ANTI-DIABETIC PROPERTIES OF EDIBLE MUSHROOMS: A COMPREHENSIVE REVIEW

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Abstract

Mushrooms, which belong to the "Fungi" family, are widely recognized for their accessibility and health advantages. The prevalence of diabetes has increased globally in recent years, necessitating the quest for alternative treatment methods**.** Mushrooms have long been recognized for their critical role in preventing and treating a variety of health issues, including immunodeficiency, cancer, inflammation, hypertension, hyperlipidemia, hypercholesterolemia, and obesity, due to their high quality proteins, polysaccharides, unsaturated fatty acids, mineral substances, triterpenes, sterols, and secondary metabolites. This study evaluates the potential anti-diabetic advantages of edible mushrooms, highlighting their potential importance in diabetes prevention and focusing on their bioactive components and processes that affect insulin sensitivity and glucose metabolism. Studies on the enormous contribution of mushrooms to the nutritional and physiological advantages they exhibit have emerged.

The current article reviewed and compiled the most recent data regarding the health advantages and underlying functional mechanisms of mushrooms, and it came to the conclusion that adding mushrooms to a diet could serve as a natural adjuvant for the prevention and treatment of a number of illnesses.The review comes to the conclusion that EM can predict insulin resistance through both preventive actions like β-glucosidase and β-amylase and active substances like polysaccharides and vitamin D. Many varieties of mushrooms have been shown to offer medicinal advantages, although the exact mechanism is still unknown. To fully realize the therapeutic potential of edible medicinal mushrooms in avoiding noncommunicable illnesses, more research is required.

1. Introduction

Mushrooms are part of the “Fungi” family which is well-known for their medical benefits globally. Mushrooms which are derived from the Latin and Greek words "fungus" and "mykes," are considered edible if they don't cause health issues. There are three categories for them: non-poisonous, edible, and inedible.[1] The major goal of this review is to explain how edible mushrooms (EM) can help treat diabetic mellitus (DM) by looking at bioactive components in mushrooms, the pathophysiology of insulin resistance (IR), and how EMs can help avoid IR. Mushrooms are also low in fat and high in dietary fiber, nutraceuticals, and polysaccharides. These substances have been shown to improve health by modulating the immune system and reducing inflammation in a number of disorders.

Notable commonly available edible mushrooms include chanterelles (Cantharellaceae), puffballs (Lycoperdon spp.), shaggy mane (Coprinus comatus), oyster mushrooms (Pleurotus ostreatus and Pleurotus cystidiosus), boletes (Boletaceae), sulfur shelf (Laetiporus sulphurous), hen of the woods (Grifora frondosa), button mushroom (Agricus bisporus) , golden oyster mushroom (Pleurotus citrinopileatus), morels (Morachella esculenta), bearded tooth (Hericium erinaceus), straw mushroom (Volvariella volvacea), enoki (Flammulina velutipes), shiitake (Lentinula edodes), beech mushroom (Hypsizygus marmoreus), French horn mushroom (Pleurotus eryngii), dancing mushroom (Grifola frondosa), and black poplar mushroom (Agrocybe aegerita).[2] A chronic metabolic disease called diabetes mellitus is typified by an abnormal rise in serum glucose levels brought on by either an imbalance in insulin production or sensitivity to the hormone's effects on cellular receptor signaling. Due to their special natural chemical and nutritional qualities, wild edible mushrooms contain increased protein and vitamin content, including B vitamins, vitamin D, vitamin K, and occasionally vitamins A and C.[3]

Diabetes mellitus (DM) is clinically categorized as type 1 diabetes mellitus (T1DM), type 2 diabetic mellitus (T2DM), gestational diabetes mellitus, and specialized forms of diabetes resulting from genetic, pharmacological, or pathological factors.The cause of type 2 diabetes, which accounts for over 90% of all cases of diabetes, is a progressive insulin insufficiency accompanied by peripheral insulin resistance. Diabetes mellitus is a leading cause of complications, including cardiovascular disorders, blindness, kidney failure, and limb amputations globally.[4]

Figure No.-1 List of various Medicinal Mushrooms Table 1. Various mushrooms and their medicinal properties.[5]

S No.	Mushroom species	Common name	Properties
1	Agaricus bisporus	Button mushroom	Antitumor property, hepatoprotective property, anti-inflammatory, anti-aging and antioxidant property
2	Pleurotus ostreatus	Oyster mushroom	Anti-diabetic property ,anti-hyperlipidemic property , neuroprotective property

