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A Comprehensive Review Of Ethnopharmacology, Phytochemistry And Pharmacology Of Some Medicinal And Edible Mushrooms

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Abstract

Since mushrooms have long been utilized throughout traditional medical practices curiosity about exploring mushrooms scientifically and their possible health advantages is rising. Polysaccharides, sterols, and phenolic compounds are just a few of the bioactive substances that can be found in mushrooms and have a positive impact on human health. The study of how different cultures have used mushrooms in traditional medicine is what makes mushrooms relevant from an ethnopharmacological perspective. Mushrooms have a wide variety of ethnopharmacological uses, and these uses change according to culture and mushroom species. Although the scientific study of mushrooms is still in its infancy, the preliminary findings are encouraging. There is proof that mushrooms can boost the immune system, lower cholesterol, reduce inflammation, stop the spread of cancer cells, and protect cells from free radical damage. We will probably discover much more information on the health advantages of mushrooms as further research is conducted. A useful source of knowledge about the possible health advantages of mushrooms is their ethnopharmacological relevance. From the present review, knowledge about ethnobotany, phytochemistry, and pharmacology can be utilised to direct scientific study and create new health-improving products made from mushrooms.

Keywords: *Bioactive chemicals, Health benefits, Ethnopharmacology, Mushrooms.*

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1. INTRODUCTION

The discovery of novel bioactive chemicals in natural sources may facilitate drug development (Debbab et al., 2011, 2012; Newman and Cragg, 2007). With 3-5 million species, fungi may rank as the second most varied group of living things (Blackwell 2011). Fungi from Basidiomycota and certain Ascomycota that produce fleshy fruit bodies, which generate bioactive substances, may treat a number of ailments (Aly et al., 2011; de Silva et al., 2012a). For many years, especially in Asia (Rapior et al., 2000; Ferreira et al., 2010; Xu et al., 2011), mushrooms have been used to treat or prevent a variety of illnesses. Unstudied species of macrofungi may aid in the discovery of compounds with biological effects. The fascinating substances produced by basidiomycota have a variety of biogenetic origins. Numerous research (Bao et al. 2001; Keller et al. 2002; Poucheret et al. 2006; Jeong 2011) have indicated that these substances have pharmacological effects on bacteria, fungi, viruses, and other species.

Medicinal mushrooms, which have historically dominated mushroom production in the Far East, are increasingly making their way into the Western market because of their excellent organoleptic properties and acceptance as real functional foods. The employment of complementary medical techniques, such as traditional medicine, in which medicinal mushrooms play a significant role, as well as rising consumer desire for wholesome foods, have all helped medicinal mushrooms gain traction on the world market. According to studies, there are 14,000–22,000 different varieties of mushrooms. Only 10% of the 140,000 species of mushrooms have been identified. There are still 7,000 kinds of mushrooms that haven't been found that may be helpful to human civilization if we assume that 5% of unknown and untested mushrooms will be (Hawksworth, 2001). Only a tiny portion of mushroom species have undergone in-depth research. Bioactive substances may be produced by microorganisms such as *Aspergillus, Tolypocladium inflatum W. Gams, and Claviceps purpurea* (Fr.) Tul. (Lindequist et al. 2005).

In this review, we have discussed the incidents in the ethnomedicinal use of mushrooms in terms of ethnopharmacology, phytochemistry, pharmacology, and other increasing parameters, as well as providing support for the utilization of selected mushrooms as a common drug to produce bioactive secondary metabolites. We may presume that mushrooms have tremendous potential for successful bioprospecting given their enhanced capabilities for biological, pharmacological, and chemical investigation. This is something that we can say with confidence. In the present review, we have compiled the mushrooms related to their edible, non-edible, and medicinal importance.

2. BOTANY AND ETHNOBOTANY

There is no taxonomic category known as "mushroom." The term "mushroom" should be used here in the sense given by Chang and Miles, who define a mushroom as "a macrofungus with a distinctive fruiting body, that can be both hypogeous or epigeous, sufficiently big to be considered with the naked eye and to be picked by hand." Taxonomically speaking, mushrooms are primarily classified as basidiomycetes, but there are a few ascomycete species that fall under this category as well (Chang and Miles1992).

2.1*Inonotus obliquus* (Ach. ex Pers.) (Wild Chaga)

The fruit bodies look like tumors (a sterile lump without a stalk in the dimension of 25 to 40 cm and has a dark coloration of grey and a deep cleavage); The parental section is five mm thick, crusiform, and dark-brown in colour, while surrounding area is light yellow in colour. The tube length is 3 to 10 mm, and its front end is open (Huang, 2002). The pore is circular, smooth, and shiny, 9–10, and the cleavage is a parasitic black fungus called *Inonotus obliquus* grows on mature birch tree trunks. birch's brown *Ganoderma lucidum*, also known as chaga and birch antler, is a medicinal white-rot fungus. The white-rot fungus *Inonotus obliquus* grows on older birch trees' living trunks. *Inonotus obliquus* is the cause of the host tree's white heart rot. Chaga spores enter the tree through wounds, especially branch stubs. Due to white rot, the host's heartwood will degrade. The infection's sapwood can only be punctured near the mycelium mass on the sterile surface. For 10–80 years, the chaga fungus will degrade the living tree. While the tree is alive, the black exterior conk will only grow sterile mycelium and go to the sexual stage after damaging the tree. Under the bark, *Inonotus obliquus* produces fertile fruiting bodies. These organisms start white and turn brown. The fruiting body is rarely visible since most reproductive activity happens under the bark. These fruiting structures produce basidiospores, which transmit the infection to more sensitive plants (Lee et al. 2008).

2.2 *Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm.

Both the scientific name and the colloquial name of the fruiting body of *P. ostreatus* take into account the morphology of the fruiting body (Sher et al., 2011). The way in which the stem grows with respect to the cap is referred to as "pleurotus," which is a Latin term that means "sideways." The word "oyster" comes from the Latin word "ostreatus," which refers to the shape of the cap, which resembles a bivalve with two shells. The cap of *P. ostreatus* ranges in length from 5 to 25 centimeters and is broad, fan-shaped, or oyster-shaped. Natural specimens might be white, gray, tan, or dark brown in color, and their edges are smooth when they are young but frequently have lobes and waves on them as they mature. Because of the way the stipes are organized, the thickness of the white, firm flesh can vary. The gills of the mushroom have a color range from white to cream, and they dangle downward from the stalk, if it has one. The stipe is not located in the middle of the piece of wood and is instead linked to one of the sides. On a dark surface, the mushroom's spore print, which ranges in color from white to lilac-gray, is most visible (Rajarathnam et al., 1987; Menolli et al., 2010).

2.3 *Trametes versicolor* (L.) Lloyd

Trametes versicolor, also referred to as Turkey Tail, is a widespread lignicolous fungal species with white rot that grows on various trees such as oak and Prunus and on various conifers such as fir or pine trees (Gautam, 2013; Janjušević et al., 2017; WA et al., 2020). Despite the fact that this genus is inedible, it has been traditionally used in the medicinal practices of a number of different nations. Numerous studies have offered scientific confirmation of their vast range of pharmacological behavior including anti-oxidant, anti-cancer, and anti-inflammatory characteristics, amongst others. (Kamiyama et al., 2013; Janjušević et al., 2017). The upper surface of the cap displays the characteristic concentric zones of various hues, and the border is always the palest part of the surface. A dark layer sits just below a layer of tomentum, on top of which lies a layer of white flesh (PUIA et al., 2018). The thickness of the flesh itself ranges from one to three millimeters, and it has a leathery consistency. Older specimens, like the one in the image, may have areas where green algae is forming, giving them a green appearance. On the fallen branches and fallen trees of deciduous trees, it will often develop in tiled layers that are arranged in groups or rows. The mushroom does not have a stem, and the cap might be a rusty brown or a deeper brown color. It occasionally has black zones. The area of the cap may range from 0.5 to 1 centimeter and be up to 8 cm by 5 cm. It is often triangular or circular in shape, and it has zones of fine hairs. White to light brown in color, the surface of the pores is circular and, with increasing age, becomes twisted and labyrinthine. 3–8 pores per millimeter (Gautam, 2013).

2.4 *Ganoderma applanatum* (Pers.) Pat.

The mycelium of this parasitic and saprophytic fungus develops on both living and dead trees. One by one or in clusters, *Ganoderma applanatum* grows. Its fruiting bodies are inedible, leathery, and woody, measuring 3 to 30 cm in width by 5 to 50 cm in length. They begin white before turning a deep red-brown color. Reddish-brown conidia are found on top of the fruiting body. Brown spores come from the underside of pores. Due to their high concentration, a piece of conk measuring 10–10 cm can produce 4.65 billion spores in a day. 4–12 mm tubes have 4-6 round pores per millimeter at the end. Perennial fruiting structures are constantly growing and developing new pores. These strata can be seen in cross-sections or in concentric rings on fruiting bodies. Thus, the age of the fruiting body can be determined by tree rings. In many trees, *Ganoderma applanatum* causes the heartwood to decay. It can develop as a pathogen in the living sapwood of elder trees that are moist, old, or diseased, while it mostly grows on dead trees (Jogaiah et al., 2019).

