

Health Benefits of Edible Mushrooms Focused on *Coriolus versicolor*: A Review

Aritson Cruz¹, Lígia Pimentel¹, Luis M. Rodríguez-Alcalá^{1, 2}, Tito Fernandes³, Manuela Pintado^{1, *}

¹Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Arquiteto Lobão Vital, Apartado 2511, 4202-401 Porto, Portugal

²Centro de Investigación en Recursos Naturales y Sustentabilidad (CIRENYS), Universidad Bernardo O'Higgins, Fábrica N° 1990, Segundo Piso, Santiago, Chile

³CEIL, Lúrio University, Marrere, Nampula, Mozambique

[Article](#)
[Metrics](#)
[Related Content](#)
[About the Authors](#)
[Comments](#)
[Follow the Authors](#)

Abstract

The biological properties present in mushrooms have been extensively studied. Besides nutritional properties, mushrooms have attracted market attention because they are a potential source of bioactive compounds able to perform several functions in organisms with benefits for consumer health. In recent years *Coriolus versicolor* aroused interest among researchers because of the bioactive properties demonstrated. Polysaccharopeptide (PSP) and polysaccharopeptide Krestin (PSK) have shown to be useful adjuncts to the therapy of cancer; these polysaccharides from *C. versicolor* have also shown prebiotic activity, stimulating the growth of probiotic bacteria. Furthermore, enzymes such as laccases produced by *Pleurotus eryngii* and *Ganoderma lucidum* can confer activity against HIV; lectins produced by *Pleurotus ostreatus* and *Ganoderma carpense* have shown anti-proliferative activity in tumour cells; superoxide dismutase present in some mushrooms has antioxidant activity. Secondary metabolites such as terpenes, steroids, anthraquinones and benzoic acid have also antitumour activity. This review article highlights the health-promoting potential of several mushroom species with special emphasis on *C. versicolor*.

Keywords: Polysaccharopeptide, Polysaccharopeptide Krestin, Health-promoting Potential, Bioactive Compounds, Prebiotic Activity

Copyright © 2016 Science and Education Publishing. All Rights Reserved.

Cite this article:

[Normal Style](#)
[MLA Style](#)
[APA Style](#)
[Chicago Style](#)

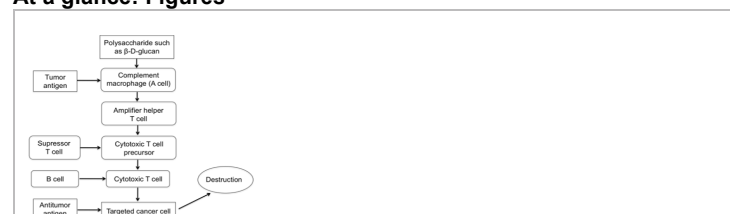
Aritson Cruz, Lígia Pimentel, Luis M. Rodríguez-Alcalá, Tito Fernandes, Manuela Pintado. Health Benefits of Edible Mushrooms Focused on *Coriolus versicolor*: A Review. *Journal of Food and Nutrition Research*. Vol. 4, No. 12, 2016, pp 773-781. <http://pubs.sciepub.com/jfnr/4/12/2>

[Import into BibTeX](#)
[Import into EndNote](#)
[Import into RefMan](#)
[Import into RefWorks](#)

- ▶ Full-Text PDF
- ▶ Full-Text ePUB
- ▶ DOAJ XML
- ▶ PubMed XML
- ▶ Citation-(RIS Format)
- ▶ Citation-(BibTeX Format)
- ▶ Citation-(EndNote Format)

Like(1)

At a glance: Figures



[View all figures](#)

1. Introduction

Mushroom cultivation has a long tradition mainly in Asian countries where it started centuries ago. Edible mushrooms constitute an element of human diet in many countries all over the world. At least 12000 species of fungi can be considered as mushrooms, and at least 2000 species are identified as edible [1]. According to Sánchez et al [2], among the 2000 edible mushroom species found in different regions of the world, only 35 are grown on a commercial scale and 20 are cultivated on an industrial scale. The most cultivated mushroom worldwide is *Agaricus bisporus* (button mushroom),

followed by *Lentinus edodes* (shiitake), *Pleurotus spp* (oyster mushrooms), *Auricula auricula* (wood ear mushroom), *Flamulina velutipes* (winter mushroom) and *Volvariella volvacea* [3].

Data reported by the Food and Agriculture Organization [4] indicate that in 2013 the world production of mushrooms was around 9.9 million tons. In the western countries mushrooms have been underestimated in nutrition field, although research has been demonstrating that mushrooms have low calorie content and high nutritive value. Edible mushrooms have high water content, for this only 5-15% of dry matter, which is mainly composed by dietary fibre and protein. They also contain vitamins B1, B2, D2, C, macro and microelements i.e. K, Mg, P, Zn, Fe and Cu [5].

Mushrooms have been used not only as a source of food, but also as medicinal resource. A total of 126 medicinal functions are thought to be produced by medicinal mushrooms, among which antitumour, immunomodulating, antioxidant, radical scavenging, cardiovascular, antihypercholesterolemia, antiviral, antibacterial, antiparasitic, antifungal, detoxification, hepatoprotective, and antidiabetic properties are the most recognized [6, 7, 8, 9]. These properties are conferred by bioactive compounds present in the mushroom and include polysaccharides, polysaccharide-peptide complexes, ribonucleases, lectins, protease inhibitors, lignocellulolytic enzymes, hydrophobins and superoxide dismutase that are present in the mycelium and fruiting body of the fungus [5, 10, 11]. Due to the health benefits demonstrated, some species of mushrooms have become attractive for development of functional foods and as a source of bioactive compounds towards the development of new drugs. Therefore, we will restrict our review to one of the most important medicinal mushroom, *Coriolus versicolor*.

2. *Coriolus Versicolor*




Coriolus versicolor, also known in the literature by *Trametes versicolor* or *Polyporus versicolor*, belongs to the genus *Coriolus*, family Polyporaceae, order Polyporales and division Basidiomycotina [12]. This mushroom rise up from lignocellulosic wastes and has a fan-shaped wavy margin and may exist in nature in several different colours. Both extracellular and intracellular polysaccharides of *C. versicolor* are physiologically active as bioactive compounds. Two polysaccharides, polysaccharopeptide (PSP) and polysaccharopeptide Krestin (PSK) were isolated from *C. versicolor* and used as a supplement to support chemotherapy and radiotherapy of cancers due to its immunostimulatory properties [13, 14]. Furthermore, it seems that these polysaccharides may also act as prebiotics by stimulating the growth and/or activity of probiotic bacteria in the colon [15].


C. versicolor may be used in the extract or biomass forms. Extract forms (PSK and PSP) were extensively studied in past years. The biomass of *C. versicolor* is more resistant to proteolytic degradation and contains not only β -glucans but also other compounds with large clinical interest. The biomass form of *C. versicolor* contains a variety of relevant enzymes with different activities such as superoxide dismutase, peroxidase, glucoamylase, protease and laccase [16, 17, 18]. For example, this mushroom produces the enzyme laccase, which is a polyphenol oxidase belonging to the family of blue multicopper oxidases [19]. Laccase can oxidize a wide range of substrates, phenolic preferably. In the presence of mediators, the fungal laccases feature a wide range of substrates and then are able to oxidize compounds with a high redox potential. This enzyme has been used in biotechnology and industry, for the delignification of lignocellulose, bioremediation and sewage treatment [17].


