

Pharmacological and Nutritional Importance of Mushrooms

By

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A thesis submitted to the Department of Pharmacy in partial fulfillment of the requirements for the degree of Bachelor of Pharmacy (Hons.)

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Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

Student's Full Name & Signature:

Masfiq Rohan Arzon

A handwritten signature in black ink, appearing to be 'Masfiq Rohan Arzon', written in a cursive style.

Approval

The project titled “Pharmacological and Nutritional Importance of Mushrooms” submitted by Masfiq Rohan Arzon (16346001) of Summer, 2016 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Pharmacy (Hons.) on January 2021.

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Ethics Statement

This study comprises no human or animal trial.

Abstract

Mushrooms are micro fungi cultivated and consumed by peoples of different countries across the world. Even though they are quite common, but their significant importance is not that much known to everyone. Mushrooms have a variety of pharmacological properties for those it works as anti-cancer, anti-bacterial, anti-oxidative, anti-viral, anti-diabetic, anti-allergic agents. Mushrooms are now widely used in different countries for the treatment of cancer, diabetes, hypertension, inflammation and many other diseases. Mushrooms are eaten all over the world because of their significant nutritional value. They contain vitamin B, zinc, selenium, protein, pantothenic acid, copper, potassium, glycerol, mannitol, β -glucans, phosphorus, polysaccharides, magnesium etc. They also fulfill a huge mineral and nutritional need of our body. This review has overviewed and compiled the information on pharmacological and nutritional benefits of mushrooms and inferred that the dietary supplementation of mushrooms could provide immense potential in the prevention and treatment of various diseases.

Key words: Mushrooms; Pharmacological; Nutritional; Antioxidant; Cancer; Vitamin

Dedication

Dedicated to my parents and specially to my mother who died at the time of doing this project.
She was my biggest inspiration.

Acknowledgement

Above all, I am appreciative to my Almighty Allah for the great wellbeing and prosperity during the project which were vital to finish the task work on schedule.

It is a real delight to communicate my profound feeling of thanks and appreciation to my supervisor, Dr. Raushanara Akter (Associate Professor, Department of Pharmacy, Brac University) for giving me this brilliant chance to do this wonderful project. Her brief motivation at each phase of my project work and opportune recommendation with generosity, devotion, logical methodology, consistent direction, cooperation, eagerness make me empower to settle the task.

I owe a deep feeling of appreciation to our respectable Professor Dr. Eva Rahman Kabir (Chairperson, Department of Pharmacy, Brac University) whose help, support, insightful counsel were the supporting elements in doing the undertaking effectively. Also, I take this opportunity to express my gratitude to all the faculty members and lab officers for their help and support.

Last but not the least, I would like to express my greatest regards to my parents for their cooperation, continuous support, unconditional love throughout my life.

TABLE OF CONTENTS

CONTENT	PAGE NO.
Student and project details	1
Declaration	2
Approval	3
Ethics Statement	4
Abstract, Keywords	5
Dedication	6
Acknowledgement	7
Table of contents	8-9
List of tables	10
List of figures	11
Chapter-1	
INTRODUCTION	12-26
Rationale of the study	27
Aim of the study	27
Objectives of the study	27
Chapter-2	
METHODOLOGY	28
Chapter-3	
PHARMACOLOGICAL PROPERTIES OF MUSHROOM	29-56
1.1 Anti-cancer properties	29-32
1.2 Anti-oxidant properties	33-35
1.3 Anti-bacterial properties	36-38
1.4 Anti-inflammatory properties	38-39
1.5 Anti-diabetic properties	39-42
1.6 Anti-allergic properties	42-44
1.7 Anti-viral properties	44-47
1.8 Lipid lowering properties	48-50
1.9 Neuroprotective properties	50-51