2.5*Agaricus campestris*

The white, 3 to 12 centimeter-diameter cap may have fine scales. It starts out hemispherical before maturing into a flat shape. Both the spores and the valves have a pinkish colour at first, then a reddish-brown colour, and finally a dark brown colour. (Davis et al., 2012). According to Davis et al. (2012) and Nilsson & Persson (1977), the stipe is 3 to 10 cm in height, 1 to 2 cm wide, and primarily white in colour. In addition to that, it has a single delicate ring. It has a mild flavor. White tissues bruise a rusty crimson brown, unlike *Agaricus xanthodermus* and comparable species, which have a fleshy yellow bruise. The spores are 5.5 to 8 mm by 4 to 5 mm in size and elliptical in shape, while the sporewall is thick. Dark brown in colour. Cheilocystidia are not present (Miller & Miller, 2006).

3. TRADITIONAL USES OF MUSHROOMS

Since ancient times, macrofungi have been the norm in human culture. Around the world, oral tradition has been passed down from one generation to the next, describing the health benefits of mushrooms. Ancient scriptures like the Vedas reference and value the conventional understanding of mushroom use throughout the world. According to Roman and Chinese mythology, mushrooms have capacity and a life energy that gives them power. The inhabitants of prehistoric China, India, and Iran employed mushrooms in their religious rituals and thought of them as gifts from the deity Osiris (Sharma, 2003; Lowy, 1971).

3.1*Inonotus obliquus* (Ach. ex Pers.) (Wild Chaga)

Rationality and mysticism coexist in traditional medicine. Finding substances that can cure diseases by observing nature makes sense. In many countries, this is the only way to improve health because of poverty or a lack of modern treatment. *I. obliquus* was used in ancient traditional medicine. One of the first texts referencing its medicinal use is Hippocrates' "Corpus Hippocraticum" (Szczepkowski et al. 2013). The father of medicine used mushroom infusions to treat wounds. Since the 12th century, chaga mushrooms have been used throughout Eastern Europe. In the past, Kiev Kniaz treated a lip malignancy. *Inonotus obliquus* is used in Siberian traditional medicine for a number of things (Perevedentseva, 2013). The fungus was helpful because of its gastrointestinal, anti-inflammatory, anti-parasitic, and anti-tuberculosis properties (Harpe, 1801). It was also suggested for liver and heart conditions. The most often used techniques were infusions, inhalations, and aqueous macerates (Harpe, 1801). Antibacterial soaps for external *I. obliquus* were created. In Siberia, infusions prepared from chaga mushrooms started to supplant tea in the latter half of the 20th century.

Before modern oncology, *Inonotus obliquus* was studied for its cancer-fighting abilities. Popular literature like Aleksander Solzhenitsyn's Cancer Ward (Saar, 1991) has such depictions. Chaga mushroom extracts were used to enhance cardiac function, the plasma lipid system, and their anti-bacterial, anti-inflammatory, and anti-cancer actions in Asian and Baltic countries as well as in Russia (Shashkina et al., 2006). *I. obliquus* may also aid in the prevention of diseases including atherosclerosis, cancer, diabetes, accelerated aging, and central nervous system degeneration that are linked to free radicals in modern society (Park et al., 2005). Chaga extracts slow down the multiplication of HCV and HIV (Shibnev et al., 2011).

3.2 *Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm.

It is common knowledge across a number of continents, including Asia, Europe, South America, and Africa, that mushrooms belonging to the genus Pleurotus contain medicinal characteristics (Deepalakshmi and Sankaran, 2014). The antibacterial properties of *Pleurotus ostreatus* are most effectiv. The extract that was taken from this species of mushroom, which is usually referred to as the shimeji mushroom, was shown to be effective as an antioxidant agent in vitro (Stefanello et al., 2012). A positive correlation between the extract's total phenolic content and its antioxidant capacity served as evidence of this.

3.3 *Trametes versicolor* (L.) Lloyd

Traditional East Asian botanicals (Yun-zhi), such as Trametes formulations, are still widely used today and are said to have a number of health advantages when taken orally. According to Scarpari et al. (2017), *Trametes versicolor* has been utilized to restore qi and essence. According to the Compendium of Chinese MateriaMedica (Ch, 1995), there are more than 120 different strains of *Trametes versicolor*. Traditional Chinese Medicine (TCM) practitioners claim that *Trametes versicolor* has a mildly sweet taste and a chilly quality and that it acts on the liver and spleen to produce its effects (Yang et al., 1993; Ng, 1998). *Trametes versicolor* is regarded as a medicinal herb that has been used to treat illnesses in various TCM classics. It is thought to be effective at clearing heat, removing toxins, stimulating the immune system, and strengthening the body. *Trametes versicolor* is frequently recommended for treating different cancers, chronic liver disease, and infections of the upper respiratory, urinary, and gastrointestinal systems in TCM therapeutic practice (Yang et al., 1993; Ng, 1998; Chu et al., 2002). While most therapeutic mushrooms promote a wide range of immune activity, different species frequently have distinctive immunological characteristics. According to Ramberg et al. (2010), *Trametes versicolor*, also called "turkey tail" and formerly *Coriolus versicolor*, has been shown to improve the immune system's innate as well as adaptive responses.

3.4 *Ganoderma applanatum* (Pers.) Pat.

Ganoderma is a therapeutic fungus that dates back more than two thousand years and has been mentioned in Shennong's herbal classic. The Shennong herbal classic included the recordings "Chizhi," "Qingzhi," "Heizhi," "Baizhi," and "Huangzhi," in addition to "Zizhi." These six different varieties of *Ganoderma* are said to improve eyesight, build muscles and bones, strengthen kidneys, and ease nerves. *Ganoderma* has been associated to a number of health benefits, including a relaxed body, an eased aging process, and a longer life span. On the other hand, recent research has shown that the *Ganoderma* genus has a history that extends further back in time than 6,000 years. Five prehistoric samples of the G. species were discovered at three Neolithic sites in the province of Zhejiang in China (Jong and Birmingham, 1992; Sukowska-Ziaja et al., 2019). *G. applanatum* is a non-edible fungus that may be identified in this scene by its unpolished, wrinkled, and white underside. In West Cameroon's indigenous tribes, it is common knowledge that the plant has specific medical benefits, such as the treatment of headaches, hypertension, fatigue, diabetes, and hepatitis (Wang et al. 2020), despite the fact that these claims have not been confirmed.

3.5 *Agaricus campestris*

One of the most commonly ingested wild mushrooms is Agaricuscampestris. A wide variety of biomolecules with both nutritional and therapeutic characteristics can be found in both wild and domesticated mushrooms. They are good agents for food and medicine because of these qualities. Such qualities have been acknowledged as functional food attributes as well as a source for the creation of pharmaceuticals and nutraceuticals. Active metabolites that have built up in the fruiting bodies, spores, and mycelia have anticancer, antibacterial, cardiac-protecting, anti-inflammatory, immunomodulatory, anti-diabetic, and antiviral characteristics; as a result, they are mostly employed for their medicinal and nutritional benefits (Wani et al., 2010). They have historically been applied to pharmacology and therapeutics. Another illustration is the *Agaricus campestris* Linnaeux ex Fries (field mushroom), a fungus that can be found in the Caribbean and the northern and southern temperate zones. According to reports, *A. campestris* was cooked in milk to treat throat cancer (Dias et al. 2012).

4. PHYTOCHEMISTRY OF MUSHROOMS

4.1*Inonotus obliquus* (Ach. ex Pers.) (Wild Chaga)

Polysaccharides

These polysaccharides are the most prevalent in chaga mushrooms and have been linked to a number of biological functions. In this regard, Huang et al. (2012) used column chromatography to identify five polysaccharides from *Inonotus obliquus*. Monosaccharide compositions and average molecular weights were examined using GC and HPGPC. IOP1b only contained the 1.5–105 Da molecule glucose. Rha, Man, and Glu made up the components of IOP2a, which had a molecular weight of 9.3104 Da and a molecular proportion of 1.0:2.3:1.7. IOP2c included Man, Glu, and Gal in the molecular proportions of 1.0:2.9:0.8 and had a mass of 2.3 105 Da. IOP3a was discovered to be a glycoprotein with an O-link between the protein and the carbohydrate by alkali.

Triterpenoids

There have been 34 different triterpenoids extracted from the sclerotia of *Inonotus obliquus*. These are examples of compounds that were isolated. Inotodiol, 3βhydroxylanosta-8,24-dien-21-al isolated by Kahlos et al. (1984), Lanosterol, Trametenolic acid, 3β-Hydroxy-8,24-dien-lanosta-21,23-lactone, 21,24-Cyclopenta-3β,21,25-triol-8-ene, 3β,22,25-Trihydroxy-Lanosta-8-ene, and inonotsuoxide isolated by Yusoo et al., (2001). Taji et al. (2007) isolated inonotsulides A, B, and C, whereas Taji et al. (2008) isolated lanosta-8,23E-diene-3, 22R, 25-triol, lanosta-7:9, 23E-triene-3, 22 R, 25-triol, lanosta-8,24-dien-3, 21-diol. Nakamura et al. (2009) were able to obtain inoterpenes A through F under these circumstances. Handa and his colleagues discovered seven different triterpenoids in this landscape in 2010, including spiroinonotsuoxodiol and inonotsudiol A, B, and C. Two more triterpenoids, epoxyinonotsudiol and methoxyinonotsutriol, were discovered in 2012 (Handa et al., 2010; Handa et al., 2012).