Among the mushroom-derived compounds with therapeutic properties, the polysaccharides obtained from extracts of *C. versicolor* are the best known commercially. Both preparations (PSP and PSK) consist of β -glucans, polymers of D-glucose with β -1,3 and α -1,4 glycosidic linkages, but some of them can also contain arabinose, mannose, fucose, galactose, xylose and glucuronic acids. PSP and PSK extracted from *C. versicolor* typically contain 34-35% soluble carbohydrates, 28-35% protein, ~7% moisture, 6-7% ash and the remainder are free sugars and amino acids [20]. Among the 18 types of amino acids present, 70% consist of acidic and neutral amino acids such as aspartic acid, threonine, serine, glutamic acid, glycine, alanine, valine, and leucine [21]. Beneficial health properties reported over the years by Chinese and Japanese researchers have attracted the attention of the scientific community worldwide. Therefore, many clinical studies have been carried out in recent years with the aim to assess and identify the main bioactive properties of polysaccharides extracted from *C. versicolor*. These bioactive properties are detailed in Table 1.

The studies published so far have used extracts or polysaccharides isolated from the mushroom. However, the extract of the fruiting bodies is more susceptible to the action of proteolytic enzymes. The non-digestible property of the polysaccharides from *C. versicolor* make them potential prebiotic agents, but more studies are needed on this subject to efficiently validate its potential. Yu *et al.* [15] found that the presence of PSP from *C. versicolor* increased the levels of *Bifidobacterium* and *Lactobacillus* when *in vitro* studies were performed using the isolated polysaccharide form. They also identified an indirect effect in inhibiting pathogenic bacteria, including coliform and clostridia species, by lowering the pH. A study reported by Pallav *et al.* [22] demonstrated that the microbiome of volunteers randomly treated with PSP extracted from *C. versicolor* showed clear and consistent changes derived from a possible prebiotic activity.

Bioactive properties	Bioactive compounds associated	Methodologies used in research	Reference	
Antitumour activity	Polysaccharopeptide (PSP)	- These results indicate that IL-2 and PSP can slow progression of H238 tumours and that the mechanisms of action may be related to their direct cytotoxic effects, as well to their immunomodulatory properties; - It was found that PSP significantly increased the number of monocytes (CD14 ⁺ /CD16 ⁺) compared to controls without PHA. This increase in monocytes was confirmed using another antibody panel of CD14 and MHCII; - Immunostaining of tumour tissues with antibody against the endothelial cell marker (Factor VIII) demonstrated a positive correlation in that both the vascular density and tumour weight were lower in mice treated with PSP;	[23] [31] [30]	
	<i>Coriolus versicolor</i> extract (CVE)	- Flow cytometry analysis on cell cycle and cell death (apoptosis) of Molt 4 cells indicated that the anticancer mechanism of PSP is related to its ability to induce S-phase cell arrest and apoptosis, respectively. - CV extract at 50 to 800 Ag/mL dose-dependently suppressed the proliferation of Raji, NB-4, and HL-60 cells by more than 90 % (p < 0.01); - <i>C. versicolor</i> aqueous extract treatments resulted in remarkable immunomodulatory effects, which was reflected by the augmentation of IL-2, 6, 12, TNF- α and IFN- γ production from the spleen lymphocytes of CV-treated tumour-bearing mice.	[34] [35] [36]	
	<i>Coriolus versicolor</i> methanol extract	- The results demonstrate that <i>C. versicolor</i> methanol extract exerts pronounced anti-melanoma activity. - <i>Trametes versicolor</i> contains putative prebiotic agents that alter human gut microbiota and pH; - PSP from <i>T. versicolor</i> acts as a prebiotic to modulate human intestinal microbiome composition.	[32] [15] [22]	
	Prebiotic activity	Polysaccharopeptide (PSP)	- PSK improved glutathione peroxidase activity through transcriptional induction of mRNA expression. - The results of the study indicated that polysaccharide extracts of <i>G. applanatum</i> , <i>G. lucidum</i> , <i>L. edodes</i> and <i>T. versicolor</i> are antioxidative.	[37] [38]
	Antioxidant activity	Polysaccharopeptide Krestin (PSK) Polysaccharide extracts	- PSP demonstrated inhibition of the interaction between HIV-1 gp120 and immobilized CD4 receptor.	[39]
Antidiabetic activity	Intracellular polysaccharides	- The α -glucosidase inhibitory properties were related to the presence of α -(1,4) glycosidic linkages in the polysaccharide structure and the total relative percentage of D-glucose and D-galactose in the structure of polysaccharides, other than triterpenoids;	[16]	
	Polysaccharopeptide (PSP)	- PSP can competitively inhibit tolbutamide 4-hydroxylation in both pooled human liver microsomes and specific human CYP2C9 <i>in vitro</i> . - CVP can bind and induce B cell activation using membrane Ig and TLR-4 as potential immune receptors. CVP activates mouse B cells through the MAPK and NF- κ B signaling pathways.	[40] [41]	
Immunoregulatory	<i>Coriolus versicolor</i> polysaccharide (CVP)	- The down regulation of GFAP further demonstrated that inflammation was reduced in the brain of AD mice following treatment. Moreover, the expression levels of superoxide dismutase and catalase were elevated in the brains of treated mice, indicating that oxidation levels were reduced upon the combination treatment.	[42]	
Memory improvement	<i>Coriolus versicolor</i> polysaccharide (CVP)	- Activation of LXA4 signaling and modulation of stress-responsive vitagen proteins could serve as a potential therapeutic target for AD-related inflammation and neurodegenerative damage.	[8]	
Modulation of the inflammatory process in Alzheimer's diseases	Lipoxin A4 expressed by <i>Coriolus versicolor</i> biomass			

 Download as
  **Tables index**
 View figure

 PowerPoint Slide
 View current table in a new window

 Larger image(png format)
 View next table

Studies carried out with mice have shown that PSK increase the levels of glutathione peroxidase in macrophages [37]. Glutathione peroxidase is part of the first line of defense against lipid peroxidation, and protects the cell membrane in an early stage against attack by free radicals. Kozarski *et al.* [38] showed that polysaccharide extracts of *C. versicolor* have antioxidant activity. The extracts contained a mixture/complex of polysaccharides, proteins and polyphenols and the antioxidant effect measured was resistant to high temperatures. Another study developed by Santos Arteiro *et al.* [47] evaluated the antioxidant effect of the polysaccharides isolated from submerged cultures of *C. versicolor*. The radical scavenging for E-PPS (extracellular protein-polysaccharides) and I-PPS (intracellular protein-polysaccharides) produced per litre of culture was equivalent of 2.115 ± 0.227 and 1.374 ± 0.364 g of ascorbic acid, respectively. These complexes have revealed a positive effect protecting erythrocyte membranes from oxidation. They also demonstrated the ability to inhibit the synthesis of methemoglobin in stressed cells.

Submerged fermentation culture of *C. versicolor* showed potential antidiabetic activity [16, 48]. One of the drugs that have been used in the treatment of type II diabetes consists of α -glucosidase inhibitors. According to Hsu *et al.* [16] *C. versicolor* LH1 mycelia can inhibit the enzyme α -glucosidase. The α -glucosidase inhibitory properties were related to the presence of α -1,4 glycosidic linkages in the polysaccharide structure and the total relative percentage of D-glucose and D-galactose in the structure of polysaccharides. Furthermore, PSP inhibit tolbutamide biotransformation by cytochrome P450s enzymes in human liver [40].

The effect of PSP on the potential interaction of HIV-1 and its target cell was investigated by Collins and Ng [39]. They demonstrated inhibition of the interaction between HIV-1 gp120 and immobilized CD4 receptor by inhibiting the recombinant HIV-1 reverse transcriptase and a glycohydrolase enzyme associated with viral glycosylation.

The combination of Ginkgo Flavonoid (GF) and *C. versicolor* polysaccharide (CVP) in the prevention and treatment of a mouse model of Alzheimer's disease was studied by Fang *et al.* [42]. A synergetic beneficial effect of GF and CVP has improved the memory in the mouse model providing new insights into the efficient utilization of traditional medicine for preventing dementia.

