor activity against sarcoma, S-180, extracted from the fruiting body of polyporaceae family [71] due to the presence of $-D-glucan [72]. Extracts of *Pleurotus* species had higher antitumor activity toward lung cancer cells (A549). Recently, a potent antioxidant activity against both DPPH and ABTS radicals was detected in the ethanolic extracts of *Pleurotus* mushroom [73]. Many more reports are available indicating that oyster mushroom possesses antitumor activity of lectin isolated from *P. citrinopileatus* exerted potent antitumor activity in mice bearing sarcoma S-180. In their *in vitro* studies with *P. ostreatus* extracts against cancer cell (HL-60), the cytotoxic effect was ubiquitin - due to the presence of higher content of flavonoids cibacron blue affinity purified protein, protein fraction extracted from *P. ostreatus*, has been shown to have potent antitumor activity against different tumors using mice model [74].

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