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Chicken of the Woods *Laetiporus Sulphureus* and *Schizophyllum Commune* Treasure of Medicinal Mushrooms

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Abstract

The medicinal uses of the mushroom still need to be worked out for their biological activities. Mushrooms are small pharmaceutical factories, manufacturing various promising biologically active chemical compounds. These compounds exist in the mushroom fruit bodies, cultured mycelium, and culture broth. The presence of various phenolic compounds, polysaccharides, terpenoids, β-glucans, schizophyllan, ganoderic acid, and other compounds, is the reason for their potent biological activities, much more biological activities are discovered every day. Several compounds are responsible for the therapeutic activities of many medicinal mushrooms genera; the main groups of these compounds are polysaccharides, terpenes, phenolic compounds, and essential amino acids, as well as minerals such as such as calcium, potassium, magnesium, iron, and zinc. Overall, studies both on the chemistry and pharmacology of *Laetiporus sulphureus* and *Schizophyllum commune* extracts and compounds are increasing in recent years and show therapeutic potential for various pathologies. The purpose of this review was to investigate the biological activities of extract prepared from fruiting bodies of *Laetiporus sulphureus* and *Schizophyllum commune*.

Keywords: Medicinal Mushrooms; *Laetiporus Sulphureus*; *Schizophyllum Commune*; Biological Activities

Abbreviations: H-SMPS: Hot-Water Extractable Polysaccharides; E-SMPS: Enzymatic-Extractable Polysaccharides; DPPH: Diphenyl-1-Picrylhydrazyl; MICs: Minimum Inhibitory Concentrations.

Introduction

Mushrooms have been used as a traditional medicine for ages. Mushrooms as higher Basidiomycetes and Ascomycetes contain secondary metabolites in their fruit bodies, cultured mycelium, and cultured broth. Mushrooms have been used in many sides of human activity for many years [1]. Mushrooms are consumed in many countries as a cooking delicacy, particularly for their taste. In recent years, scientists have expanded their research area concerning other uses of mushrooms, particularly for medicinal and food-preserving purposes. Some of these mushrooms have been called medicinal mushrooms due to their various morphological, physiological, and ecological characteristics that are also responsible for their diversity. The mushrooms constitute 16,000 species worldwide with more than 2000 species identified as safe.

Among these mushrooms, 1000 are edible, while others have been used as a source of biofuel, in medicinal formulation, as biochemicals, and for other purposes. Mushrooms have also huge potential, such as a "mushroom pharmaceuticals" with 130 medicinal functions [2]. Medicinal mushrooms possess medicinal properties such as anti-tumor, immunomodulating, antioxidant, cardiovascular, anti-hypercholesterolemic, anti-viral, anti-bacterial, anti-parasitic, antifungal, detoxification, hepatoprotective, and anti-diabetic effects [3-9].

Mushrooms have been reported as the most valuable microbes to humankind [10,11], and have been valued throughout the world both as food and medicine, mushrooms possess high contents of qualitative protein, crude fibre, minerals and vitamins. Investigations on the therapeutic and nutritional properties of mushrooms are on-going throughout the world. Researchers are providing vital data on the collection of biologically active secondary metabolites originated from mushrooms. Generally, mushrooms grow wild in many environments around the world and are also commercially cultivated for pharmaceutical and nutritional purposes. Nutritionally, mushrooms are healthy food which is rich in nutrients and vitamins. On the other hand, mushrooms have pharmaceutical and medical applications from centuries especially in Asian countries [12-14]. Mushrooms have been exploited in the last years as an alternative source of new antimicrobials. Wild and cultivated mushrooms contain a huge diversity of biomolecules with nutritional and/or medicinal properties. Because of their medicinal properties, mushrooms traditionally could be used with great potential for therapeutic applications in the treatment of some diseases. Life-threaten diseases, especially those caused by viruses, require searching and investigation in order to find potent compounds and drugs. Mushrooms are promising sources of compounds showing bioactive potency whenever tested. Recently, isolation and purification of biologically active secondary metabolites from mushrooms has been showed mainly on the products of fruiting bodies. Though, collection of fruiting bodies is a difficult work and is limited by collecting season and area. Also the small amounts of the collected samples are limited to find metabolites from mushrooms. Thus, mycelial culture of basidiomycetes and ascomycetes originated from wild mushrooms would be suggested as an alternative, dependable, and controllable method that can obtain various bioactive metabolites from mushrooms [15-20].