Recently, researchers have studied a protein expressed by *C. versicolor* biomass (lipoxin A4), which is able to modulate the inflammatory process involved in the Alzheimer's disease pathogenesis. This

study gives a positive view about possible therapeutic strategies for neurodegenerative damage [8]. A recent study developed by Barros *et al.* [49] tested the safety profile of biomass of *C. versicolor* in rats. Of the results obtained, it was possible to infer about the degree of safety for human consumption.

3. Health-promoting Potential of Edible Mushrooms

Recently, mushrooms have attracted much research interest because among other benefits they are a good source of β -glucans. Some properties such as molecular weight, chemical composition and the number of branches of side chains can determine the physical and therapeutic properties of β -glucans, providing specific biological properties to mushrooms. It was shown that they are a rich source of bioactive compounds such as polysaccharides, polysaccharide-peptide complex, proteases and lectins, exhibiting antitumour, antioxidant, antimicrobial, prebiotic and anti-inflammatory properties [5, 50, 52]. Furthermore, mushrooms also accumulate enzymes and secondary metabolites that may play important metabolic functions in the body. Studies carried out in recent years in order to discover and study bioactive compounds from mushrooms are summarized in Table 2, except those related with *C. versicolor*, previously detailed.

3.1. Antitumour Activity

Polysaccharides of mushrooms may have antitumour activity, which is associated with the immunostimulatory effect that they can exert, since they are foreign bodies to our immune system [53, 54, 55]. The immunostimulatory potential of glucans was recently summarized by Vannucci *et al.* [55]. This antitumour activity is not caused by a direct cytotoxic effect but via activation of the innate immune system of the host (Figure 1). The mechanism of action is related to the presence of pattern recognition receptors (PRRs) that can recognize the polysaccharides as pathogen-associated molecular patterns (PAMPs), due to its high molecular weight. Consequently, pro-inflammatory cytokines are secreted including tumour necrosis factor alpha (TNF- α), interleukin-1 (IL-1) and interleukin-6 (IL-6) which regulate the mechanisms against infections, recognition of foreign cells and tumour cells [5]. Some structures of the β -glucans seem to be better adapted to the PRR receptors, which suggests a relationship between the structure and antitumour activity of polysaccharides. Chang *et al.* [1] found that glucans with β -1,3 and β -1,6 linkages have higher antitumour activity.

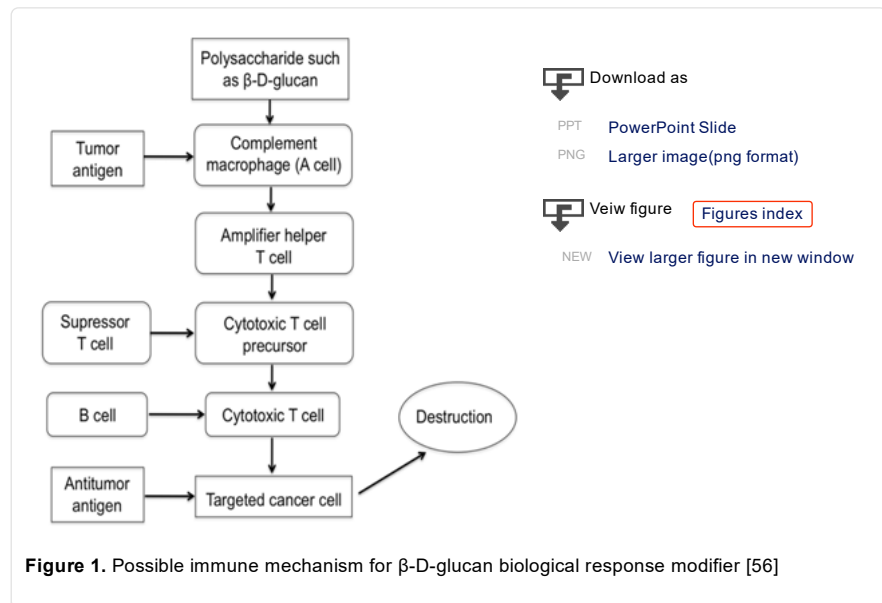








Table 2. Bioactive properties found in edible mushrooms

	Bioactive properties	Bioactive compounds associated	Methodologies used in research	References
<i>Agaricus bisporus</i>	Antioxidant activity	Gallic acid, protocatechuic acid, catechin, caffeic acid, ferulic acid and myricetin	- Ethanolic extract of <i>A. bisporus</i> ; - Assay of antioxidant activity <i>in vitro</i> and <i>in vivo</i> .	[52]
	Immune system enhancer	Polysaccharide	- Bone marrow cell culture with GM-CSF; FACS analysis. - A hospital-based case-control study of breast cancer risk was conducted. All participants were Chinese women aged between 20 and 87 years.	[59]
	Anticancer	—	—	[57]
<i>Lyophyllum shimeji</i>	Blood anticoagulant	A novel fibrinolytic enzyme: α -chymotrypsin	- Combination of anion exchange chromatography on a Mono Q 5/5 column and size exclusion gel filtration chromatography on Superdex 200 100/300 column.	[60]
<i>Phallus indusiatus</i>	Anti-inflammatory properties;	A β -D-glucan called T-5-N	- Desiccated fruiting bodies of <i>D. indusiata</i> (100 g) were extracted three times while avoiding direct sunlight by refluxing with 2000 mL of double distilled water at 90 °C with constant stirring at 400 rpm for 2 h. On cooling, the solution was centrifuged at 10000 rpm for 30 min.	[61]
	Antioxidant capability		—	—
<i>Pleurotus eryngii</i>	Antitumor activity; Immune system enhancer; Antibacterial activity	Acidic glycosphingolipids (AGLs)	- Animal experiments.	[63]
<i>Hydnellum peckii</i>	Anticoagulant	(2,5-dihydroxy-3,6-bis (4-hydroxyphenyl)-1,4-benzoquinone)	- Tests in albino rats; - <i>In vitro</i> anticoagulant evaluation; - Pharmacodynamic studies.	[64]
	Antibacterial activity	Atromentin and Leucomelone	- Structures were identified by various spectral analysis; - FabK assay.	[65]
<i>Pleurotus ostreatus</i>	Reduction of cholesterol levels	Lovastatin: inhibitor of 3-hydroxy-3-methylglutaryl Coenzyme A reductase	- Analysis of the inhibitor on a HPLC Knauer Lichrosphere 100 column.	[6]
	Anti-inflammatory activity	Oyster mushroom concentrate	- Electrophoretic mobility shift assay (EMSA)	[66]
<i>Hericium erinaceus</i>	Hemagglutinating activity	Glycoprotein HEG-5	- Isolation and purification in a DEAE-Sephrose Fast Flow anionics resin. - Isolation of HEPs fractions by gradient ethanol precipitation;	[67]
	Antibacterial activity against <i>Helicobacter pylori</i>	Polysaccharides (HEPs)	- Thin layer chromatography (TLC) and column chromatography.	[51]
	Anticancer potential against human gastrointestinal cancers	HE extracts (HTJS and HTJSA)	- Animal experiments; - Antitumor activity was assessed by tumour growth inhibition (TGI).	[50]
<i>Crucibulum laeve</i>	Inhibition of the enzyme aldose reductase	A new salfradin-type metabolites (DSM 1653 and DSM 8519)	- The structures were elucidated on the basis of UV-VIS spectroscopic, mass spectrometric and NMR spectroscopic evidence.	[68]
<i>Lentinula edodes</i> (Shiitake)	Antioxidant	Polysaccharide	- The crude polysaccharide (LEP) was extracted by hot water from the fruiting bodies. Hydroxyl and Superoxide radical assay was used to determine the antioxidant activity.	[69]

 Download as
  **Tables index**
 View figure

 PowerPoint Slide
 View current table in a new window

 Larger image(png format)
 View previous table 

A recent study by Li *et al.* [50] showed that polysaccharide extracts from *Hericium erinaceus* are active against liver cancer cells *in vitro* and *in vivo*. According to Zhang *et al.* [57] the highest consumption of dietary mushrooms, including *Agaricus bisporus* and *Lentinula edodes*, is associated with a decreased risk of breast cancer in premenopausal women and postmenopausal women. *Grifola frondosa* is one of the most popular medicinal mushrooms. The levels of Natural Killer (NK) cell cytotoxic activity in cancer patients receiving D-fraction extracted from *G. frondosa* were monitored by Kodama *et al.* [58]. D-fraction markedly suppressed tumour growth, corresponding with increases in TNF- α and IFN- γ released from spleen cells and a significant increase in TNF- α expressed in NK cells. *Ganoderma tsugae* is the other medicinal mushroom in which polysaccharides have been well investigated in both the fruiting body and mycelia. Sixteen polysaccharides obtained from *G. tsugae* were examined for antitumour effects on Sarcoma 180 in mice.

