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Activity of mushrooms against diabetic and inflammation: A review

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Abstract

Since ancient people, mushroom have been used as a source of food and in therapeutic remedies. Many recent studies confirm different biological activities of mushrooms which include antioxidant, antimicrobial, anticancer, antidiabetic and anti-inflammatory activities.

Many mushroom species have been evaluated for their antidiabetic and anti-inflammatory activities. This study highlights the effectiveness of mushrooms as antidiabetic and anti-inflammatory agents.

Keywords: Inflammation; Diabetic; Mushrooms; Active compounds; Anti-inflammation; Antidiabetic

1. Introduction

1.1. Diabetes

Diabetes mellitus its a group of metabolic diseases characterized by hyperglycemia, in which level of blood sugar elevated either because body cells do not respond properly to the insulin produced (insulin dysfunction) or the pancreas do not produce enough insulin (lack of insulin). Its a common health problem around the world and it have been estimated that by 2045 the number of diabetic patients could reach 629 million [1, 2].

1.2. Diabetes mellitus classification

Diabetes mellitus is classified as: type I diabetes, type II diabetes, gestational and other specific types of diabetes mellitus [3].

In type I diabetes mellitus, there is an absolute deficiency of insulin secretion due to the autoimmune destruction of beta pancreatic cells that lead to metabolic disturbances, especially affecting glucose homeostasis [4]. In type II diabetes mellitus, some mechanisms get damaged which regulate the cell sensitivity to insulin that ultimately leads to insufficient insulin secretion by the pancreatic beta cells, insulin dysfunction, and delayed insulin secretion through insulin resistance [5, 6]. In gestational diabetes mellitus, diabetes mellitus arises during second or third trimester of pregnancy.

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The women about 20-50% are affected with this type. Insufficient insulin production during pregnancy to meet the extra needs leads to gestational diabetes [7]. In Other specific types of diabetes mellitus, maturity onset diabetes of the young (MODY) is a non-insulin dependent diabetes. Studies show that 1% to 2% of diabetes cases diabetic patients about have this diabetic type [8].

1.3. Symptoms of diabetes mellitus

Symptoms of diabetes mellitus include weight loss, polyuria, blurring of vision and thrust [9]. The effects of diabetes mellitus include long-term complications like cardiovascular diseases, nephropathy that may be lead to renal failure, or neuropathy with risk of foot ulcers, amputation, charcot joints, sexual dysfunction, cancer and stroke [10- 13].

1.4. Treatment of diabetes mellitus

Exogenous insulin is required for the treatment of diabetes mellitus type I [14]. Several drugs are currently used in the treatment of diabetes mellitus type II, which include various oral antidiabetic agents such as biguanides, sulfonylureas, tolbutamide, glinides, α-glucosidase inhibitors, thiazolidinediones, phenformin, troglitazone, repaglinide and rosiglitazone [15, 16]. Although, these drugs have a side effect on patients and may probably increase the incidence of acute hepatitis, hepatic injury and renal tumors [17, 19].

Besides conventional oral and injectable medications, diabetes treatments include changing of lifestyle, diet modification, weight regulation, regular exercising and using of alternatives therapies such as herbal therapy [20- 22].

Recently, researchers focused on the development of new drugs that are free from adverse effects such as nausea, diarrhoea, liver problems, and weight gain [23]. They are working on an alternative therapeutic approach to combat diabetes mellitus. Many studies aimed to decreasing postprandial hyperglycemia by delaying the absorption of carbohydrates/glucose through inhibition of α-amylase, α-glucosidase and carbohydrate hydrolysing enzymes using natural sources such as extracts from various species of plants and fungi [24].

1.5. Antidiabetic activity of mushrooms

Edible and medicinal mushrooms are functional foods which contain a variety of biologically active compounds with anti-diabetic effects. Numerous mushroom species appear to be effective in controlling of blood glucose levels and the modification of the course of diabetic complications. Both edible and medicinal mushrooms are ideal low calorie foods for diabetic patients since they contain low levels of carbohydrates, very low amounts of fats and cholesterol, high content of proteins, polysaccharides, lipids, vitamins and minerals, as well as a number of low molecular weight metabolites such as lectins, phenolic, alkaloids, sterols, terpenoids, and lactones substances [25- 28].