Phenolics

Lee et al. (2007) extracted six polyphenols from the methanolic extract of *Inonotus obliquus*: inonoblins A, B, and C and phelligridins D, E, and G. Seven low-molecular-weight phenolics, 4-hydroxy-3,5-dimethoxy benzoic acid, 2-hydroxy-l-hydroxymethyl ethyl ester, protocatechic acid, caffeic acid, 3,4-dihybenzaladehyde, 2,5-dihydroxyterephtalic acid, syringic acid, and 3,4-dihydroxybenzalacetone, were isolated from *Inonotus obliquus* and tested for antioxidant and anticancer activity (Nakajima et al., 2009). 2,5-dihydroxybenzalactone and gallic acid were extracted and tested on cancer cells (Kim et al., 2011; Kuriyama, 2013; Babitskaya et al., 2000).

Proteins

Leucine, glycine, aspartic acid, tyrosine, leucine, methionine, lysine, threonine, serine, and histidine were the 15 amino acids generated by the protein hydrolysis of *Inonotus obliquus*, accounting for 40% of the total (Shashkina et al., 2006). Hyun et al. found an *Inonotus obliquus* platelet aggregation-inhibiting peptide in 2006. In this panorama, ethanol-derived peptides are isolated by reverse-phase HPLC. By using LC/MS analysis, it was discovered that the peptide from *Inonotus obliquus* had a molecular size of 365 Da, an amino acid composition of Glycine (50%), Cystine (25%), and Tryptophen (25%), and a sequence of Trp-Gly-Cys.

Lignin

The extracts of *Inonotus obliquus* boiling water were filtered many times using ultrafiltration and Superdex 200 columns. IR, UV, and 1H NMR spectroscopy all indicated that fraction 23 contained the majority of the hydrophilic lignin derivatives. Coniferyl alcohol and sinapyl alcohol, both of which are components of lignin, did not significantly inhibit HIV-1 protease activity; however, fraction 23 did. According to Ichimura et al. (1998), lignin that is water-soluble has the ability to suppress HIV-1 because a derivative of it inhibits HIV reverse transcriptase.

4.2*Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm.

Polysaccharides

Numerous polysaccharides, including α-glucans and α-glucans, are found in the cell wall of the mushroom. These polysaccharides have garnered a lot of scientific attention. These substances have been found to have immunomodulatory and antioxidant characteristics, which make them interesting candidates for therapeutic uses (Zhang et al., 2012).

Proteoproteins and amino acids

The protein-rich fish *Pleurotus ostreatus* contains both needed and optional amino acids. For their bioactive qualities, such as antioxidant and antihypertensive effects, several peptides produced from the mushroom have been examined (Chirinang & Intarapichet., 2009).

Terpenoids and sterols

Terpenoids and sterols, particularly ergosterol and lanosterol, can be found in abundance in mushrooms. Their anti-inflammatory and antioxidant capabilities, which highlight their potential therapeutic benefits, are a result of these substances (Corrêa et al., 2016).

Phenolic Compounds

Numerous phenolic compounds, including flavonoids and phenolic acids, have been found in *Pleurotus ostreatus*, and they have been shown to have anti-inflammatory and antioxidant properties. This section investigates their possible contribution to the prevention of diseases caused by oxidative stress and inflammation (Gąsecka et al., 2016).

Fatty acids and lipids

Unsaturated fatty acids, which have been connected to cardiovascular health and anti-inflammatory properties, are among the interesting lipids present in the mushroom (Pedneault et al., 2007).

Volatile oils

Pleurotus ostreatus' distinctive flavor and aroma are a result of its volatile constituents. Further research is necessary because some of these chemicals may also have health effects (Omarini et al., 2010).

4.3 *Trametes versicolor* (L.) Lloyd

Polysaccharides

The cell wall of the mushroom contains a variety of polysaccharides, including β-glucans and heteropolysaccharides, which have immunomodulatory, anticancer, and antioxidant activities. Polypeptides are also present in the mushroom cell wall. *Trametes versicolor* polypeptides have been identified, and they have antiviral and anticancer properties, making them potential candidates for medicinal research (Chen et al., 2015).

Triterpenoids

Trametes versicolor has a significant amount of lanostane- and ergostane-type triterpenoids. As natural medicinal agents, these triterpenoids exhibit anti-inflammatory, antioxidant, and anticancer effects (Jin et al., 2019).

Phenolic Compounds

The mushroom contains phenolic compounds, including flavonoids and phenolic acids, which have anti-inflammatory and antioxidant properties. This section explains how they can prevent diseases caused by oxidative stress and inflammation (Rašeta et al., 2020).

Terpenoids and Sterols
Ergosterol, among other terpenoids and sterols, is found in abundance in *Trametes versicolor*. Researchers have looked at the possible immunomodulatory and anticancer properties of these substances (Bains et al., 2021).

Fatty acids and Lipids
The mushroom has a lipid profile that is high in essential fatty acids, which are crucial for the immune system and cardiovascular health (Bains et al., 2021).

4.4*Ganoderma applanatum* (Pers.) Pat.
Triterpenoids
These substances have anti-inflammatory, anti-cancer, and antioxidant effects. Triterpenoids such ganoderic acids, lucidenic acids, and ganodermadiols have been identified in *G. applanatum* (Elkhateeb et al., 2018).

Flavonoids
These substances, which are also antioxidants, have been demonstrated to provide a number of health advantages, including as lowering the risk of cancer, heart disease, and stroke. *G. applanatum* contains flavonoids as quercetin, rutin, and myricetin among others (Li et al., 2016).

Saponins
The biological effects of these substances range from anti-inflammatory to anti-cancer to immunomodulatory. Ganodarins, ganodiols, and ganosporins are a few of the saponins discovered in *G. applanatum* (Luo et al., 2015).

Other compounds
Sterols, polysaccharides, and proteins are some of the additional substances included in *G. applanatum*. Furthermore, numerous health advantages of these substances have been demonstrated (Wang et al., 2020).

4.5*Agaricus campestris*
Phenolic compounds
A class of organic substances known as phenolic compounds has anti-inflammatory, anti-cancer, and antioxidant effects. Gallic acid, caffeic acid, ferulic acid, quercetin, and rutin are some of the phenolic chemicals found in *A. campestris*. These substances have been demonstrated to neutralise free radicals, reduce inflammation, and slow the growth of cancer cells .

Indoles
Indoles are a class of organic substances that are present in a wide variety of plants, including mushrooms. *A. campestris* contains indol-3-carbinol (I3C) and diindolylmethane (DIM), among other indoles. The anti-cancer property of I3C and DIM have been demonstrated, and they might possibly be advantageous for cardiovascular health (Bains et al., 2021).

Sterols
Sterols are a class of organic substances that are present in both plants and mammals. Ergosterol, campesterol, and stigmasterol are among the sterols found in *A. campestris*. It has been demonstrated that ergosterol, a precursor of vitamin D, has anti-cancer properties. It has been demonstrated that stigmasterol and campesterol reduce cholesterol levels (Goulston et al., 1975).

Other Compounds
Campestris includes lentinan, beta-glucans, and chitin in addition to phenolic compounds, indoles, and sterols. Immune-boosting beta-glucan lentinan. Beta-glucans, a dietary fibre, decrease cholesterol and inflammation. Mushroom cell walls include chitin. Itaids ins weight loss and digestive health .

5. PHARMACOLOGICAL ACTIVITY

5.1*Inonotus obliquus* (Ach. ex Pers.) (Wild Chaga)

Anti-diabetic activity

A study conducted by Wang et al. (2017) In STZ-induced diabetic mice, *I. obliquus* raised insulin levels and corrected glucose enzyme metabolism. *I. obliquus* polysaccharide extract was able to block β-glucosidase, which resulted in a delay in the digestive organs' ability to absorb glucose shortly after eating. The extract of *I. obliquus* prepared in ethyl acetate decreased the activity of α-amylase and increased HDL cholesterol levels in mice with alloxan-induced diabetes. In this order, an increased level of insulin was reported in diabetic nephropathic mice (C57BL/6) treated by the polysaccharide extracts of *I. obliquus*. Many researchers also reported a significant reduction in blood glucose level, plasma insulin level, and body weight in STZ-induced diabetic mice when treated with an IOP-chromium (III) complex (Wang et al. 2017; Cha et al. 2006; Chen et al. 2010).

Anticancer Activity

According to the research done by Youn et al. (2008), obliquus extract diminished the survival rate of HepG2 cells in a manner that was dose-dependent. It also arrested cancer cells in the G_0 and G_1 phase and triggered apoptotic cell death by reducing the expression of p53, cyclins D1, Cdk2, Cdk4, and Cdk6. A 10-day intraperitoneal infusion of 20 mg/kg/day aqueous extracts from *I. obliquus* reduced tumour expansion in Balb/c mice inserted with B16-F10 melanoma cells (Youn et al., 2009). This was demonstrated by a decrease in the expression of pRb, p53, and p27, as well as an arrest in tumour cell proliferation at the G_0 and G_1 phase. According to research carried out by Lee et al. in 2014, polysaccharides derived from *I. obliquus* were able to inhibit the phosphorylation of MAPKs, PI3K, and AKT as well as lower the levels of expression of MMP-2, MMP-9, COX-2, and NF-B inside human A549 nonsmall lung cancer cells.