The heteroglucan had a low tumour inhibition ratio, but caused a high survival ratio [70, 71, 72].

3.2. Antioxidant Activity

Polysaccharopeptides found in mushrooms can benefit general health by inducing enzymes that remove free radicals and reduce the oxidative damage. Many synthetic chemicals, such as synthetic phenolic compounds, are strong radical scavengers, but they usually have side effects. For this reason, natural antioxidants have been preferred for food applications [38] in particular due to the increasing demand of consumer by natural additives and ingredients. The antioxidant activities of ethanolic extract from edible mushroom *Agaricus bisporus* were evaluated by Liu *et al.* [52] and the results suggested that ethanolic extract of *A. bisporus* had potent antioxidant activity and could be explored as a novel natural antioxidant.

An analysis of the antioxidant capacity of *Phallus indusiatus* polysaccharides carried out by Ker *et al.* [62] demonstrated a potent scavenging effect against oxygen free radicals. A study by Chen *et al.* [69] showed that the water-extractable polysaccharide fraction from *Lentinus edodes* exhibited significantly antioxidant activity against hydroxyl radicals, superoxide radicals and Fe²⁺ chelating ability.

Besides the antioxidant effect that polysaccharides may have, there are phenolic compounds naturally occurring in mushrooms. Total phenolic and flavonoid contents occurring in eight types of edible mushrooms (*Agaricus bisporus*, *Boletus edulis*, *Calocybe gambosa*, *Cantharellus cibarius*, *Craterellus cornucopioides*, *Hygrophorus marzuolus*, *Lactarius deliciosus* and *Pleurotus ostreatus*)

have been evaluated by Palacios *et al.* [73] with *C. cibarius* being the most effective against lipid oxidation and *A. bisporus* the species with lowest antioxidant activity.

3.3. Prebiotic Activity

The interest in the gut microbiome and host interaction is increasing. Initially, prebiotics were defined as non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth of one or a limited number of bacteria in the colon [74]. In 2004, the concept has been updated as "selectively fermented ingredients that allow specific changes in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well-being and health" [75].

The probiotics added to the foods are living microorganisms that must be kept alive and may be killed by heat, stomach acid or simply die with time. However, prebiotics are essentially dietary fibre and are not affected by heat, acid or time. Prebiotics act as food for probiotics. Furthermore, some health benefits of prebiotics (such as reducing glucose levels in the blood and improvement of the bowel function) have been medically proven and recognized by the European Food Safety Authority [76], [77].

Currently, inulin, fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), lactulose and polydextrose are recognized as the well-established prebiotics in the market but there is evidence that the beta-glucans can also be a source of long chain prebiotics [78]. Synytsya *et al.* [7] indicated that mushroom extract of *Pleurotus ostreatus* and *Pleurotus eryngii* have a potential stimulator effect on the growth of probiotic bacteria. Later, a study carried out by Chou *et al.* [79] showed that a low concentration of polysaccharides from *Lentinula edodes*, *P. eryngii* and *Flammulina velutipes* may enhance the survival rate of *Lactobacillus acidophilus*, *Lactobacillus casei* and *Bifidobacterium longum* during cold storage.

According to Yamin *et al.* [80] polysaccharide mixtures from *Ganoderma lucidum* supported the growth of probiotics with population of *Bifidobacterium* and *Lactobacillus* genus with 0.3–0.7 and 0.7–1 log₁₀ cells/mL increase, respectively. Giannenas *et al.* [81] investigated the consequences of consumption of *Agaricus bisporus* on turkey. The populations of total aerobes and anaerobes, *Lactobacillus* spp., *Bifidobacterium* spp., *Escherichia coli*, *Bacteroides* spp. and *Enterococcus* spp. were enumerated in ileum and caecum and the results showed that dietary mushroom inclusion beneficially affected performance and exerted changes in intestinal microbial communities.

3.4. Enzymes and Secondary Metabolites

Some species of mushrooms synthesize enzymes that may play important functions in the organism. *Pleurotus eryngii* and *Ganoderma lucidum* can produce laccases. In the human body this protein can confer activity against HIV by inhibiting the reverse transcriptase [82, 83]. The lectins produced by the species *Pleurotus ostreatus* and *Ganoderma carpense* have shown anti-proliferative activity on tumour cells [84].

Superoxide dismutase (SOD) is also present in some mushrooms. The recent interest in this enzyme is determined by its important physiological role in primary cellular antioxidant defense and its potential therapeutic use. Sabotic *et al.* [85] investigated the proteolytic potential of a large number of basidiomycetes. Proteolysis is an essential part of many physiological processes in all living organisms and basidiomycetes could prove to be a valuable source of proteases that could find use in biotechnological processes.

In addition to the presence of enzymes, mushroom low-molecular-weight secondary metabolites (such as terpenes, steroids, anthraquinones and benzoic acid) can regulate processes such as apoptosis, autophagy, angiogenesis, metastasis, cell cycle regulation, and signal transduction cascades that are associated with the development of cancer [86].

4. Conclusions

Nowadays mushrooms are used not only as a source of nutrients, but also as medicinal resources. Polysaccharides from mushrooms were reported to exhibit immunomodulation properties, antitumour, antioxidant, antimicrobial and prebiotic activity due to the greatest potential for structural variability in comparison with other biological active molecules.

An extremely large range of bioactive properties has been linked with the use of *C. versicolor* polysaccharides. Throughout the literature survey conducted to accomplish this review article, no studies were found using biomass from *Coriolus versicolor* mushroom to demonstrate bioactive effects. Two polysaccharides extracted from *C. versicolor* (PSP and PSK) have shown important biological properties during the past few years, and a special interest in researches in the area of cancer has aroused. It seems that *C. versicolor* polysaccharopeptide can be a useful adjunct to the therapy of cancer but, in certain cases, further work is necessary to prove some of the effects that have been observed *in vitro* and in experimental animal studies.

The role of prebiotics in improving human health has been extensively studied. It is hypothesized that prebiotic substances, like PSP and PSK found in *C. versicolor*, may be applied to modulate any microbial community to achieve advantageous effects. Furthermore, the antidiabetic, antimicrobial

and antioxidant activity demonstrated by studies carried out in *C. versicolor* indicate that this is a potential source of bioactive compounds that can bring important benefits to health.