Mushrooms are known to contain compounds which help in proper functioning of the liver [29], pancreas and other endocrinal glands, thereby promoting formation of insulin and related hormones which ensure healthy metabolic functioning [30- 32]. Polysaccharides, such as beta glucans contained in mushrooms have the ability to restore the function of pancreatic tissues by causing increased insulin output by β – cells, which leads to lowering of blood glucose levels. It has also been shown to improve the sensitivity of peripheral tissues to insulin. Consumption of mushrooms markedly decreases the lipid levels including total cholesterol, total triglyceride, and low-density lipoproteins; and increases the level of high-density lipoproteins [33].

Many studies indicated antidiabetic activity of mushrooms. Mycelial extract of *Pleurotus ostreatus* was noticed to reduce the serum glucose level in streptozotocin-induced diabetes mellitus in rats [34]. *Ganoderma lucidum* ethanol extract of powdered fruiting bodies reduce serum glucose in white rats [35]. Also, water and 80% ethanol extracts of fruiting bodies of *Ganoderma lucidum* decreased glucose level in serum of streptozotocin-induced diabetic rats [36].

Also, *Pleurotus florida* methanolic extract showed a significant antidiabetic activity in rats which suggest its potential pharmacological activity to control diabetics and prevent it [37]. 70% ethanol extracts of *Hericium erinaceus, Tremella fuciformis, Ganoderma lucidum, Auricularia auriculajudae, Lentinus edodes, Grifola frondosa, Russula sanguinea* and *Agrocybe aegerita* were investigated for their antidiabetic activity. Among all mushrooms *Ganoderma lucidum* express a significant antidiabetic activity [38].

In this connection, four antidiabetic-related proteins which are glyceraldehyde-3-phosphate dehydrogenase-like protein, catalase-like protein, profilin-like protein and trehalose phosphorylase-like (TP-like) protein which have high potential in lowering blood glucose level, reducing insulin resistance and vascular complications were extracted from *Pleurotus pulmonarius* [39]. Ethanolic extract of fruiting bodies of *Astraeus hygometricus* showed a significant reduced

levels of blood glucose and better tolerance to glucose in alloxan induced diabetic mice [40]. Aqueous extract of fruiting bodies and mycelial biomass of *Phellinus Badius* showed a significant reduction in blood glucose in alloxan-induced diabetic rats [41]. Also, Mushrooms such as *Phellinus linteus, Ganoderma lucidum, Agaricus bisporus, Agaricus subrufescens, Cordyceps sinensis, Pleurotus* spp, *Sparassis crispa, Inonotus obliquus, Poria cocos* and *Coprinus comatus* have been reported to have anti-hyperglycemic effects and hypoglycemic effects (reduction of glucose levels in blood) [25].

Clinical trials of mushroom extracts effects were also reported. Dietary supplementation with fruiting bodies of *Agaricus sylvaticus* shows a significant reduction of fasting plasma glucose on 56 patients with colorectal cancer [42, 43]. Also, dietary supplementation with powdered fruiting bodies of *Pleurotus ostreatus* on 120 patients with type II diabetes showed significant association between mushroom supplementation and gradual reduction in hyperglycemia in type II diabetic patients [44].

2. Inflammation

Inflammation is a normal protective response to tissue injury which involves enzyme activation, cell migration, mediator release, tissue breakdown, tissue repair and fluid extravasations [45]. Its frequently associated with fever, swelling, pain and involves the increase in vascular permeability, increase of protein denaturation, plasma extravasation, vasodilation, and membrane alterations [46]. Inflammation is a physiologic defense mechanism that helps the body to protect itself against poisonous chemicals, infection, burn, allergens, or other noxious stimuli. Inflammations are mainly as acute and chronic inflammations [47]. While the initial intention of an inflammatory event is to support the human body, a prolonged and excessive inflammation is correlated with various clinical presentations like cardiovascular complications, arthritis and tumor progression (Fig. 1) [48- 51]. The present non-steroidal anti-inflammatory drugs (NSAIDS) are commonly used to treat inflammation, but their long-term use causes severe side effects such as gastrointestinal bleeding, peptic ulcers and other effects such as hypersensitivity reactions [48, 52, 53]. For this reason, searching for alternative medicines, especially natural products that are more safer options to treat inflammation become necessary and beneficial [48]. Plants and mushrooms have been targeted, screened and identified as sources to treat inflammation [54- 56].