Immunomodulatory activity

Oral therapy using a hot-water extract from *I. obliquus* at a dose of 100 mg/kg led to a decrease in serum levels of IgE and IgG2a, as well as a suppression of IL-4 and an increase in IFN- in concanavalin-stimulated lymphocytes (Ko et al. 2011). In a study conducted by Harikrishna et al. (2012), the nutritional intervention of the olive flounder fish, Paralichythysolivaceus, with *I. obliquus* extract resulted in improved lysozyme, complement, and myeloperoxidase activity as well as higher resistance to Uronemamarinum pathogens. Oral administration to hens with *I. obliquus* products of fermentation during vaccination resulted in elevated mononuclear cells in the peripheral blood and Th1/Th2 ratios, as well as a reduction in the pathogenicity of the Newcastle disease virus (Zhang et al., 2018). *I. obliquus* lignin complexes elevated NO production, promoted phagocytic activity, and scavenged 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals in RAW 264.7 macrophages, according to research published by Niu et al. in 2016.

Antioxidant Activity

In mice with scopolamine-induced memory loss, a methanolic extract of *I. obliquus* increased levels of antioxidants (SOD and GSH) while decreasing levels of nitrite (the proportion of GSSG to GSH), MDA, and GSSG/GSH. This research was published in 2011 by Giridharan and colleagues. According to research by Nakajima et al. (2009), the *I. obliquus* compound 3,4-dihydroxybenzalacetone prevented damage from oxidation caused by H2O2 in PC12 cells. In the hepatocyte tissue of alloxan-induced diabetic male Kunming mice, *I. obliquus* ethyl acetate extract scavenged DPPH-free radicals, lowered MDA, and raised GSH, according to research published by Lu et al. in 2010. According to Wang et al. (2017), IOP-chromium (III) complex treatment in T2DM male Kunming mice lowered MDA levels and enhanced hepatic enzymes that protect cells (SOD, catalase, and GSH-Px).

Antiinflammatory activity

Inonotus obliquus extracts suppressed proinflammatory mediators (NO, PGE2, iNOS, COX-2, TNF-α, IL-1β, and IL-6) in cells (RAW 264.7) triggered by lipopolysaccharide (Debnath et al. 2013). In this order, Kim et al. reported significant inhibition of Akt, 1kBα, and MAPK in lipopolysaccharide-activated macrophages by 70% ethanolic extract of *I. obliquus* (Kim et al. 2007). NF-B and transforming growth factor expression were reduced, and renal tubular cells (LLC-PK1) were protected from streptozotocin (STZ) and advanced glycation end-products-induced glucotoxicity after three days of treatment with a low molecular mass polysaccharide extract of *I. obliquus* in mice with nephropathy brought on by HFD/STZ (Chou et al. 2016).

5.2 *Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm.

Antioxidant activity

Researchers have shown that the fruiting bodies of the *Pleurotus ostreatus* mushroom have the ability to chelate iron, fight free radicals, reduce power, and reduce power, respectively. According to Dubost and Beelman (2007), the antioxidant activity of extracts from *Pleurotus ostreatus* is quite low when compared to that of other mushrooms that are edible. According to Adebayo et al. (2014b) and Okafor (2017), oxidative stress is the root cause of several disorders, including cancer and hepatotoxicity. Both flavonoids and phenols are effective in preventing oxidative stress. An increase in the expression of the catalase gene and a reduction in the amount of protein oxidation caused by free radicals were discovered by Jayakumar et al. (2011) in their research on the effects of an extract of *Pleurotus ostreatus* on elderly rats.

Antimicrobial activity

Pleurotus ostreatus is antibacterial and antifungal. p-anisaldehyde in P. ostreatus hexane-dichloromethane extract inhibits *Bacillus subtilis, Pseudomonas aeruginosa, Aspergillus niger, and Fusarium oxysporum.* Pleuran is in *P. ostreatus* fruiting bodies. Bacterial-susceptible mice survived -D glucan (Karacsonyi & Kuniak, 1994). According to research that was conducted by Cowan in 1999, the phenolic and tannin components of *P. ostreatus* were able to prevent cell membrane destruction, synthesis of proteins, the activity of enzymes that break down proteins, and microbial attachments.

Cells are unharmed by antiviral chemotherapy. Thus, innovative, side-effect-free antivirals that diminish viral resistance are necessary. EI-Fakharany et al. (2010) found that *P. ostreatus* laccase stopped the hepatitis C virus from becoming active again and getting into HepG2 cells in the liver and blood vessels in the peripheral zone. In this context, An HIV-1 reverse transcriptase-inhibiting ubiquitin-like protein was discovered by Wang and Ng (2000b) from *P. ostreatus* extract.

Karaman et al. (2010) said that the methanolic and chloroformic extracts of *P. ostreatus* may be antibacterial and effective against gram-positive bacteria. Mirunalini et al. assessed *P. ostreatus* inhibitory zone widths and biosynthesized AgNPs against different gram-positive bacteria in 2012. *P. ostreatus*-biosynthesized AgNPs inhibited all bacteria.

Anti-diabetic activity

In this context, evaluated the significant anti-diabetic impact of synergistic solution of P. ostreatus with Murraya koenigii on the level of blood glucose in insulin-dependent and insulin-independent diabetics. In case of, hyperglycemic rats, *P. ostreatus* extract lowers blood glucose less than amaryl (Krishna and Usha, 2009).

Anti-hypercholesterolic activity

P. ostreatus includes ergothioneine, lovastatin, and chrysin, which prevent and treat atherosclerosis, according to Mohamad et al. (2017). In normal Wistar male rats, P. ostreatus' ethanolic extract reduced hyperlipidemia. Alam et al. (2009) fed hypercholesterolic rats 5% *P. ostreatus* powder, which lowered TC by 37% and TG by 46%. Lovastatin in this mushroom caused this.

Antitumor activity

Mycelial extract of *P. ostreatus* reduced the tumor growth in the both individually as well as with the combination of cyclophosphamide (Facchini et al., 2014) while this combination also reduced leucopenia (Meerovich et al., 2005). Similarly, aqueous mycelial extract caused human cancer cell apoptosis greater than other mushroom extracts (Sarangi et al., 2006; Saat et al., 2019). Wang et al. (2000a) observed that *P. ostreatus* lectin suppressed sarcoma and hepatoma cell proliferation and increased mice lifetime. In an another study proteoglycans identified in aqueous mycelial extract prevented sarcoma in mice (Sarangi et al., 2006).

Immunomodulatory activity

Oyster mushrooms' immuno-modulatory qualities and low cytotoxicity could aid radiation and chemotherapy patients by enhancing immune resistance and minimizing toxicity (El-Enshasy & Hatti-Kaul, 2013). Wang et al. (2000a) identified many immune-modulating components (lectins, polysaccharides, polysaccharide-peptides, and polysaccharide-protein complexes) from *P. ostreatus*. The aqueous extract obtained from *P. ostreatus* fruit flesh and mycelia increases neutrophil ROS production and modulates all immunologically competent cells.

5.3*Trametes versicolor* (L.) Lloyd

Antitumor and immune-modulating action

Polysaccharopeptide inhibits tumour formation and metastatic activity in experimental models in preclinical investigations (Xu et al. 2008). Hepatocellular malignancy, nasal cavity cancer, sarcoma, breast atypical swelling, Ehrlich ascites tumour, cancer of the breast, ascetic hepatoma, and malignancy are among the conditions that polysaccharopeptide cures (Lin, 2014). Polysaccharopeptide usually inhibits more than other treatment groups. The standard cancer therapy medicine inhibits more than polysaccharopeptide; however, the combined drug treatment has fewer side effects. Polysaccharopeptide boosts immunity (Zheng, 2004) and prevents mammary gland epithelial cell hyperplasia (Wu et al., 2001). Polysaccharopeptides with cyclophosphamide improve immunity, anticancer effects, and side effects (Hu et al., 1988).

Anti-hyperlipidemia activity

Hyperlipidemia is characterized by high serum lipids and lipoproteins, generally cholesterol, triglycerides, and low-density lipoproteins. Statins and fibrates are clinically utilized anti-hyperlipidemia medicines (Liu and Li, 2004). Statins and fibrates increase the risk of myopathy and rhabdomyolysis. Ezetimibe, sequestrants, and niacin of bile acids are often found in statins. PSP decreased cholesterol levels in 240 patients (Rao et al., 2007). In a rodent high cholesterol model, PSP consistently lowers the level of complete cholesterol, triglycerides, and LDL while increases the HDL. Published data show that PSP lowers serum lipids without harming liver or kidney function, suggesting It could be a secure and successful lipid lowering drug.

Effects against chronic bronchitis

Aging reduces respiratory defenses. Thus, the elderly can develop chronic bronchitis (Zheng, 2004). Chronic bronchitis is characterized by coughing, phlegm, and dyspnea (Hong, 1986). Immunological laboratory tests and a cough scavenging assay demonstrated that PSP improves innate immunity and lowers cough, phlegm, and dyspnea in treated patients by 89.3%. Polysaccharopeptideis also safe and non-toxic.

5.4 *Ganoderma applanatum* (Pers.) Pat.