References

- [1] Chang, S. T., "Global impact of edible and medicinal mushrooms on human welfare in the 21st century: Nongreen revolution," *International Journal of Medicinal Mushrooms*, 1. 1-7. 1999.
[↴ In article](#) [View Article](#)
- [2] Sánchez, C., "Modern aspects of mushroom culture technology," *Applied Microbiology and Biotechnology*, 64 (6). 756-762. June 2004.
[↴ In article](#) [View Article](#) [PubMed](#)
- [3] Aida, F. M. N. A., Shuhaimi, M., Yazid, M. and Maaruf, A. G., "Mushroom as a potential source of prebiotics: a review," *Trends in Food Science & Technology*, 20 (11-12). 567-575. December 2009.
[↴ In article](#) [View Article](#)
- [4] FAOSTAT, "FAOSTAT," *Food and Agricultural Organization of the United Nations*. 2014.
[↴ In article](#)
- [5] Stachowiak, B. and Reguła, J., "Health-promoting potential of edible macromycetes under special consideration of polysaccharides: a review," *European Food Research and Technology*, 234 (3). 369-380. January 2012.
[↴ In article](#) [View Article](#)
- [6] Gunde-Cimerman, N. and Cimerman, A., "*Pleurotus* fruiting bodies contain the inhibitor of 3-hydroxy-3-methylglutaryl-coenzyme A reductase–lovastatin," *Experimental Mycology*, 19 (1). 1-6. March 1995.
[↴ In article](#) [View Article](#) [PubMed](#)
- [7] Synytsya, A., Míčková, K., Synytsya, A., Jablonský, I., Spěváček, J., Erban, V., Kovářiková, E. and Čopíková, J., "Glucans from fruit bodies of cultivated mushrooms *Pleurotus ostreatus* and *Pleurotus eryngii*: structure and potential prebiotic activity," *Carbohydrate Polymers*, 76 (4). 548-556. May 2009.
[↴ In article](#) [View Article](#)
- [8] Trovato, A., Siracusa, R., Di Paola, R., Scuto, M., Fronte, V., Koverech, G., Luca, M., Serra, A., Toscano, M. A., Petralia, A., Cuzzocrea, S. and Calabrese, V., "Redox modulation of cellular stress response and lipoxin A4 expression by *Coriolus versicolor* in rat brain: relevance to Alzheimer's disease pathogenesis," *Neurotoxicology*, 53. 350-358. March 2016.
[↴ In article](#) [View Article](#) [PubMed](#)
- [9] Wasser, S. P., "Current findings, future trends, and unsolved problems in studies of medicinal mushrooms," *Applied Microbiology and Biotechnology*, 89 (5). 1323-1332. March 2011.
[↴ In article](#) [View Article](#) [PubMed](#)
- [10] Angelova, M., Dolashka-Angelova, P., Ivanova, E., Serkedjieva, J., Slokoska, L., Pashova, S., Toshkova, R., Vassilev, S., Simeonov, I., Hartmann, H. J., Stoeva, S., Weser, U. and Voelter, W., "A novel glycosylated Cu/Zn-containing superoxide dismutase: production and potential therapeutic effect," *Microbiology*, 147 (Pt 6). 1641-1650. June 2001.
[↴ In article](#) [View Article](#) [PubMed](#)
- [11] Erjavec, J., Kos, J., Ravnikar, M., Dreo, T. and Sabotic, J., "Proteins of higher fungi—from forest to application," *Trends in Biotechnology*, 30 (5). 259-273. May 2012.
[↴ In article](#) [View Article](#) [PubMed](#)
- [12] Chen, J., Jin, X., Zhang, L. and Yang, L., "A study on the antioxidant effect of *Coriolus versicolor* polysaccharide in rat brain tissues," *African Journal of Traditional, Complementary, and Alternative Medicines: AJTCAM/African Networks on Ethnomedicines*, 10 (6). 481-484. October 2013.
[↴ In article](#)
- [13] Jiménez-Medina, E., Berruguilla, E., Romero, I., Algarra, I., Collado, A., Garrido, F. and Garcia-Lora, A., "The immunomodulator PSK induces in vitro cytotoxic activity in tumour cell lines via arrest of cell cycle and induction of apoptosis," *BMC Cancer*, 8 (1). 78. January 2008.
[↴ In article](#) [View Article](#) [PubMed](#)
- [14] Sakamoto, J., Morita, S., Oba, K., Matsui, T., Kobayashi, M., Nakazato, H. and Ohashi, Y., "Efficacy of adjuvant immunochemotherapy with polysaccharide K for patients with curatively resected colorectal

cancer: a meta-analysis of centrally randomized controlled clinical trials," *Cancer Immunology, Immunotherapy*, 55 (4). 404-411. April 2006.

[↵ In article](#)

[View Article](#) [PubMed](#)

[15] Yu, Z.-T., Liu, B., Mukherjee, P. and Newburg, D. S., "Trametes versicolor extract modifies human fecal microbiota composition in vitro," *Plant Foods for Human Nutrition*, 68 (2). 107-112. June 2013.

[↵ In article](#)

[View Article](#) [PubMed](#)

[16] Hsu, W., Hsu, T., Lin, F., Cheng, Y. and Yang, J. P., "Separation, purification, and α -glucosidase inhibition of polysaccharides from *Coriolus versicolor* LH1 mycelia.," *Carbohydrate Polymers*, 92 (1). 297-306. January 2013.

[↵ In article](#)

[View Article](#) [PubMed](#)

[17] Que, Y., Sun, S., Xu, L., Zhang, Y. and Zhu, H., "High-level coproduction, purification and characterisation of laccase and exopolysaccharides by *Coriolus versicolor*," *Food Chemistry*, 159. 208-213. September 2014.

[↵ In article](#)

[View Article](#) [PubMed](#)

[18] Lin, J.-P., Wei, L., Xia, L.-M. and Cen, P.-L., "Production of laccase by *Coriolus versicolor* and its application in decolorization of dyestuffs: (I). Production of laccase by batch and repeated-batch processes," *Journal of Environmental Sciences (China)*, 15 (1). 1-4. January 2003.

[↵ In article](#)

[19] Arockiasamy, S., Krishnan, I. P. G., Anandakrishnan, N., Seenivasan, S., Sambath, A. and Venkatasubramani, J. P., "Enhanced production of laccase from *Coriolus versicolor* NCIM 996 by nutrient optimization using response surface methodology," *Applied Biochemistry and Biotechnology*, 151 (2-3). 371-379. December 2008.

[↵ In article](#)

[View Article](#) [PubMed](#)

[20] Cui, J. and Chisti, Y., "Polysaccharopeptides of *Coriolus versicolor*: physiological activity, uses, and production," *Biotechnology Advances*, 21 (2). 109-122. April 2003.

[↵ In article](#)

[View Article](#)

[21] Ng, T. B., "A review of research on the protein-bound polysaccharide (polysaccharopeptide, PSP) from the mushroom *Coriolus versicolor* (Basidiomycetes: Polyporaceae)," *General Pharmacology*, 30 (1). 1-4. January 1998.

[↵ In article](#)

[View Article](#)

[22] Pallav, K., Dowd, S. E., Villafuerte, J., Yang, X., Kabbani, T., Hansen, J., Dennis, M., Leffler, D. A., Newburg, D. S. and Kelly, C. P., "Effects of polysaccharopeptide from *Trametes versicolor* and amoxicillin on the gut microbiome of healthy volunteers: a randomized clinical trial," *Gut Microbes*, 5 (4). 458-467. July 2014.

[↵ In article](#)

[View Article](#) [PubMed](#)

[23] Mao, X. W., Archambeau, J. O. and Gridley, D. S., "Immunotherapy with low-dose interleukin-2 and a polysaccharopeptide derived from *Coriolus versicolor*," *Cancer Biotherapy & Radiopharmaceuticals*, 11 (6). 393-403. December 1996.

[↵ In article](#)

[View Article](#) [PubMed](#)

[24] Dong, Y., Yang, M. M.-P., and Kwan, C.-Y., "In vitro inhibition of proliferation of HL-60 cells by tetrandrine and coriolus versicolor peptide derived from Chinese medicinal herbs," *Life Sciences*, 60 (8). PL135-PL140. January 1997.

[↵ In article](#)

[View Article](#)

[25] Yang, M. M. P., Chen, Z. and Kwok, J. S. L., "The anti-tumor effect of a small polypeptide from *Coriolus versicolor* (SPCV)," *The American Journal of Chinese Medicine*, 20 (3-4). 221-232. January 1992.

[↵ In article](#)

[View Article](#) [PubMed](#)

[26] Patel, S. and Goyal, A., "Recent developments in mushrooms as anti-cancer therapeutics: a review," *3 Biotech*, 2 (1). 1-15. March 2012.