3	Lentinula edodes	Shiitake mushroom	Strong antitumor property,anti-inflammatory, enhances immune response
4	Ganoderma lucidum	Reishi mushroom	Anti-diabetic, antitumor activity, neuroprotective, anti-inflammatory, improves gut health
5	Pleurotus eryngii	King oyster mushroom	Antitumor activity, hypolipidemic , hypoglycemic
6	Flammulina velutipes	Enoki mushroom	Anti-inflammatory, antiviral, neuroprotective, anti-cancer
7	Hypsizygus marmoreus	Beech mushroom	Antifungal property, anti-proliferative property, antiviral property
8	Ganoderma applanatum	Artist's conk	Antitumor activity, cytotoxic and pro-apoptotic effects
9	Ganoderma atrum	Black reishi	Antitumor activity, induces apoptosis and inhibits tumor growth
10	Ganoderma tsugae	Hemlock varnish shelf	Antitumor property, induces autophagy-related cancer cell death
11	Sparassis latifolia	Cauliflower mushroom	Antibacterial property, antifungal property, effective against pathogenic microbes
12	Ramaria formosa	Coral mushroom	Antiviral property (HIV inhibition)
13	Tuber indicum	Chinese black truffle	Antitumor property, Inhibits liver and breast cancer cells

14	Hohenbuehelia serotina	Late oyster mushroom	Antiviral property (HIV inhibition)
15	Lyophyllum shimeji	Shimeji mushroom	Antitumor property, suppresses cancer cell proliferation
16	Pleurotus cornucopiae	Branched oyster mushroom	Antiviral property, anti-proliferative property
17	Coprinus comatus	Shaggy ink cap	Antiviral (HIV inhibition), antitumor Property
18	Cerrena unicolor	Mossy maze polypore	Induces apoptosis in leukemia cells
19	Calocybe indica	Milky mushroom	Antioxidant and anti-aging property, neuroprotective effects

2. Diabetes Mellitus And Insulin Resistance

Obesity is the one of the major factor in the development of diabetes mellitus (Type 2 diabetes mellitus), which is a growing global issue.[6] Diabetes is a long-term metabolic disease marked by elevated blood glucose levels due to decreased insulin production and action.[7] The human body uses insulin and glucagon to keep blood glucose levels within a very specific range. In order to produce energy, glucagon causes the liver to release glucose from its cells into the blood.[8] Insulin resistance is a problematic condition that frequently worsens metabolic syndrome.[9]

Although insulin resistance has generally been associated with type 2 diabetes, emerging research suggests that insulin resistance in type 1 diabetes is rising.[10] When normal plasma insulin levels are unable to regulate blood glucose levels, the condition is known as insulin sensitivity. Numerous conditions, such as cancer, nonalcoholic fatty liver disease, and cardiovascular disease, are associated with IR.[11] It is essential to diagnose insulin resistance in order to prevent and treat it early. Pharmacological treatments and lifestyle modifications can improve insulin sensitivity and glycemic control.[12]

3. Eating Edible Mushrooms Can Help Prevent Diabetes And Insulin Resistance

Numerous chronic conditions, including obesity, diabetes, cancer and cardiovascular disease, can be avoided with proper diet. For thousands of years, edible mushrooms have been utilized as food and medicine. Extracts from mushrooms show well-tolerated anti-diabetic, anti-hyperlipidemic, anti-inflammatory, antioxidant, cardio

protective, anti-osteoporotic, and anti-tumor properties.[13] Triterpenoids, alkaloids, fibers, antioxidants, and other phytochemicals are

found in edible mushrooms, which have been utilized for centuries to treat various illnesses. The active ingredients in mushrooms, such as Comatin, β-glucan, Tremellastin, and Lentinan KS-2, have a significant impact on diabetes mellitus by altering either biochemical pathways or cellular function.[14] It has been demonstrated that bioactive metabolites derived from medicinal mushrooms and their cultured mycelia, such as polysaccharides, proteins, dietary fibers, and numerous other biomolecules, are effective in treating diabetes as biological anti-hyperglycemic drugs.[15]Additionally, mushrooms enhance pancreatic function and insulin secretion. To guarantee that medications made from mushrooms are as safe and effective as possible, more research is necessary.[16]

3.1 Polysaccharide Lowers Blood Glucose Levels

Mushrooms and their bioactive chemicals, particularly polysaccharides obtained from different species of mushrooms, have been used for centuries to treat diabetes mellitus. Polysaccharides are biopolymers made up of monosaccharides or simple sugars joined by glycosidic linkages. Treatment with mushroom polysaccharides demonstrated an anti-hyperglycemic impact by increasing insulin-signaling pathways, improving pancreatic β-cell mass, and reducing the effectiveness of glucose absorption, according to both in vitro and in vivo evidence.[17] Recent research has examined how mushroom polysaccharides can reduce oxidative stress, beta-cell dysfunction, and insulin resistance, all of which are strongly linked to diabetes mellitus through antioxidant action.[18]

3.2 Reduction in the Absorption of Glucose

The water-soluble dietary fibers and polysaccharides in mushrooms make the gastrointestinal tract more viscous, which slows down the rate at which the stomach empties and delays the digestion and absorption of carbohydrates. Furthermore, polysaccharide has been shown to be able to bind and adsorb glucose, which keeps the concentration of glucose in the small intestine low.[19] Several studies have shown that mushrooms significantly lower blood glucose levels.[20]