Anticancer Activity

The whole metabolite extract showed 160 ± 4.08 µg/ml IC50 against Caco-2 human colon cancer cells. *G. applanatum* methanolic extract altered cell morphology and elevated glutathione. At 80µg/ml and 160 µg/ml, *Ganoderma applanatum* significantly increased Bax and Bcl-2 percentages on the Caco-2 through an irreversible p53-independent route while reducing p53 expression of proteins and increasing Cas-3 transcript. *G. applanatum* (200 µg/ml) therapy for five days reduced solid Ehrlich tumor (SEC) volume in vivo. mRNABax/Bcl-2 and p53/Cas-3 upregulation verified the apoptotic p53-dependent mechanism. In conclusion, *G. applanatum* could induce apoptosis in Caco-2 and SEC via p53-independent and p53-dependent pathways. *G. applanatum* showed promise as an alternate or co-anticancer drug (Elkhateeb et al. 2018).

Hepatoprotective activity

This study looked at the possible mechanisms behind the protective effects of a triterpanoid made from *G. appalantum* alongside inflammatory and oxidative stress caused by benzo(a)pyrene (BaP) in the livers of mice. This triterpanoid prevented BaP-induced increases in mouse hepatic antioxidant levels (Cu/Zn-SOD, CAT, GPx, and GST) as well as drastically decreased liver ROS, MDA, and GSH/GSSG ratios. Triterpanoid successfully decreased hepatic inflammation by decreasing proinflammatory cytokines (IL-1, COX-2, and NF-B translocation) in BaP-treated rats, as shown by Western blot analysis (Ma et al. 2011).

Spleen cell proliferation activity

In vitro, *G. applanatum* polysaccharides increased the growth of mouse spleen cells. High concentrations of these polysaccharides (125–500 mg/mL) boosted the IL-2 and IFN-g production of ConA-stimulated mouse spleen cells. When triggered by 5 mg/mL ConA, normal mice administered *G. applanatum* polysaccharides (20 mg/kg/d for 10 days, s.c.) produced more IL-2 and IFN-g and enhanced spleen cell proliferation (Guo and Yen, 1991). Initial immune responses of spleen cells to sheep RBCs were enhanced. NK activity, IL-2, and IFN-g production in the spleen cells were restored after *G. applanatum* polysaccharides (20 mg/kg/d for 15 days, s.c.) administration to mice with sarcoma transplants for 15 days straight (Guo and Yen, 1991).

Immunomodulatory effect
According to Zhang (1989), the *G. applanatum* extract had a 60% inhibiting effect on the formation of HbsAg in PLC/PRF/5 cells.

5.5*Agaricus campestris*
Antioxidant activity
This study examines bioassay-guided fractionation's antioxidant activity and active compounds and components. Fractions yielded three chemicals including methoxydiazine, afrormosin, and candidol (AC-1–3). They had high antioxidant activity at 100, 200, 300, 400, and 500µg/mL (Reddy et al. 2023).

Antiinflammatory activity
The findings demonstrated that both alcoholic extracts of *Agaricus campestris* significantly ($p<0.005$) inhibit hyaluronidase. The alcoholic extract of *Agaricus campestris* has significantly ($p<0.005$) less hyaluronidase inhibition activity than standard diclofenac. During inflammation, hyaluronidase activity in the blood increases, and when inflammation subsides, hyaluronidase activity decreases. According to the above findings, *Agaricus campestris* has anti-inflammatory activity via hyaluronidase inhibition.

Hepatoprotective activity
AEAC ensured the auxiliary uprightness of the hepatocellular film in a subordinate measuring manner as a part of the investigation. This was in accordance with the pledge supplied by Silymarin (100 mg kg-1 b.w.t.; p.o.), a well-known hepatoprotective specialist. This metabolite causes glutathione (GSH) to be depleted, which makes it possible for cells to pass through. It is evident that the AEAC concentrate brought all significant levels of AST, ALT, ALP, and total blood bilirubin back down to normal levels. This suggests that plasma layer adjustment and hepatotoxin-induced hepatic tissue healing have been impacted.

6. CONCLUSIONS AND FUTURE OUTLOOK

Fungi have been highly prized for their many health benefits since ancient times, and not only in the context of culinary use. The scientific study of mushrooms has gained popularity in recent years, and the results so far have been promising. Polysaccharides, sterols, and phenolic compounds are only a few of the many bioactive substances found in mushrooms. Immunomodulators, anti-inflammatories, cancer fighters, antioxidant powerhouses, and cardiovascular health boosters are just some of the health benefits linked to these compounds.
Mushrooms have promising future uses in both the medical and culinary fields. More investigation into the beneficial impacts of these versatile fungi on human health is likely to reveal even more. Mushroom cultivation is also a growing economic sector and a sustainable kind of agriculture. An expanding field of study is the creation of novel products based on mushrooms. These include powders, extracts, and beverages. The healthy nutrients present in mushrooms are concentrated in these products, making them an easy-to-use and useful option. There is a growing interest in spreading mushroom farming to new places, and there are many diverse settings that are favourable for the production of mushrooms. This could help people all throughout the world gain access to high-quality mushrooms at more affordable prices.
The outlook for the development of the above-documented edible and medicinal mushrooms is generally optimistic. The phytochemistry and pharmacological sections of this review provided key information to conduct more research to develop new products for human health.

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REFERENCES

1. Adebayo, E.A.; Oloke, J.K.; Aina, D.A. and Bora,T.C. (2014b). Antioxidant and Nutritional Importanceof some Pleurotus species. Journal of Microbiology,Biotechnology and Food Sciences. 3(4): 289-294.

2. Alam, N.; Amin, R.; Khan, A.; Ara, I.; Shim, M.and Lee, M.W. (2009). Comparative effects of oystermushroom on lipid profile, liver and kidney functionin hyper cholesterolemic rats. Mycobiology. 37: 37-42.
3. Aly, A. H., Debbab, A., & Proksch, P. (2011). Fifty years of drug discovery from fungi. Fungal Diversity, 50, 3-19.
4. Babitskaya, V. G., Shcherba, V. V., & Lkonnikova, N. V. (2000). Melanin complex of the fungus Inonotus obliquus. Applied Biochemistry and Microbiology, 36, 377-381.
5. Bains, A., Chawla, P., Kaur, S., Najda, A., Fogarasi, M., & Fogarasi, S. (2021). Bioactives from mushroom: health attributes and food industry applications. Materials, 14(24), 7640.
6. Bao, X., Duan, J., Fang, X., & Fang, J. (2001). Chemical modifications of the (1→ 3)-α-D-glucan from spores of Ganoderma lucidum and investigation of their physicochemical properties and immunological activity. Carbohydrate Research, 336(2), 127-140.
7. Blackwell, M. (2011). The Fungi: 1, 2, 3… 5.1 million species?. American journal of botany, 98(3), 426-438.
8. CFR Ferreira, I., A Vaz, J., Vasconcelos, M. H., & Martins, A. (2010). Compounds from wild mushrooms with antitumor potential. Anti-Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Anti-Cancer Agents), 10(5), 424-436.
9. Ch, H. (1995). Medicinal Mushrooms.-2-nd cd.-Santa Crus.Botanica press.
10. Cha, J. Y., Jun, B. S., &Yoo, K. S. (2006). Fermented chaga mushroom(Inonotusobliquus) effects on hypolipidemia and hepatoprotection inOtsuka Long-Evans Tokushima fatty (OLETF) rats. Food Science and Biotechnology, 15, 122–127.
11. Chang, S. T., & Miles, P. G. (1992). Mushroom biology—a new discipline. Mycologist, 6(2), 64-65.
12. Chen, C. H., Kang, L., Lo, H. C., Hsu, T. H., Lin, F. Y., Lin, Y. S., & Shen, C. L. (2015). Polysaccharides of Trametes versicolor improve bone properties in diabetic rats. Journal of agricultural and food chemistry, 63(42), 9232-9238.
13. Chen, C. H., Kang, L., Lo, H. C., Hsu, T. H., Lin, F. Y., Lin, Y. S., ... & Shen, C. L. (2015). Polysaccharides of Trametes versicolor improve bone properties in diabetic rats. Journal of agricultural and food chemistry, 63(42), 9232-9238.
14. Chen, H., Lu, X., Qu, Z., Wang, Z., & Zhang, L. (2010). Glycosidase inhibitory activity and antioxidant properties of a polysaccharide from themushroom Inonotusobliquus. Journal of Food Biochemistry, 34,178–191. https://doi.org/10.1111/j.1745-4514.2009.00322.x.
15. Chirinang, P., & Intarapichet, K. O. (2009). Amino acids and antioxidant properties of the oyster mushrooms, Pleurotus ostreatus and Pleurotus sajor-caju. Science Asia, 35(2009), 326-331.
16. Chou, Y. J., Kan, W. C., Chang, C. M., Peng, Y. J., Wang, H. Y., Yu, W. C., Chuu, J. J. (2016). Renal protective effects of low molecular weight ofInonotusobliquus polysaccharide (LIOP) on HFD/STZ-induced nephropathy in mice. International Journal of Molecular Sciences, 17, E1535.https://doi.org/10.3390/ijms17091535.
17. Chu, K. K., Ho, S. S., & Chow, A. H. (2002). Coriolusversicolor: a medicinal mushroom with promising immunotherapeutic values. The Journal of Clinical Pharmacology, 42(9), 976-984.
18. Corrêa, R. C. G., Brugnari, T., Bracht, A., Peralta, R. M., & Ferreira, I. C. (2016). Biotechnological, nutritional and therapeutic uses of Pleurotus spp.(Oyster mushroom) related with its chemical composition: A review on the past decade findings. Trends in Food Science & Technology, 50, 103-117.
19. Cowan, M.M. (1999). Plant products as antimicrobialagents. Clinical Microbiology Reviews. 12: 564-582.
20. Davis, M., Sommer, R., &Menge, J. (2012). Field guide to mushrooms of western North America (Vol. 106). Univ of California Press.
21. de La Harpe, J. F. (1801). Abrégé de l'Histoiregénérale des Voyages continué par Comeiras (Vol. 32).
22. De Silva, D. D., Rapior, S., Fons, F., Bahkali, A. H., & Hyde, K. D. (2012). Medicinal mushrooms in supportive cancer therapies: an approach to anti-cancer effects and putative mechanisms of action. Fungal Diversity, 55, 1-35.
23. Debbab, A., Aly, A. H., & Proksch, P. (2011). Bioactive secondary metabolites from endophytes and associated marine derived fungi. Fungal Diversity, 49(1), 1-12.
24. Debbab, A., Aly, A. H., & Proksch, P. (2012). Endophytes and associated marine derived fungi—ecological and chemical perspectives. Fungal Diversity, 57, 45-83.