[↵ In article](#)

[27] Katoh, R. and Ooshiro, M., "Enhancement of antitumor effect of tegafur/uracil (UFT) plus leucovorin by combined treatment with protein-bound polysaccharide, PSK, in mouse models," *Cellular & Molecular Immunology*, 4 (4). 295-299. August 2007.

[↵ In article](#)

[PubMed](#)

- [28] Morimoto, T., Ogawa, M., Orita, K., Sugimachi, K., Toge, T., Dohi, K., Nomura, Y., Monden, Y. and Ogawa, N., "Postoperative adjuvant randomised trial comparing chemoendocrine therapy, chemotherapy and immunotherapy for patients with stage II breast cancer: 5-year results from the Nishinohon Cooperative Study Group of Adjuvant Chemoendocrine Therapy for Breast Cancer (ACETBC) of Japan," *European Journal of Cancer*, 32A (2). 235-242. February 1996.
- [↵ In article](#) [View Article](#)
- [29] Hayakawa, K., Mitsuhashi, N., Saito, Y., Takahashi, M., Katano, S., Shiojima, K., Furuta, M. and Niibe, H., "Effect of krestin (PSK) as adjuvant treatment on the prognosis after radical radiotherapy in patients with non-small cell lung cancer," *Anticancer Research*, 13 (5C). 1815-1820. September-October 1993.
- [↵ In article](#) [PubMed](#)
- [30] Ho, J. C. K., Konerding, M. a, Gaumann, A., Groth, M. and Liu, W. K., "Fungal polysaccharopeptide inhibits tumor angiogenesis and tumor growth in mice," *Life Sciences*, 75 (11). 1343-56. July 2004.
- [↵ In article](#) [View Article](#) [PubMed](#)
- [31] Sekhon, B. K., Sze, D. M., Chan, W. K., Fan, K., Li, G. Q., Moore, D. E. and Roubin, R. H., "PSP activates monocytes in resting human peripheral blood mononuclear cells: Immunomodulatory implications for cancer treatment," *Food Chemistry*, 138 (4). 2201-2209. June 2013.
- [↵ In article](#) [View Article](#) [PubMed](#)
- [32] Harhaji, L., Mijatović, S., Maksimović-Ivanić, D., Stojanović, I., Momčilović, M., Maksimović, V., Tufegdžić, S., Marjanović, Z., Mostarica-Stojković, M., Vucinić, Z. and Stosić-Grujčić, S., "Anti-tumor effect of *Coriolus versicolor* methanol extract against mouse B16 melanoma cells: in vitro and in vivo study.," *Food and Chemical Toxicology*, 46 (5). 1825-1833. May 2008.
- [↵ In article](#) [View Article](#) [PubMed](#)
- [33] Choi, J.-H., Kim, Y.-B., Lim, H.-Y., Park, J. S., Kim, H. C., Cho, Y. K., Han, S. W., Kim, M. W. and Joo, H. J., "5-fluorouracil, mitomycin-C, and polysaccharide-K adjuvant chemoimmunotherapy for locally advanced gastric cancer: the prognostic significance of frequent perineural invasion," *Hepatogastroenterology*, 54 (73). 290-297. January-February 2007.
- [↵ In article](#) [PubMed](#)
- [34] Lee, C. L., Yang, X. and Wan, J. M. F., "The culture duration affects the immunomodulatory and anticancer effect of polysaccharopeptide derived from *Coriolus versicolor*," *Enzyme and Microbial Technology*, 38 (1-2). 14-21. January 2006.
- [↵ In article](#) [View Article](#)
- [35] Lau, C. B. S., Ho, C. Y., Kim, C. F., Leung, K. N., Fung, K. P., Tse, T. F., Chan, H. H. L. and Chow, M. S. S., "Cytotoxic activities of *Coriolus versicolor* (Yunzhi) extract on human leukemia and lymphoma cells by induction of apoptosis," *Life Sciences*, 75 (7). 797-808. July 2004.
- [↵ In article](#) [View Article](#) [PubMed](#)
- [36] Luo, K.-W., Yue, G. G.-L., Ko, C.-H., Lee, J. K.-M., Gao, S., Li, L.-F., Li, G., Fung, K.-P., Leung, P.-C. and Lau, C. B.-S., "In vivo and in vitro anti-tumor and anti-metastasis effects of *Coriolus versicolor* aqueous extract on mouse mammary 4T1 carcinoma.," *Phytomedicine*, 21 (8-9). 1078-1087. July-August 2014.
- [↵ In article](#) [View Article](#) [PubMed](#)
- [37] Pang, Z. J., Chen, Y., Zhou, M. and Wan, J., "Effect of polysaccharide Krestin on glutathione peroxidase gene expression in mouse peritoneal macrophages," *British Journal of Biomedical Science*, 57 (2). 130-136. 2000.
- [↵ In article](#) [PubMed](#)
- [38] Kozarski, M., Klaus, A., Nikšić, M., Vrvic, M. M., Todorović, N., Jakovljević, D. and Van Griensven, L. J. L. D., "Antioxidative activities and chemical characterization of polysaccharide extracts from the widely used mushrooms *Ganoderma applanatum*, *Ganoderma lucidum*, *Lentinus edodes* and *Trametes versicolor*," *Journal of Food Composition and Analysis*, 26 (1-2). 144-153. May-June 2012.
- [↵ In article](#) [View Article](#)
- [39] Collins, R. A. and Ng, T. B., "Polysaccharopeptide from *Coriolus versicolor* has potential for use against human immunodeficiency virus type 1 infection," *Life Sciences*, 60 (25). PL383-PL387. May 1997.
- [↵ In article](#) [View Article](#)
- [40] Yeung, J. H. K. and Or, P. M. Y., "Polysaccharide peptides from *Coriolus versicolor* competitively inhibit tolbutamide 4-hydroxylation in specific human CYP2C9 isoform and pooled human liver microsomes," *Phytomedicine*, 18 (13). 1170-1175. October 2011.
- [↵ In article](#) [View Article](#) [PubMed](#)