Laetiporus Sulphureus

Laetiporus sulphureus (Bull.) Murrill (also known as sulfur polypore, sulfur shelf, or chicken of the woods) is an edible wood-rotting basidiomycete fungus belonging to the family Polyporaceae. It is widely distributed in Asia, Europe, and North America. This mushroom commonly occurs on hardwoods or conifers [21-23]. *Laetiporus sulphureus* can be easily recognized due to its striking yellowish or orange-coloured shelf-like fruit bodies. Also is easily recognizable in forests and urban areas due to its impressive size (up to 40 cm wide) and vibrant bright sulphur yellow to orange coloured porous basidiocarps (Figures 1 & 2). *Laetiporus sulphureus* is a source of bioactive compounds such as mono- and polysaccharides, laetiporic acids, beauvericin, lectins, triterpenes, pigments, benzofurans, α-glucans, carotenoid pigments, and phenolic compounds [24,25]. Unlike other polypores, the *Laetiporus sulphureus* has a long history of consumption especially in North America, Japan and Thailand where it is considered a delicacy. Moreover, this fungus has long been used in Asian herbal medicine and is also known as a source of antitumor, antiviral, anti-inflammatory, anticoagulant, antioxidant, antibacterial, cytostatic, and immunostimulative agents and a producer of HIV-1 reverse transcriptase inhibitors [26].

Figure 1: *Laetiporus sulphureus* (Photographs taken by Shirley Zundell, Locality: United States, Vermont, Eagle Mountain, Milton, USA, hosted by *http://mycoportal.org*).

Figure 2: *Laetiporus sulphureus* (Photographs taken by Jillian Mattern, Locality: USA, Mississippi, Marshall, Wall Doxey State Park, hosted by *http://mycoportal.org*).

Antioxidant and Antimicrobial Activities of *Laetiporus Sulphureus*

Due to their long history of medical use, the biologically active compounds and extracts from *Laetiporus sulphureus* exhibit a broad spectrum of pharmacological activities. Therefore, it can be easily assumed that presence of this mushroom into our lifestyle may benefit us. The numerous studies have shown that *Laetiporus sulphureus* nutritionally provides various key components such as carbohydrate, essential amino acids and fatty acids, vitamins, minerals, and fibre. Besides, the extracts prepared from fruiting bodies or mycelia of this mushroom have exhibited a number of medicinal properties such as immunomodulation, antitumor, anti-inflammatory, antioxidant, antimicrobial, and antihyperglysemic activities because of their biologically active components such as phenolics, triterpenes, and polysaccharides. *Laetiporus sulphureus* is also a suitable candidate to be used as a natural food preserving source [27].

Laetiporus sulphureus delivers bioactive ingredients that possess health benefits. About 75% of *Laetiporus sulphureus* secondary metabolites are composed of triterpenoids [28]. *Laetiporus sulphureus* can also be cultivated on a larger scale in a laboratory both as fruiting bodies in a solid-state surface culture and as a hyphal mycelium in a fermented submerged culture [29]. Zhang, et al. reported that twelve compounds were found in the mycelia extracts of *Laetiporus sulphureus*: oleic acid, palmitic acid, glycerol α-monopalmitate, ergosterol, lactic acid, glycerol, succinate, uracil, D-mannitol, ring-(proline-glycine), cyclo-L-Hyp-Gly, and L-methyl L-glutamate, all showed antioxidant and antimicrobial activities [30-33]. Petrović, et al. reported that *Laetiporus sulphureus* is a rich source of carbohydrates and proteins. Mannitol and trehalose were the main free sugars, also the polyunsaturated fatty acids a-, g- and d-tocopherols were found. Oxalic and citric acids were the most abundant organic acids; cinnamic and p-hydroxybenzoic acids were quantified in the methanolic extract and could be related to the antioxidant properties. It was the polysaccharidic extract that exhibited higher antioxidant and antimicrobial activities, indicating that the compounds present in *Laetiporus sulphureus* possess stronger bioactivity [22,24].

Laetiporus sulphureus, hot-water extractable polysaccharides (H-SMPS) and enzymatic-extractable polysaccharides (E-SMPS) were successfully isolated from *L. sulphureus*. Both H-SMPS and E-SMPS were found to have high reducing power and potential scavenging activities against hydroxyl, DPPH, and superoxide anion radicals [34]. Antioxidant and antimicrobial potentials of *Laetiporus sulphureus* alcoholic extracts from dried fruiting bodies, dried mycelia broth and mycelia-free broth submerged cultures were investigated. For determination of potential antioxidant activity of the dried fruiting bodies and mycelia-free broth methanol extracts, the total phenols amount and scavenging capacity on 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals have been analyzed. The results showed that the highest total phenols amount was found in fruiting bodies extract. Radical scavenging activity was found higher for fruiting bodies followed by mycelia-free broth extract. The antimicrobial effects of the ethanol extracts were analyzed against *Candida albicans* ATCC10321, *Candida parapsilopsis* CBS604, *Escherichia coli* ATCC8739, *Staphylococcus aureus* ATCC6538, *Enterococcus faecalis* and *Staphylococcus epidermidis* ATCC12228. Two extracts presented a wide antimicrobial spectrum and were active against both yeast and bacteria tested: fruit bodies extract and dried biomass extract [35,36]. Cyclohexane, dichloromethane, and methanol extracts of the medicinal mushroom *Laetiporus sulphureus* were tested for their antimicrobial, cytotoxic, and radical scavenging activities. All extracts resulted in the removal of 50% of the DPPH radicals. The average minimum inhibitory concentrations (MICs) against a select panel of microorganisms were between 125 and 250 mμ g/mL, and the methanolic extract significantly inhibited the growth of Staphylococcus aureus (MIC, 31.25 mμ g/mL). Also, cyclohexane and dichloromethane extracts inhibited the growth of Helicobacter pylori (MIC, 62.5 mμ g/mL). Cyclohexane and dichloromethane extracts showed higher antiproliferative action compared with the methanol extract [37].