3.3 Sustains the Activity of Pancreatic Beta Cells

Mushrooms contain polysaccharides (β-D-glucan), which have been demonstrated to have potent immunological modulatory effects, such as reducing oxidative damage and suppressing NF-kB activity. Mushroom polysaccharides and other bioactive compounds decrease glucotoxicity and shield pancreatic beta cells from apoptosis. It has been demonstrated that extracts from Pleurotus spp. and other mushrooms significantly affect β-cell functionality and, consequently, sustain β-cell proliferation.[21] Growing understanding of the mechanisms and health benefits of mushrooms is promoting the development of a possible clinical application for β-glucans as well as further documentation of their role in maintaining health and preventing disease in the context of healthy lifestyles.[22]

3.4 Terpenoids Hypoglycemic Effect on Blood

Many higher fungi are known to produce terpenes, a significant bioactive metabolite.
They are made up of several isoprene units. Terpenoids, which are oxygenated derivatives of hydrocarbons, are frequently referred to as terpenes. The most prevalent metabolites found in mushrooms are riterpenoids and sesquiterpenoids, some of which share similarities with terpenoid molecules found in plants. Because

triterpenes are lipophilic, they can attach to cell membranes, potentially limiting their bioavailability by changing their fluidity. Despite their size, studies have shown that triterpenoids can pass through cell membranes and the blood–brain barrier and build up in the liver, circulatory system, and other tissues.[23] It is believed that terpenoids from Plagiophorus species Laetiporussulphurous, Tremella fuciformis, Ganoderma lucidum, and Pholiota microspore have β-glucosidase inhibitory activity, which prevents the synthesis of monosaccharide molecules and encourages the production of glycogen in the muscle and liver.[24]

3.5 Vitamin D's Function in Blood Glucose Regulations

Common mushroom species can produce quantities of vitamin D that are nutritionally significant when exposed to ultraviolet (UV) radiation, such as sunshine or a UV lamp. D2 is the kind of vitamin D that is most frequently found in mushrooms. Additionally, cardiovascular disease, neurological illnesses, respiratory conditions in children, type 1 and type 2 diabetes, and certain types of cancer can all be prevented with adequate vitamin D. The cell walls of mushrooms contain large amounts of ergosterol, which functions similarly to animal cholesterol. It was first noted in the early 1930s that mushrooms contained both ergosterol and vitamin D2. Ergosterol in the mushroom cell wall is converted to pre-vitamin D2 when exposed to UV light. This pre-vitamin D2 is then thermally isomerized in a temperature-dependent process to ergocalciferol, also referred to as vitamin D2.[25]

Sunlight and dietary sources of vitamin D produce 25-hydroxyvitamin D and 1, 25-dihydroxyvitamin D, which are both metabolically active and physiologically inert. Following consumption, vitamin D enters the bloodstream and travels to the liver, where it undergoes hydroxylation to produce 25-hydroxyvitamin D, which is the main form of vitamin D in circulation.[26] With the help of calbindin, vitamin D enhances PLC synthesis, PKA activation, and Ca+ absorption. As a result, the vitamin mediates the vitamin D receptor's (VDR) genetic mechanism of action. 1,25 (OH)2 D3, the active form of vitamin D, binds to VDR and forms a heterodimer with the retinoid receptors (RXR). Insulin resistance is prevented and epigenetic alterations are facilitated when the 1,25 (OH)2 D3-VDR-RXR complex is transported into the nucleus and binds to vitamin D-responsive elements (VDRE).[27]

Button mushrooms that have been treated with UV-B can make vitamin D2 more available to people.[28] The bioavailability of vitamin D2 from UV-B-irradiated button mushrooms enhanced with vitamin D2 was effective in improving vitamin D status and was comparable to a vitamin D2 supplement.[29]Based on the information we have, scientists still don't agree on how well vitamin D works to treat diabetes. It is still unknown how vitamin D works or how much of it is needed to treat diabetes mellitus.[30]

Conclusions

Diabetes is a major global health problem that causes a lot of deaths and illnesses every year. Numerous research have been conducted on novel strategies to avoid diabetes or its consequences, but their practical use is still unclear. For generations, people have known that edible mushrooms may have therapeutic uses. The review discusses the possible health advantages of edible mushrooms as well as ways to avoid diabetes. They have anti-diabetic properties mostly due to their polysaccharide and vitamin D content.

Numerous terpenoids and polysaccharides have been isolated from a broad range of mushroom species, and the processes behind their hypoglycemic effects have been clarified. The potential medical applications of mushrooms, especially the link between insulin resistance and vitamin D insufficiency, need more research. We

may conclude from the available data that mushrooms are beneficial and offer a great deal of promise for treating disorders like diabetes.

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