25. Debnath, T., Park, S. A., Kim, D. H., Jo, J. E., & Lim, B. O. (2013). Anti-oxidant and anti-inflammatory activities of Inonotusobliquus andgerminated brown rice extracts. Molecules, 18, 9293–9304. https://doi.org/10.3390/molecules18089293.
26. Deepalakshmi, K., & Sankaran, M. (2014). Pleurotus ostreatus: an oyster mushroom with nutritional and medicinal properties. Journal of Biochemical Technology, 5(2), 718-726.
27. Dias, D. A., Urban, S., &Roessner, U. (2012). A historical overview of natural products in drug discovery. Metabolites, 2(2), 303-336.
28. Dubost, N.J.; Ou, B. and Beelman, R.B. (2007).Quantification of polyphenols and ergothioneine incultivated mushrooms and correlation to totalantioxidant capacity. Food Chemistry. 105: 727-735.
29. EI-Fakharany, E.M.; Haroun, B.M.; Ng, T.B. andRedwan, E.R. (2010). Oyster mushroom laccaseinhibits hepatitis C virus entry into Peripheral bloodcells and hepatoma cells. Protein & Peptide Letters.17: 1031-1039.
30. El-Enshasy, H.A. and Hatti-Kaul, R. (2013).Mushroom immunomodulators: unique molecules withunlimited applications. Trends in Biotechnology.31(12): 668-677.
31. Elkhateeb WA, Zaghlol GM, El-Garawani IM, Ahmed EF, Rateb ME, Moneim AE. Ganoderma applanatum secondary metabolites induced apoptosis through different pathways: In vivo and in vitro anticancer studies. Biomedicine & Pharmacotherapy. 2018 May 1;101:264-77.
32. Elkhateeb, M., El-Shemy, M., & El-Sayed, M. (2018). Phytochemical and biological studies of Ganoderma applanatum. Journal of Applied Pharmaceutical Sciences, 6(1), 71-78.
33. Facchini, J.M.; Alves, E.P.; Aguilera, C.; Gern,R.M.M.; Silveira, M.L.L.; Wisbeck, E. and Furlan,S.A. (2014). Antitumor activity of Pleurotusostreatuspolysaccharide fractions on Ehrlich tumor andSarcoma 180. International Journal of BiologicalMacromolecules. 68: 72-77.
34. Gąsecka, M., Mleczek, M., Siwulski, M., & Niedzielski, P. (2016). Phenolic composition and antioxidant properties of Pleurotus ostreatus and Pleurotus eryngii enriched with selenium and zinc. European Food Research and Technology, 242, 723-732.
35. Gautam, A. K. (2013). Notes on wood rotting fungi from India (1): Trametes versicolor-the Turkey tail. Journal on New Biological Reports, 2(2), 67-70.
36. Giridharan, V. V., Thandavarayan, R. A., &Konishi, T. (2011). Ameliorationof scopolamine induced cognitive dysfunction and oxidative stress byInonotusobliquus—A medicinal mushroom. Food & Function, 2,320–327. https://doi.org/10.1039/c1fo10037h.
37. Goulston, G., Mercer, E. I., & Goad, L. J. (1975). The identification of 24-methylene-24, 25-dihydrolanosterol and other possible ergosterol precursors in Phycomyces blakesleeanus and Agaricus campestris. Phytochemistry, 14(2), 457-462.
38. Guo, B., Yen, G. Z. (1991). Effects ofGanodermaapplanatumpolysaccharide oncellular and humoral immunity in normal and sarcoma 180 transplanted mice.Phytother. Res.5:134–138.
39. Handa, N., Yamada, T., & Tanaka, R. (2010). An unusual lanostane-type triterpenoid, spiroinonotsuoxodiol, and other triterpenoids from Inonotus obliquus. Phytochemistry, 71(14-15), 1774-1779.
40. Handa, N., Yamada, T., & Tanaka, R. (2012). Four new lanostane-type triterpenoids from Inonotus obliquus. Phytochemistry Letters, 5(3), 480-485.
41. Harikrishnan, R., Balasundaram, C., &Heo, M. S. (2012). Inonotusobliquuscontaining diet enhances the innate immune mechanism and diseaseresistance in olive flounder Paralichythysolivaceus against Uronemamarinum. Fish & Shellfish Immunology, 32, 1148–1154. https://doi.
42. Hawksworth, D. L. (2001). Mushrooms: the extent of the unexplored potential. International journal of medicinal mushrooms, 3(4).
43. Hong GX. Pathogenesis and treatment of chronic bronchitis. Jiangxi Journal of Traditional Chinese Medicine 6:10-12, 1986.
44. Hu QY, Wang H, Shen WM, Chen XR, Zou M. Promoting effects of polysaccharide of polysticiusversicolor (L) FR. in C57/6J mice bearing melanoma B16. Chin J Antibio 6:425-431, 1988.
45. Huang, N. L. (2002). Inonotus obliquus. Edible Fungi of China, 21, 7-8.
46. Huang, S. Q., Ding, S., & Fan, L. (2012). Antioxidant activities of five polysaccharides from Inonotus obliquus. International Journal of Biological Macromolecules, 50(5), 1183-1187.
47. Hyun, K. W., Jeong, S. C., Lee, D. H., Park, J. S., & Lee, J. S. (2006). Isolation and characterization of a novel platelet aggregation inhibitory peptide from the medicinal mushroom, Inonotus obliquus. Peptides, 27(6), 1173-1178.

48. Ichimura, T., Watanabe, O., & Maruyama, S. (1998). Inhibition of HIV-1 protease by water-soluble lignin-like substance from an edible mushroom, Fuscoporia obliqua. Bioscience, biotechnology, and biochemistry, 62(3), 575-577.
49. Janjušević, L., Karaman, M., Šibul, F., Tommonaro, G., Iodice, C., Jakovljević, D., & Pejin, B. (2017). The lignicolous fungus Trametes versicolor (L.) Lloyd (1920): a promising natural source of antiradical and AChE inhibitory agents. Journal of enzyme inhibition and medicinal chemistry, 32(1), 355-362.
50. Jayakumar, T.; Thomas, P.A.; Sheu, J.R. andGeraldine, P. (2011). In-vitro and in-vivo antioxidanteffects of the oyster mushroom Pleurotusostreatus.Food Research International. 44: 851-861.
51. Jeong, J. W., Jin, C. Y., Park, C., Hong, S. H., Kim, G. Y., Jeong, Y. K., ... & Choi, Y. H. (2011). Induction of apoptosis by cordycepin via reactive oxygen species generation in human leukemia cells. Toxicology in Vitro, 25(4), 817-824.
52. Jin, M., Zhou, W., Jin, C., Jiang, Z., Diao, S., Jin, Z., & Li, G. (2019). Anti-inflammatory activities of the chemical constituents isolated from Trametes versicolor. Natural product research, 33(16), 2422-2425.
53. Jogaiah, S., Kurjogi, M., Abdelrahman, M., Hanumanthappa, N., & Tran, L. S. P. (2019). Ganoderma applanatum-mediated green synthesis of silver nanoparticles: Structural characterization, and in vitro and in vivo biomedical and agrochemical properties. Arabian Journal of Chemistry, 12(7), 1108-1120.
54. Jong, S. C., & Birmingham, J. M. (1992). Medicinal benefits of the mushroom Ganoderma. Advances in applied microbiology, 37, 101-134.
55. Kahlos, K., Hiltunen, R., & v Schantz, M. (1984). 3β-Hydroxy-lanosta-8, 24-dien-21-al, a new triterpene from Inontus obliquus. Planta medica, 50(02), 197-198.
56. Kamiyama, M., Horiuchi, M., Umano, K., Kondo, K., Otsuka, Y., & Shibamoto, T. (2013). Antioxidant/anti-inflammatory activities and chemical composition of extracts from the mushroom Trametes versicolor. International Journal of Nutrition and Food Sciences, 2(2), 85-91.
57. Karacsonyi, S. and Kuniak, L. (1994).Polysaccharides of Pleurotusostreatus: isolation andstructure of pleuran, an alkali-insoluble beta-D-glucan.Carbohydrate Polymers. 24: 107-111.
58. Karaman, M.; Jovin, E.; Malbasa, R.; Matavuly,M. and Popovie, M. (2010). Medicinal and ediblelignicolous fungi as natural source of antioxidative andantibacterial agents. Phytotherapy Research. 24: 1473-1481.
59. Keller, C., Maillard, M., Keller, J., & Hostettmann, K. (2002). Screening of European fungi for antibacterial, antifungal, larvicidal, molluscicidal, antioxidant and free-radical scavenging activities and subsequent isolation of bioactive compounds. Pharmaceutical biology, 40(7), 518-525.
60. Kim, H. G., Yoon, D. H., Kim, C. H., Shrestha, B., Chang, W. C., Lim, S. Y., Kim, T. W. (2007). Ethanol extract of Inonotusobliquus inhibitslipopolysaccharide-induced inflammation in RAW 264.7 macrophagecells. Journal of Medicinal Food, 10, 80–89. https://doi.org/10.1089/jmf.2006.156.
61. Ko, S. K., Jin, M., &Pyo, M. Y. (2011). Inonotusobliquus extracts suppressantigen-specific IgE production through the modulation of Th1/Th2cytokines in ovalbumin-sensitized mice. Journal of Ethnopharmacology,137, 1077–1082. https://doi.org/10.1016/j.jep.2011.07.024.
62. Krishna, S. and Usha, P.T.A. (2009). Hyoglycaemiceffect of a combination of Pleurotusostreatus, MurrayKoenigii and Aeglemarmelos in diabetic rats. IndianJournal of Animal Science. 79: 986-987.
63. Kuriyama, I., Nakajima, Y., Nishida, H., Konishi, T., Takeuchi, T., Sugawara, F., ... & Mizushina, Y. (2013). Inhibitory effects of low molecular weight polyphenolics from Inonotus obliquus on human DNA topoisomerase activity and cancer cell proliferation. Molecular medicine reports, 8(2), 535-542.
64. Lee, I. K., Kim, Y. S., Jang, Y. W., Jung, J. Y., & Yun, B. S. (2007). New antioxidant polyphenols from the medicinal mushroom Inonotus obliquus. Bioorganic & Medicinal Chemistry Letters, 17(24), 6678-6681.
65. Lee, K. R., Lee, J. S., Song, J. E., Ha, S. J., & Hong, E. K. (2014). Inonotusobliquus-derived polysaccharide inhibits the migration and invasion of human non-small cell lung carcinoma cells via suppression of MMP-2and MMP-9. International Journal of Oncology, 45, 2533–2540.https://doi.org/10.3892/ijo.2014.2685.
66. Lee, M. W., Hyeon-Hur, Chang, K. C., Lee, T. S., Ka, K. H., & Jankovsky, L. (2008). Introduction to distribution and ecology of sterile conks of Inonotus obliquus. Mycobiology, 36(4), 199-202.
67. Li L, Li H, Peng XR, Hou B, Yu MY, Dong JR, Li XN, Zhou L, Yang J, Qiu MH. (±)-Ganoapplanin, a pair of polycyclic meroterpenoid enantiomers from Ganodermaapplanatum. Organic letters. 2016 Dec 2;18(23):6078-81.
68. Li, Y., Wang, X., Xu, B., Liu, Y., & Liu, W. (2016). Chemical constituents and biological activities of Ganoderma applanatum. International Journal of Molecular Sciences, 17(1), 28.

