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Review

In-vitro and *in-vivo* antioxidant effects of the oyster mushroom *Pleurotus ostreatus*

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ABSTRACT

Although almost all organisms are equipped with antioxidant defense and repair systems that have evolved to protect them against oxidative damage, these systems are often inadequate to completely prevent oxidative stress-induced damage. Therefore, antioxidant supplements, or natural products containing antioxidants, may be used to help reduce oxidative damage to the human body. Mushrooms have been part of the normal human diet for thousands of years and, in recent times, the amounts consumed have risen greatly, involving a large number of species. The genus *Pleurotus* comprises 40 different species that are commonly referred to as "oyster mushrooms". It has been shown to possess cholesterol-lowering, anti-tumor, antiviral, anti-thrombotic and immunomodulating effects. *Pleurotus ostreatus* contains higher concentrations of cystine, methionine and aspartic acid than other edible mushrooms, such as *Agaricus bisporus* (brown), *A. bisporus* (white) and *Lentinus edodes*. Until now, research has tended to focus on the dietary value of edible mushrooms; however, there is relatively little information pertaining to the antioxidant activity and the possible use of such mushrooms to neutralize oxidative stress. Hence, the aim of the present review was to summarize the *in-vitro* and *in-vivo* antioxidant effects of the mushroom *P. ostreatus*.

Contents

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1. Introduction

It is pertinent to note that antioxidant defense systems may only partially prevent oxidative damage (Simic, 1988). Hence, there is currently great interest in using dietary supplements containing antioxidants with a view to protect the components of the human body from oxidative damage. The most commonly used synthetic antioxidants at the present time are butylated hydroxyanisole (BHA), butylated hydroxyltoluene (BHT), propyl gallate and tert-butylhydroquinone. However, BHA and BHT have restricted use in foods as they are suspected to be carcinogenic and to cause liver damage (Sherwin, Branen, Davidson, & Salminen, 1990). Therefore, there is growing interest in the use of natural additives as potential antioxidants (Jayaprakasha, Selvi, & Sakariah, 2003; Oktay, Gulcin, & Kurrevioglu, 2003). This may explain why there is currently much research on the application of antioxidants from natural products (Gu & Weng, 2001).

Mushrooms have been part of the normal human diet for thousands of years and, in recent times, the amounts consumed have risen greatly, involving a large number of species. Mushrooms are valuable health foods since they are low in calories, fats, and essential fatty acids, and high in vegetable proteins, vitamin and minerals (Agrahar-Murugkar & Subbulakshmi, 2005; Manzi, Aguzzi, & Pizzoferrato, 2001; Manzi, Gambelli, Marconi, Vivanti, & Pizzoferrato, 1998; Sanmee, Dell, Lumyong, Izumori, & Lumyong, 2003). Mushrooms are the only non-animal-based food containing vitamin D, and hence they are the only natural source of vitamin D for vegetarians (Mattila, Suonpa, & Piironen, 2000). Many medicinal properties have been attributed to mushrooms (Borchers, Stern, Hackman, & Keen, 1999), including inhibition of platelet aggregation (Hokama & Hokama, 1981), reduction of blood cholesterol concentrations (Aletor, 1995), prevention or alleviation of heart disease and reduction of blood glucose levels (Manzi & Pizzoferrato, 2000), and also prevention or alleviation of infections caused by bacterial, viral, fungal and parasitic pathogens (Breene, 1990). Mushrooms have also shown cholesterol-lowering, anti-tumor, antiviral, anti-thrombotic and immunomodulating effects (Mau, Lin, & Chen, 2002).

The genus *Pleurotus* comprises about 40 species (Jose & Janardhanan, 2000) that are commonly referred to as "oyster mushrooms". *Pleurotus ostreatus* is reported to contain higher concentrations of cystine, methionine and aspartic acid than other edible mushrooms, such as *Agaricus bisporus* (brown), *A. bisporus* (white) and *Lentinus edodes* (Mattila, Vaananen, Kongo, Aro, & Jalava, 2002). Levostatin, a cholesterol-lowering drug derived from *Pleurotus* species, and its analogs are reported to be the best therapeutic agents for correcting hypercholesterolemia (Endo, 1988). The antioxidant effects of a polysaccharide–peptide complex (F22) from mushroom (*Pleurotus abalonus*)-fruiting bodies have been well documented by Li, Ma, and Liu (2007), Li, Ng, et al. (2007). Hitherto, research has tended to focus on the dietary value of edible mushrooms; however, there is relatively little information pertaining to their antioxidant activity and their possible use to inhibit oxidative stress. Hence, this review was designed to summarize the antioxidant effect of the mushroom *P. ostreatus* in an *in-vitro and in-vivo* model.