- [41] Yang, S., Zhuang, T., Si, Y., Qi, K. and Zhao, J., "Coriolus versicolor mushroom polysaccharides exert immunoregulatory effects on mouse B cells via membrane Ig and TLR-4 to activate the MAPK and NF- κ B signaling pathways," *Molecular Immunology*, 64 (1). 144-151. March 2015.
[↵ In article](#) [View Article](#) [PubMed](#)
- [42] Fang, X., Jiang, Y., Ji, H., Zhao, L., Xiao, W., Wang, Z. and Ding, G., "The synergistic beneficial effects of ginkgo flavonoid and *Coriolus versicolor* polysaccharide for memory Improvements in a mouse model of dementia," *Evidence-Based Complementary and Alternative Medicine*, 2015. 128394. 2015.
[↵ In article](#)
- [43] Fritz, H., Kennedy, D. A., Ishii, M., Fergusson, D., Fernandes, R., Cooley, K. and Seely, D., "Polysaccharide K and *Coriolus versicolor* extracts for lung cancer: a systematic review," *Integrative Cancer Therapies*, 14 (3). 201-211. May 2015.
[↵ In article](#) [View Article](#) [PubMed](#)
- [44] Fujita, H., Ogawa, K., Ikuzawa, M., Muto, S., Matsuki, M., Nakajima, S., Shimamura, M., Togawa, M., Yoshikumi, C. and Kawai, Y., "Effect of PSK, a protein-bound polysaccharide from *Coriolus versicolor*, on drug-metabolizing enzymes in sarcoma-180 bearing and normal mice," *International Journal of Immunopharmacology*, 10 (4). 445-450. February 1988.
[↵ In article](#) [View Article](#)
- [45] Sakagami, H. and Takeda, M., "Diverse biological activity of PSK (Krestin), a protein-bound polysaccharide from *Coriolus versicolor* (Fr.) Quel., in: Chang ST, Buswell JA, Chiu SW (eds)., in *Mushroom Biology and Mushroom Products.*, 1993, 237-245.
[↵ In article](#)
- [46] Chu, K. K. W., Ho, S. S. S. and Chow, A. H. L., "*Coriolus versicolor*: A medicinal mushroom with promising immunotherapeutic values," *Journal of Clinical Pharmacology*, 42 (9). 976-984. September 2002.
[↵ In article](#) [View Article](#) [PubMed](#)
- [47] Santos Arteiro, J. M., Martins, M. R., Salvador, C., Candeias, M. F., Karmali, A. and Caldeira, A. T., "Protein-polysaccharides of *Trametes versicolor*: production and biological activities," *Medicinal Chemistry Research*, 21 (6). 937-943. June 2012.
[↵ In article](#) [View Article](#)
- [48] Yang, J. P., Hsu, T., Lin, F., Hsu, W. and Chen, Y., "Potential antidiabetic activity of extracellular polysaccharides in submerged fermentation culture of *Coriolus versicolor* LH1.," *Carbohydrate Polymers*, 90 (1). 174-80. September 2012.
[↵ In article](#) [View Article](#) [PubMed](#)
- [49] Barros, A. B., Ferrão, J. and Fernandes, T., "A safety assessment of *Coriolus versicolor* biomass as a food supplement," *Food & Nutrition Research*, 60. 29953. March 2016.
[↵ In article](#) [View Article](#) [PubMed](#)
- [50] Li, G., Yu, K., Li, F., Xu, K., Li, J., He, S., Cao, S. and Tan, G., "Anticancer potential of *Heridium erinaceus* extracts against human gastrointestinal cancers," *Journal of Ethnopharmacology*, 153 (2). 521-530. April 2014.
[↵ In article](#) [View Article](#) [PubMed](#)
- [51] Zhu, Y., Chen, Y., Li, Q., Zhao, T., Zhang, M., Feng, W., Takase, M., Wu, X., Zhou, Z., Yang, L. and Wu, X., "Preparation, characterization, and anti-*Helicobacter pylori* activity of Bi3+-*Heridium erinaceus* polysaccharide complex," *Carbohydrate Polymers*, 110. 231-237. September 2014.
[↵ In article](#) [View Article](#) [PubMed](#)
- [52] Liu, J., Jia, L., Kan, J. and Jin, C.-H., "*In vitro* and *in vivo* antioxidant activity of ethanolic extract of white button mushroom (*Agaricus bisporus*)," *Food and Chemical Toxicology*, 51. 310-316. January 2013.
[↵ In article](#) [View Article](#) [PubMed](#)
- [53] Ohno, N., Miura, N. N., Nakajima, M. and Yadomae, T., "Antitumor 1,3-beta-glucan from cultured fruit body of *Sparassis crispa*," *Biological & Pharmaceutical Bulletin*, 23 (7). 866-872. July 2000.
[↵ In article](#) [View Article](#) [PubMed](#)
- [54] Novak, M. and Vetvicka, V., "Glucans as biological response modifiers," *Endocrine, Metabolic & Immune Disorders Drug Targets*, 9 (1). 67-75. March 2009.
[↵ In article](#) [View Article](#) [PubMed](#)

- [55] Vannucci, L., Krizan, J., Sima, P., Stakheev, D., Caja, F., Rajsiglova, L., Horak, V. and Saieh, M., "Immunostimulatory properties and antitumor activities of glucans (Review)," *International Journal of Oncology*, 43 (2). 357-364. August 2013.
[↴ In article](#) [View Article](#)
- [56] Wasser, S. P., "Medicinal mushrooms as a source of antitumor and immunomodulating polysaccharides," *Applied Microbiology and Biotechnology*, 60 (3). 258-274. November 2002.
[↴ In article](#) [View Article](#) [PubMed](#)
- [57] Zhang, M., Huang, J., Xie, X. and Holman, C. D. J., "Dietary intakes of mushrooms and green tea combine to reduce the risk of breast cancer in Chinese women.," *International Journal of Cancer*, 124 (6). 1404-1408. March 2009.
[↴ In article](#) [View Article](#) [PubMed](#)
- [58] Kodama, N., Komuta, K., Sakai, N. and Nanba, H., "Effects of D-Fraction, a polysaccharide from *Grifola frondosa* on tumor growth involve activation of NK cells," *Biological & Pharmaceutical Bulletin*, 25 (12). 1647-1650. December 2002.
[↴ In article](#) [View Article](#) [PubMed](#)
- [59] Ren, Z., Guo, Z., Meydani, S. N. and Wu, D., "White button mushroom enhances maturation of bone marrow-derived dendritic cells and their antigen presenting function in mice," *The Journal of Nutrition*, 138 (3). 544-550. March 2008.
[↴ In article](#) [PubMed](#)
- [60] Moon, S.-M., Kim, J.-S., Kim, H.-J., Choi, M. S., Park, B. R., Kim, S.-G., Ahn, H., Chun, H. S., Shin, Y. K., Kim, J.-J., Kim, D. K., Lee, S.-Y., Seo, Y.-W., Kim, Y. H. and Kim, C. S., "Purification and characterization of a novel fibrinolytic α chymotrypsin like serine metalloprotease from the edible mushroom, *Lyophyllum shimeji*," *Journal of Bioscience and Bioengineering*, 117 (5). 544-550. May 2014.
[↴ In article](#) [View Article](#) [PubMed](#)
- [61] Hara, C., Kiho, T., Tanaka, Y. and Ukai, S., "Anti-inflammatory activity and conformational behavior of a branched (1 \rightarrow 3)- β -D-glucan from an alkaline extract of *Dictyophora indusiata* Fisch," *Carbohydrate Research*, 110 (1). 77-87. November 1982.
[↴ In article](#) [View Article](#)
- [62] Ker, Y.-B., Chen, K.-C., Peng, C.-C., Hsieh, C.-L. and Peng, R. Y., "Structural characteristics and antioxidative capability of the soluble polysaccharides present in *Dictyophora indusiata* (Vent. Ex Pers.) *Fish Phallaceae*," *Evidence-Based Complementary and Alternative Medicine*, 2011. 396013. January 2011.
[↴ In article](#) [View Article](#) [PubMed](#)
- [63] Nozaki, H., Itonori, S., Sugita, M., Nakamura, K., Ohba, K., Suzuki, A. and Kushi, Y., "Mushroom acidic glycosphingolipid induction of cytokine secretion from murine T cells and proliferation of NK1.1 alpha/beta TCR-double positive cells in vitro," *Biochemical and Biophysical Research Communications*, 373 (3). 435-439. August 2008.
[↴ In article](#) [View Article](#) [PubMed](#)
- [64] Khanna, J. M., Malone, M. H., Euler, K. L. and Brady, L. R., "Atromentin. Anticoagulant from *Hydnellum diabolus*," *Journal of Pharmaceutical Sciences*, 54 (7). 1016-1020. July 1965.
[↴ In article](#) [View Article](#) [PubMed](#)
- [65] Zheng, C., Sohn, M. and Kim, W., "Atromentin and leucomelone, the first inhibitors specific to enoyl-ACP reductase (FabK) of *Streptococcus pneumoniae*," *The Journal of Antibiotics*, 59 (12). 808-812. December 2006.
[↴ In article](#) [View Article](#) [PubMed](#)
- [66] Jedinak, A., Dudhgaonkar, S., Wu, Q.-L., Simon, J. and Sliva, D., "Anti-inflammatory activity of edible oyster mushroom is mediated through the inhibition of NF- κ B and AP-1 signaling," *Nutrition Journal*, 10 (1). 52. May 2011.
[↴ In article](#) [View Article](#) [PubMed](#)
- [67] Cui, F.-J., Li, Y.-H., Zan, X.-Y., Yang, Y., Sun, W.-J., Qian, J.-Y., Zhou, Q. and Yu, S.-L., "Purification and partial characterization of a novel hemagglutinating glycoprotein from the cultured mycelia of *Hericium erinaceus*," *Process Biochemistry*, 49 (8). 1362-1369. August 2014.
[↴ In article](#) [View Article](#)