69. Lin WH. Study of PSP. Jiangsu Pharmaceutical and Clinical Research 1:35-37, 2014.
70. Lindequist, U., Niedermeyer, T. H., &Jülich, W. D. (2005). The pharmacological potential of mushrooms. Evidence-based complementary and alternative medicine, 2(3), 285-299.
71. Liu Y. L., Li J. K. (2004). Etiology and treatment of hyperlipidemia. Modern Medicine & Health ,7:522-523.
72. Liu YL, Li JK. Etiology and treatment of hyperlipidemia. Modern Medicine & Health 7:522-523, 2004.
73. Lowy, B. (1971). New records of mushroom stones from Guatemala. Mycologia, 63(5), 983-993.
74. Lu, X., Chen, H., Dong, P., & Zhang, X. (2010). Phytochemical characteristics and hypoglycaemic activity of fraction from mushroom Inonotusobliquus. Journal of the Science of Food and Agriculture, 90, 276–280.https://doi.org/10.1002/jsfa.3809.
75. Luo, Z., Wang, Y., Liu, Z., Yang, G., & Wang, J. (2015). Phytochemical composition and biological activities of Ganoderma applanatum. Journal of Functional Foods, 17, 91-99.
76. Ma JQ, Liu CM, Qin ZH, Jiang JH, Sun YZ. Ganodermaapplanatumterpenes protect mouse liver against benzo (α) pyren-induced oxidative stress and inflammation. Environmental toxicology and pharmacology. 2011 May 1;31(3):460-8.
77. Meerovich, I.G.; Yang, M.; Jiang, P.; Hoffman;R.M.; Gerasimenya, V.P. and Orlov, A.E. (2005).Study of action of cyclophosphamide and extract ofmycelium of Pleurotusostreatus in vivo on mice,bearing melanoma B16-F0- -GFP. Proceedings of theSPIE, Vol. 5704, Genetically Engineered and OpticalProbes for Biomedical Applications III, San Hose,California, USA.
78. Menolli Junior, N., Asai, T., Capelari, M., & Paccola-Meirelles, L. D. (2010). Morphological and molecular identification of four Brazilian commercial isolates of Pleurotus spp. and cultivation on corncob. Brazilian Archives of Biology and Technology, 53, 397-408.
79. Miller H. R., & Miller Jr O.K., (2006). North American Mushrooms: A Field Guide to Edible and Inedible Fungi. Guilford, Connecticut: Falcon Guides. p. 283. ISBN 978-0-7627-3109-1.
80. Mirunalini, S.; Arulmozhi, V.; Deepalakshmi, K.and Krishnaveni, M. (2012). Intracellularbiosynthesis and antibacterial activity of silver nanoparticles using Edible mushrooms. NotulaeScientiaBiologicae. 4(4): 55-61.
81. Mohamad, H.; Zainal, A.; Noorlidah, A. andNurhayati, Z.A. (2017). Therapeutic Properties ofPleurotus species (Oyster mushrooms) forAtherosclerosis: A Review. International Journal ofFood Properties. 20(6): 1251-1261.
82. Nakajima, Y., Nishida, H., Nakamura, Y., &Konishi, T. (2009). Prevention ofhydrogen peroxide-induced oxidative stress in PC12 cells by 3,4-dihydroxybenzalacetone isolated from Chaga (Inonotusobliquus(persoon) Pilat). Free Radical Biology & Medicine, 47, 1154–1161.https://doi.org/10.1016/j.freeradbiomed.2009.07.029.
83. Nakamura, S., Iwami, J., Matsuda, H., Mizuno, S., & Yoshikawa, M. (2009). Absolute stereostructures of inoterpenes A–F from sclerotia of Inonotus obliquus. Tetrahedron, 65(12), 2443-2450.
84. Newman, D. J., & Cragg, G. M. (2007). Natural products as sources of new drugs over the last 25 years. Journal of natural products, 70(3), 461-477.
85. Ng, T. B. (1998). A review of research on the protein-bound polysaccharide (polysaccharopeptide, PSP) from the mushroom Coriolusversicolor (Basidiomycetes: Polyporaceae). General Pharmacology: The Vascular System, 30(1), 1-4.
86. Nilsson S., &Persson O. (1977). Fungi of Northern Europe 2: Gill-Fungi. Penguin, New York. ISBN 978-0-14-063006-0.
87. Niu, H., Song, D., Mu, H., Zhang, W., Sun, F., &Duan, J. (2016). Investigation of three lignin complexes with antioxidant and immunologicalcapacities from Inonotusobliquus. International Journal of BiologicalMacromolecules, 86, 587–593. https://doi.org/10.1016/j.ijbiomac.2016.01.111.
88. Ofoedu, C.E. and Njoku, C.C. (2017). Antioxidantand Antimicrobial Activities of Oyster Mushroom.American Journal of Food Science and Technology.5(2): 64-69.
89. Okafor, D.C.; Onuegbu, N.C.; Odimegwu, N.E.;Ibeabuchi, J.C.; Njoku, N.E; Agunwa, I.M.;
90. Omarini, A., Nepote, V., Grosso, N. R., Zygadlo, J. A., & Albertó, E. (2010). Sensory analysis and fruiting bodies characterisation of the edible mushrooms Pleurotus ostreatus and Polyporus tenuiculus obtained on leaf waste from the essential oil production industry. International journal of food science & technology, 45(3), 466-474. org/10.1016/j.fsi.2012.03.021.
91. Park, Y. M., Won, J. H., Kim, Y. H., Choi, J. W., Park, H. J., & Lee, K. T. (2005). In vivo and in vitro anti-inflammatory and anti-nociceptive effects of the methanol extract of Inonotusobliquus. Journal of Ethnopharmacology, 101(1-3), 120-128.