2. *In-vitro* antioxidant effect of the mushroom *P. ostreatus*

The antioxidant potential of a compound could be attributed to its various characteristics, the most important of these being the ability to scavenge and reduce free radicals, to chelate transition metal ion catalysts, to inhibit lipid peroxidation (Rajeshwar, Senthil Kumar, Gupta, & Upal Kanti, 2005) and to quench singlet-excited fluorescence of 2,3-diazabicyclo [2, 2, 2]oct-2-ene (DBO) (Nau, 1998).

2.1. Radical scavenging activity

The hydroxyl radical (OH•) is the most reactive of the reactive oxygen species and hence can induce severe damage to adjacent biomolecules (Gutteridge, 1984). The superoxide radical ($O_2^{\bullet -}$), which is generated in numerous biological reactions, is also a highly toxic species. Although $O_2^{\bullet -}$ radicals cannot directly initiate lipid oxidation, they serve as potential precursors of highly reactive oxygen species, such as the hydroxyl radical (Kanatt, Chander, & Sharma, 2007). Extracts of the plants *Mucuna pruriens* (Rajeshwar et al., 2005), *Vigna aconitifolia* (Siddhuraju, 2006), *Mentha spicata* (Kanatt et al., 2007), and *Andrographis passiculata* and *Swerta chirata* (Tripathi, Mohan, & Kamat, 2007), have been found to scavenge OH• and $O_2^{\bullet -}$ radicals. Studies have also demonstrated that an extract of *Ginkgo biloba* exerts potent antioxidant activity by acting as a scavenger of free radicals, such as $O_2^{\bullet -}$, OH• and NO•, therein protecting antioxidant defense systems (Kwon et al., 2004; Mahady, 2002). Extracts from other plant sources such as *Coleus aromaticus* (Kumaran & Karunakaran, 2006), and potato peel (Singh & Rajini, 2006), have also been reported to exhibit good superoxide radical-scavenging activity. Different species of mushrooms such as *Ganoderma lucidum*, *G. lucidum antler*, *Ganoderma tsugae* and *Coriolus versicolor* have also been reported to scavenge OH• and $O_2^{\bullet -}$ radicals (Mau et al., 2002). In our previous study, the efficacy of the mushroom extract in scavenging OH• and $O_2^{\bullet -}$ radicals was tested in comparison to ascorbic acid as a standard. When tested at a concentration of 10 mg/ml, the scavenging effect of the mushroom extract and of ascorbic acid was found to be 56.2% and 60.17%, respectively (Fig. 1) (Jayakumar, Thomas, & Geraldine, 2009). The IC_{50} value, that is the concentration at which 50% scavenging of the free radicals was achieved, was found to be 8 mg/ml for the mushroom extract and 6 mg/ml for ascorbic acid (Fig. 1). In related studies, the scavenging effects of a methanolic extract of black, snow and silver ear mushrooms were found to be 10.52–14.01% at a concentration of 5 mg/ml, whereas no scavenging effects were observed with methanolic extracts of red and jin ear mushrooms (Mau, Chao, & Wu, 2001).

The mushroom extract was also found to be a notable scavenger of superoxide radicals generated in the riboflavin-NBT light system (Fig. 2). The extract in a concentration of 10 mg/ml, inhibited the formation of blue formazan and the % of inhibition was 60.02; the % of scavenging (O_2^- is scavenged and thus blue formazan formation is inhibited) of O_2^- increased with increasing concentrations of the extract ascorbic acid (Jayakumar et al., 2009).

2.2. Effect of reducing power on ferric ions

The reducing capability of a compound may serve as a significant indicator of its potential antioxidant activity (Meir, Kanner, & Akiri, 1995). Reducing properties of a substance are generally associated with the presence of reductones (Duh, 1998), such as ascorbic acid (a potent reducing agent), which have been reported to exert antioxidant action by breaking the free radical chain by donating a hydrogen atom (Gordon, 1990). Extracts of the plants *M. spicata* (Kanatt et al., 2007), and *A. passiculata* and *S. chirata* (Tripathi et al.,

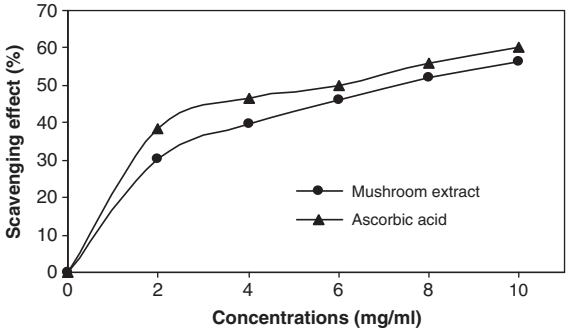

Fig. 1. Scavenging effect of an ethanolic extract of the mushroom *Pleurotus ostreatus* on hydroxyl radicals compared to that of ascorbic acid.