- [68] Neumann, T., Schlegel, B., Hoffmann, P., Heinze, S. and Gräfe, U., "Isolation and structure elucidation of new salfredin-type metabolites from *Crucibulum laeve* DSM 1653 and DSM 8519," *Journal of Basic Microbiology*, 39 (5-6). 357-363. December 1999.
- [↴ In article](#) [View Article](#)
- [69] Chen, H., Ju, Y., Li, J. and Yu, M., "Antioxidant activities of polysaccharides from *Lentinus edodes* and their significance for disease prevention," *International Journal of Biological Macromolecules*, 50 (1). 214-218. January 2012.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [70] Hsu, S.-C., Ou, C.-C., Li, J.-W., Chuang, T.-C., Kuo, H.-P., Liu, J.-Y., Chen, C.-S., Lin, S.-C., Su, C.-H. and Kao, M.-C., "*Ganoderma tsugae* extracts inhibit colorectal cancer cell growth via G(2)/M cell cycle arrest," *Journal of Ethnopharmacology*, 120 (3). 394-401. December 2008.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [71] Hsu, S.-C., Ou, C.-C., Chuang, T.-C., Li, J.-W., Lee, Y.-J., Wang, V., Liu, J.-Y., Chen, C.-S., Lin, S.-C. and Kao, M.-C., "*Ganoderma tsugae* extract inhibits expression of epidermal growth factor receptor and angiogenesis in human epidermoid carcinoma cells: *in vitro* and *in vivo*," *Cancer Letters*, 281 (1). 108-116. August 2009.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [72] Zhang, J., Wang, G., Li, H., Zhuang, C., Mizuno, T., Ito, H., Mayuzumi, H., Okamoto, H., and Li, J. "Antitumor active protein-containing glycans from the Chinese mushroom *Songshan Lingzhi*, *Ganoderma tsugae* mycelium," *Bioscience, Biotechnology, and Biochemistry*, 58 (7). 1202-1205. 1994.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [73] Palacios, I., Lozano, M., Moro, C., D'Arrigo, M., Rostagno, M. A., Martínez, J. A., García-Lafuente, A., Guillamón, E., and Villares, A., "Antioxidant properties of phenolic compounds occurring in edible mushrooms," *Food Chemistry*, 128 (3). 674-678. October 2011.
- [↴ In article](#) [View Article](#)
- [74] Gibson, G. R., and Roberfroid, M. B., "Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics," *The Journal of Nutrition*, 125 (6). 1401-1412. June 1995.
- [↴ In article](#) [PubMed](#)
- [75] Gibson, G. R., Probert, H. M., Loo, J. Van, Rastall, R. A. and Roberfroid, M. B., "Dietary modulation of the human colonic microbiota: updating the concept of prebiotics.," *Nutrition Research Reviews*, 17 (2). 259-275. December 2004.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [76] EFSA, "Scientific Opinion on the substantiation of a health claim related to non-digestible carbohydrates and a reduction of post-prandial glycaemic responses pursuant to Article 13 (5) of Regulation (EC) No 1924/2006 1," *EFSA Journal*, 12 (1). 3513. 2014.
- [↴ In article](#) [View Article](#)
- [77] EFSA, "Scientific Opinion on the substantiation of a health claim related to "native chicory inulin " and maintenance of normal defecation by increasing stool frequency pursuant to Article 13 (5) of Regulation

Health Benefits of Edible Mushrooms Focused on *Coriolus versicolor*: A Review

Aritson Cruz, Lúgia Pimentel, Luis M. Rodríguez-Alcalá, Tito Fernandes, Manuela Pintado



[↴ In article](#) [View Article](#)

Abstract

1. Introduction

2. *Coriolus Versicolor*

3. Health-promoting Potential of Edible Mushrooms

4. Conclusions

References

- [78] Lam, K.-L. and Cheung, P. C-K., "Non-digestible long chain beta-glucans as novel prebiotics," *Bioactive Carbohydrates and Dietary Fibre*, 2 (1). 45-64. July 2013.
- [↴ In article](#) [View Article](#)
- [79] Chou, W.-T., Sheih, I.-C. and Fang, T. J., "The applications of polysaccharides from various mushroom wastes as prebiotics in different systems," *Journal of Food Science*, 78 (7). M1041-M1048. July 2013.
- [↴ In article](#) [View Article](#) [PubMed](#)
- [80] Yamin, S., Shuhaimi, M, Arbakariya, A., Fatimah, A. B., Khalilah, A. K., Anas, O. and Yazid, A. M., "Effect of *Ganoderma lucidum* polysaccharides on the growth of *Bifidobacterium* spp. as assessed using Real-time PCR," *International Food Research Journal*, 19 (3). 1199-1205. 2012.
- [↴ In article](#)
- [81] Giannenas, I., Tsalie, E., Chronis, E., Mavridis, S., Tontis, D., and Kyriazakis, I., "Consumption of *Agaricus bisporus* mushroom affects the performance, intestinal microbiota composition and morphology, and antioxidant status of turkey poults," *Animal Feed Science and Technology*, 165 (3-4). 218-229. May 2011.

[↴ In article](#)

[View Article](#)

[82] Wang, H. X. and Ng, T. B., "A laccase from the medicinal mushroom *Ganoderma lucidum*," *Applied Microbiology and Biotechnology*, 72 (3). 508-513. September 2006.

[↴ In article](#)

[View Article](#) [PubMed](#)

[83] Wang, H. X. and Ng, T. B., "Purification of a laccase from fruiting bodies of the mushroom *Pleurotus eryngii*," *Applied Microbiology and Biotechnology*, 69 (5). 521-525. January 2006.

[↴ In article](#)

[View Article](#) [PubMed](#)

[84] Ngai, P. H. K. and Ng, T. B., "A mushroom (*Ganoderma capense*) lectin with spectacular thermostability, potent mitogenic activity on splenocytes, and antiproliferative activity toward tumor cells," *Biochemical and Biophysical Research Communications*, 314 (4). 988-993. February 2004.

[↴ In article](#)

[View Article](#) [PubMed](#)

[85] Sabotič, J., Trček, T., Popovič, T. and Brzin, J., "Basidiomycetes harbour a hidden treasure of proteolytic diversity," *Journal of Biotechnology*, 128 (2). 297-307. February 2007.

[↴ In article](#)

[View Article](#) [PubMed](#)

[86] Zaidman, B.-Z., Yassin, M., Mahajna, J. and Wasser, S. P., "Medicinal mushroom modulators of molecular targets as cancer therapeutics," *Applied Microbiology and Biotechnology*, 67 (4). 453-468. June 2005.

[↴ In article](#)

[View Article](#) [PubMed](#)

Pages

[Home](#)
[About Us](#)
[Journals](#)
[Conferences](#)
[Special Issues](#)

Partners

[Google Scholar](#)
[CrossRef](#)
[IBAAS](#)
[VIRAL HEPATITIS CONGRESS](#)
[JournalTOCs](#)

Help & Contacts

[Contact Us](#)
[Sitemap](#)
[Feedback](#)
[FAQ](#)
[Questionnaire](#)

Follow Us



Copyright © 2012-2016
Science and Education
Publishing Co. Ltd All rights
reserved.

Health Benefits of Edible Mushrooms Focused on *Coriolus versicolor*: A Review
Aritson Cruz, Lígia Pimentel, Luis M. Rodríguez-Alcalá, Tito Fernandes, Manuela Pintado



Abstract

1. Introduction
2. *Coriolus Versicolor*
3. Health-promoting Potential of Edible Mushrooms
4. Conclusions

[References](#)