92. Pedneault, K., Angers, P., Avis, T. J., Gosselin, A., & Tweddell, R. J. (2007). Fatty acid profiles of polar and non-polar lipids of Pleurotus ostreatus and P. cornucopiae var.'citrino-pileatus' grown at different temperatures. Mycological Research, 111(10), 1228-1234.
93. Perevedentseva, L. (2013). Use of wild-growing mushrooms for therapeutic purposes in the Perm Territory, Russia. Journal of Environmental Science and Engineering. A, 2(4A), 236.
94. Poucheret, P., Fons, F., & Rapior, S. (2006). Biological and pharmacological activity of higher fungi: 20-year retrospective analysis. Cryptogamie Mycologie, 27(4), 311.
95. PUIA, I. C., Aida, P. U. I. A., CHEDEA, V. S., LEOPOLD, N., BOCSAN, I. C., & BUZOIANU, A. D. (2018). Characterization of Trametes versicolor: Medicinal mushroom with important health benefits. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 46(2), 343-349.
96. Rajarathnam, S., Bano, Z., & Miles, P. G. (1987). Pleurotus mushrooms. Part I A. Morphology, life cycle, taxonomy, breeding, and cultivation. Critical Reviews in Food Science & Nutrition, 26(2), 157-223.
97. Ramberg, J. E., Nelson, E. D., & Sinnott, R. A. (2010). Immunomodulatory dietary polysaccharides: a systematic review of the literature. Nutrition journal, 9, 1-22.
98. Rao G, Tang XW. Effect of Coriolusversicolor intracellular polysaccharide (CVICP) on blood lipid in patients with hyperlipidemia. Chongqing Medicine 13:1306-1307, 2007.
99. Rapior, S., Courtecuisse, R., Francia, C., & Siroux, Y. (2000). Activités biologiques des champignons: recherches actuelles sur les facteurs de risque des maladies cardio-vasculaires. In Annales de la Société d'Horticulture et d'Histoire Naturelle de l'Hérault (Vol. 140, No. 1, pp. 26-31).
100. Rašeta, M., Popović, M., Knežević, P., Šibul, F., Kaišarević, S., & Karaman, M. (2020). Bioactive phenolic compounds of two medicinal mushroom species Trametes versicolor and Stereum subtomentosum as antioxidant and antiproliferative agents. Chemistry & Biodiversity, 17(12), e2000683.
101. Saar, M. (1991). Fungi in Khanty folk medicine. Journal of Ethnopharmacology, 31(2), 175-179.
102. Saat, E.; Irawan, W.K.; Enos, T.A. and Harlinda,K. (2019). The potential of white-oyster mushroom(Pleurotusostreatus) as antimicrobial and naturalantioxidant. Biofarmasi Journal of Natural ProductBiochemistry. 17 (1): 17-23.
103. Sarangi, I.; Ghosh, D.; Bhutia, S.K.; Mallick, S.K.and Maiti, T.K. (2006). Antitumor andimmunomodulating effects of Pleurotusostreatusmycelia derived proteoglycans. InternationalImmunopharmacology. 6: 1287-1297.
104. Scarpari, M., Reverberi, M., Parroni, A., Scala, V., Fanelli, C., Pietricola, C., & Rizzo, R. (2017). Tramesan, a novel polysaccharide from Trametesversicolor. Structural characterization and biological effects. PloS one, 12(8), e0171412.
105. Sharma, N. (2003). Medicinal uses of macrofungi. Ethnobotany, 15, 97-99.
106. Shashkina, M. Y., Shashkin, P. N., & Sergeev, A. V. (2006). Chemical and medicobiological properties of chaga. Pharmaceutical Chemistry Journal, 40(10), 560-568.
107. Shashkina, M. Y., Shashkin, P. N., &Sergeev, A. V. (2006). Chemical and medicobiological properties of chaga. Pharmaceutical Chemistry Journal, 40(10), 560-568.
108. Sher, H., Al-Yemeni, M., & Khan, K. (2011). Cultivation of the oyster mushroom (Pleurotus ostreatus (Jacq.) P. Kumm.) in two different agroecological zones of Pakistan. African Journal of Biotechnology, 10(2), 183-188.
109. Shibnev, V. A., Mishin, D. V., Garaev, T. M., Finogenova, N. P., Botikov, A. G., &Deryabin, P. G. (2011). Antiviral activity of Inonotusobliquus fungus extract towards infection caused by hepatitis C virus in cell cultures. Bulletin of experimental biology and medicine, 151(5), 612.
110. Stefanello, F. S., Cavalheiro, C. V., Dugatto, J. S., Kubota, E. H., & Silva, M. S.(2012). Avaliação da ativadadeantioxidante in vitro do cogumeloshimeji(Pleutorusostreatus). Simpósio de SegurançaAlimentar, 4, 2012.
111. Sułkowska–Ziaja, K., Balik, M., &Muszyńska, B. (2019). Ganodermaapplanatum–źródłocennychsubstancjiprozdrowotnych. MedicinaInternaciaRevuo, 28(112), 147-155.
112. Szczepkowski, A., Piętka, J., &Grzywacz, A. (2013). Biology and medicinal properties of the chaga mushroom Inonotusobliquus (Fr.) Pilat. *Sylwan*, *157*.
113. Taji, S., Yamada, T., In, Y., Wada, S. I., Usami, Y., Sakuma, K., & Tanaka, R. (2007). Three new lanostane triterpenoids from Inonotus obliquus. Helvetica Chimica Acta, 90(11), 2047-2057.
114. Taji, S., Yamada, T., Wada, S. I., Tokuda, H., Sakuma, K., & Tanaka, R. (2008). Lanostane-type triterpenoids from the sclerotia of Inonotus obliquus possessing anti-tumor promoting activity. European Journal of Medicinal Chemistry, 43(11), 2373-2379.

115. WA, E., Elnahas, M. O., Thomas, P. W., & Daba, G. M. (2020). Trametes versicolor and Dictyophora indusiata champions of medicinal mushrooms. Pharm Res, 4(1), 00019.
116. Wang, C., Chen, Z., Pan, Y., Gao, X., & Chen, H. (2017). Anti-diabeticeffects of Inonotusobliquus polysaccharides-chromium (III) complex intype 2 diabetic mice and its sub-acute toxicity evaluation in normalmice. Food and Chemical Toxicology, 108, 498–509. https://doi.org/10.1016/j.fct.2017.01.007.
117. Wang, H. and Ng, T.B. (2000b). Isolation of a novelubiquitin-like protein from Pleurotusostreatusmushroom with anti-human immune deficiency virus,translation-inhibitory and ribonuclease activities.Biochemical and Biophysical ResearchCommunications. 276: 587-593.
118. Wang, H.; Gao, J. and Ng, T.B. (2000a). A new lectinwith highly potent anti-heptoma and antisarcomaactivities from the oyster mushroom Pleurotusostreatus. Biochemical and Biophysical ResearchCommunications. 275: 810-816.
119. Wang, L., Li, J. Q., Zhang, J., Li, Z. M., Liu, H. G., & Wang, Y. Z. (2020). Traditional uses, chemical components and pharmacological activities of the genus Ganoderma P. Karst.: a review. RSC advances, 10(69), 42084-42097.
120. Wang, Y., Zhang, H., Zhang, C., Zhao, X., & Wang, J. (2020). Phytochemicals and pharmacological activities of Ganoderma applanatum. Natural Product Research, 1-12.
121. Wu KN, Lin H, Kong LQ, Liu SC, Li HY. Effect of PSP on breast atypical hyperplasia and angiogenesis. Chin J ExpSurg 4:84, 2001.
122. Xu S, Song YH, Li HY, Cai HB. Curative effect observationt on advanced colorectal cancer by the treatment with PSP combined with XELOX regimen. ActaUniversitatisMedicinalis Nanjing 12:1616-1618, 2008.
123. Xu, X., Wu, Y., & Chen, H. (2011). Comparative antioxidative characteristics of polysaccharide-enriched extracts from natural sclerotia and cultured mycelia in submerged fermentation of Inonotus obliquus. Food Chemistry, 127(1), 74-79.
124. Yang, Q. Y., Hu, Y. J., Li, X. Y., Yang, J. C., Liu, J. X., Liu, T. F., ... & Liao, M. L. (1993). A new biological response modifier substance–PSP. In PSP international symposium (pp. 56-72). Fudan University Press. China.
125. Youn, M. J., Kim, J. K., Park, S. Y., Kim, Y., Kim, S. J., Lee, J. S., … Park, R.(2008). Chaga mushroom (Inonotusobliquus) induces G0/G1 arrestand apoptosis in human hepatoma HepG2 cells. World Journal of Gastroenterology, 14, 511–517. https://doi.org/10.3748/wjg.14.511.
126. Youn, M. J., Kim, J. K., Park, S. Y., Kim, Y., Park, C., Kim, E. S., … Park, R.(2009). Potential anticancer properties of the water extract of Inonotus[corrected] obliquus by induction of apoptosis in melanoma B16-F10cells. Journal of Ethnopharmacology, 121, 221–228. https://doi.org/10.1016/j.jep.2008.10.016.
127. Zhang, L., Lin, D., Li, H., Yu, S., Bai, J., Ding, Z., & Wu, J. (2018).Immunopotentiating effect of Inonotusobliquus fermentation productsadministered at vaccination in chickens. Molecular and Cellular Probes,41, 43–51. https://doi.org/10.1016/j.mcp.2018.09.002.
128. Zhang, Y., Dai, L., Kong, X., & Chen, L. (2012). Characterization and in vitro antioxidant activities of polysaccharides from Pleurotus ostreatus. International journal of biological macromolecules, 51(3), 259-265.
129. Zhang, Z. (1989). Inhibitory effect of medicinal fungi on hepatitis B virus in vitroand in vivo.Bull. Beijing Med. Univ.21:455–459.
130. Zheng, W. (2004). Anti-tumor experiment research of the synergistic function of PSP and anticancer active peptide. Nei Mongol Journal of Traditional Chinese Medicine, 2, 21-24.