Patocka J, et al. [38] suggested that *Laetiporus* species could be used as supplementary agents in treatment of various diseases in addition to their nutritional properties and they would occupy an important place in the development of new pharmacological new agents due to their active components. The potential of *Laetiporus* species for use in design of modern medicines by determination of their phytochemical content and isolation of these compounds is noteworthy.

Schizophyllum Commune

Schizophyllum commune is a species of fungus in the genus *Schizophyllum*. The mushroom resembles undulating waves of tightly packed corals or loose Chinese fan. “Gillies” or “split gills” vary from creamy yellow to pale white in colour as illustrated in, Figures 3 & 4. The caps are 1–4 cm wide with white or grayish hairs. They grow in shelf-life arrangements, without stalks [39]. The gills, which produce basidiospores on their surface, split when the mushroom dries out, earning this mushroom the common name split gill. It is common in rotting wood [40]. It is the only known fungus capable of retracting by movement [41]. This mushroom is found throughout the world except Antarctica, where there is no wood to be used as a substrate. It is found in the wild on decaying trees after rainy seasons followed by dry spell where the mushrooms

are naturally collected. The scientific classification of *Schizophyllum commune* was kingdom Fungi, Division Basidiomycota, Class *Agaricomycetes*, Order *Agaricales*, Family *Schizophyllaceae*, Genus *Schizophyllum*, species *S. commune*. *Schizophyllum commune* has been the subject of genetic analysis since the early twentieth century, when Kniep first described its tetrapolar pattern of sexuality. It has been utilized as a model system for studying mating-type gene function and mushroom development. In addition, the biochemistry and enzymology of the cell walls of *S. commune* has been a long-term focus of research. It belongs to the group of gilled mushrooms that includes the commercially valuable species *Agaricus bisporus* (white button mushroom) and *Pleurotus ostreatus* (oyster mushroom) [42].

Figure 3: *Schizophyllum commune* (Photo was taken by Bernard Spragg, Locality: from Christchurch, New Zealand. Cited in *https://en.wikipedia.org/wiki/Schizophyllum commune*).

Figure 4: *Schizophyllum commune* (Locality: Marteleira, Lourinhã, Portugal. (Cited in *https://commons.wikimedia.org/wiki/File:Schizophyllum_commune_Fr_299074.jpg*).

Schizophyllum Commune as Therapeutic Food

Wild mushrooms with their delicate flavour and texture are recognized as a nutritious food and an important source of biologically active compounds with medicinal values. Generally, mushrooms are low in energy and high in dietary fibre [43], and an excellent source for antioxidants as they accumulate a variety of secondary metabolites, including phenolic compounds [44]. There are about 1200 species of mushroom used in 85 different countries for their gastronomic value and/or medicinal properties [45]. On the other hand, edible wild mushrooms are often regarded as being nutritionally high and with potential economic value. Many species with medicinal value are widely used in traditional medicine for a broad range of diseases [46]. Some species are regarded as therapeutic food for their anti-carcinogenic, anti-cholesterolemic and anti-viral properties. Different medicinal (anticarcinogenic, anticholesterol, immunostimulating) effects of *Schizophyllum commune* are known but little is known about its nutritive values [47]. Edible wild mushrooms are often regarded as being nutritionally high and with potential economic value. Many species with medicinal value are widely used in traditional medicine for a broad range of diseases [46]. Some species like *Schizophyllum commune* are regarded as therapeutic food for their anti-carcinogenic, anti-cholesterolemic and anti-viral properties.

Most of the medicinal extracts from mushrooms *Schizophyllum commune* are different forms of polysaccharides and all of them are strengthens of the immune system with little or no side effects. Recent studies on various white rot fungi possess a number of beneficial medicinal properties such as antitumor, immune-modulators, anti-genotoxic, anti-oxidant, anti-inflammatory, anti-allergic, hypocholesterolemic, antihypertensive, anti-hyperglycemic, antimicrobial and antiviral activities. These activities have been reported for varies extracts and isolated compounds, such as polysaccharides, polysaccharide-protein complexes, proteoglycans, protein and DNA from oyster mushroom fermentation broth, mycelia or fruiting bodies. In particular, polysaccharides appear to be potent antitumor and immune-modulating substances, besides possessing other beneficial activities (Wound healing, anti-coagulate anti-nematode and others) [48-53].

Conclusion

In conclusion, it was considered that the use of *Laetiporus sulphureus* and *Schizophyllum commune* in complementary medicine is very important and urgent needed and these mushrooms have a significant potential as important natural agents in development of pharmacological drugs.

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