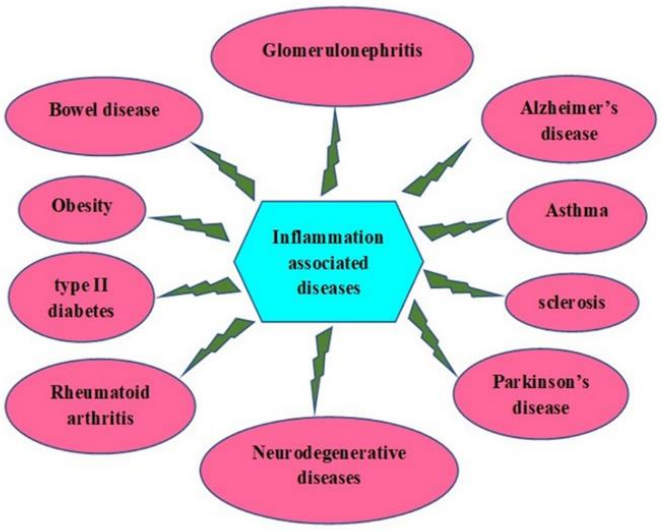

Figure 1 Inflammation associated diseases

2.1. Anti-inflammatory activity of mushrooms

Many previous studies have reported the bioactive compounds found in mushrooms exhibit significant anti-inflammatory properties (Table 1). Anti-inflammatory activity of metabolite compounds, cordycepin, from *Cordyceps* species have been reported [57- 60]. Cultured mycelia and fruiting bodies of *Cordyceps militaris* ethanolic extracts were reported to have an anti-inflammatory effect [60]. Also, anti-inflammatory effect against nociception and peritonitis in mice using an alkaline extract of *Cordyceps militaris* was reported [61]. Another compound, Adenosine, present in *Cordyceps* species showed an anti-inflammatory property by preventing tissue damage [58, 62- 64].

Table 1 Some anti-inflammatory compounds from mushrooms.

Mushroom	Extract	Active compounds	Study model	References
Tylopilus ballouii	Methanolic	Galactomannan and non-sulphated polysaccharide	Paw edema in mice	[65]
Trametes orientalis	Ethanolic	Polysaccharides	Lewis lung carcinoma	[66]
Ganoderma lucidum	Aqueous	β-D-glucan	Lewis lung carcinoma	[67]
Pleurotus sajor-caju	Chloroform–methanol	β-D-glucan	Peritonitis in Swiss mice induced by bacterial lipopolysaccharide (LPS)	[68]
Cordyceps militaris	Aqueous	β-D-glucan	Nociception induced by formalin in mice	[69]
Hericium erinaceus	Ethanolic	Erinacin and its derivative Erinacin A	Ischemic stroke model in mice	[70]

Culinary mushroom *Pleurotus ostreatus* freeze-dried powdered and acetone extracts have promising activity against inflammation induced in carrageenan-induced rat paw oedema model [54]. Anti-inflammatory effect of hydroalcoholic extracts of *Ganoderma lucidum* strains DARL-4 and MS-1were reported [71]. Ethanol extract of *Agaricus bisporus* fruiting bodies showed anti-inflammatory activity [72]. Ethyl acetate and petroleum ether extracts of *Inonotus obliquus* fruiting bodies reported to have anti-inflammatory effect [73].

In a study, water and ethanol extracts of fruiting bodies of *Lactarius rufus* showed a potent anti-inflammatory activity [74]. *Pleurotus pulmonarius* water and ethanol extracts demonstrated activity against inflammation [75]. *Agaricus blazei* whole mushroom chloroform extract and *Agaricus bisporus* whole mushroom methanol extract reported to have anti-inflammatory property [76, 77]. *Agaricus blazei* powder in the form of capsules showed anti-inflammatory effect on Paw edema in rats [78]. Anti-inflammatory activity of ethanol and methanol extracts of *Elaphomyces granulatus* and *Caripia montagnei* were documented [79, 80].

3. Conclusion

This review documented different extracts and active compounds from mushrooms and the using of this extracts/ compounds as antidiabetic and anti-inflammatory compounds.

Compliance with ethical standards

Disclosure of conflict of interest

All authors disclose that they have no conflict of interest.

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