1.10 Sedative properties	52
1.11 Immune function properties	53-55
Nutritional properties of mushroom	55-68
2.1 Source of vitamin B	56-57
2.2 Source of zinc	57-58
2.3 Source of copper	59
2.4 Source of potassium	60
2.5 Low fat	61
2.6 Source of polysaccharides	61-62
2.7 Source of protein	62
2.8 Source of selenium	63-64
2.9 Source of vitamin D	64
2.10 Source of triterpenes	64-65
2.11 Source of magnesium	65-66
2.12 Few calories	66
2.13 Source of phosphorus	67
2.14 Source of fiber	68
Chapter-4	
CONCLUSION & FUTURE RECOMMENDATION	69
REFERENCES	70-74

List of Tables	Page No.
Table 1: Chemical constituents of mushrooms	22-26
Table 2: Some popular mushrooms with their anti-oxidant activity	33-34
Table 3: Extraction yields and antioxidant activity values of wild edible mushrooms	34-35
Table 4: Clinical studies carried out with mushrooms for management of DM	41
Table 5: Fungal orders with positive antiviral activities	46-47
Table 6: Quantity of nutritional elements present in mushrooms	56
Table 7: Zinc content in different types of mushrooms	58-59
Table 8: Copper content in different types of mushrooms	59-60
Table 9: Potassium content in different types of mushrooms	60
Table 10: Low fat content in different types of mushrooms	61
Table 11: Protein content in different types of mushrooms	62
Table 12: Selenium content in different types of mushrooms	63-64
Table 13: Vitamin D content in different types of mushrooms	64-65
Table 14: Triterpene acid content in different types of mushrooms	65
Table 15: Magnesium content in different types of mushrooms	66
Table 16: Calorie content in different types of mushrooms	66-67
Table 17: Phosphorus content in different types of mushrooms	67-68
Table 18: Fiber content in different types of mushrooms	68

List of Figures	Page No.
Figure 1: Various types of Mushroom	13
Figure 2: Portobello Mushrooms	16
Figure 3: Cremini Mushroom	16
Figure 4: Maitake Mushroom	17
Figure 5: Button Mushroom	17
Figure 6: Hedgehog Mushroom	18
Figure 7: Morel Mushroom	18
Figure 8: Shiitake Mushroom	19
Figure 9: Porcini Mushroom	19
Figure 10: Lobster Mushroom	20
Figure 11: Enoki Mushroom	20
Figure 12: Chanterelle Mushroom	21
Figure 13: Clamshell mushroom	21
Figure 14: Tiger milk mushroom benefits	29
Figure 15: Activation of NF-kappa B	30
Figure 16: Some medicinal mushrooms with anti-cancer potential	32
Figure 17: Anti-cancer mechanism of mushroom bioactive compounds	32
Figure 18: Oyster mushroom which is enriched with antibacterial properties	37
Figure 19: <i>Inonotus obliquus</i> mushroom	39
Figure 20: Activity and function of beta glucan	40
Figure 21: Royal Sun Mushrooms	44
Figure 22: Reishi mushrooms	45
Figure 23: Shiitake Mushrooms	46
Figure 24: Lion's mane mushroom	52
Figure 25: Mushrooms with sedative properties	53
Figure 26: Different immune function properties of mushrooms	54
Figure 27: Mushrooms with immune function properties	55

Chapter 1:

INTRODUCTION

General information on mushrooms

Mushrooms are fungi. They belong to their own kingdom which is separate from flora and other plants. Fungi differ from plants and flora based on their way to produce nutrient. Generally, flora makes their food using the sun's energy (photosynthesis). But mushrooms rather just like the fruit of a plant, besides that the "seeds" it produces consist of thousands of microscopic spores. Those spores blow away into the wind, or are spread by using other means, such as animal feeding (Kamal Perera & Li, 2011). If they come upon on a preferable substrate such as wooden things or soil spores will germinate to form a web of microscopic rooting threads (mycelium) which perforate into their new food source. Mycelium of mushrooms can be persevered for many years, and can be used as dietary supplements. They do not grow on one or the other: their mycelium develops into or round the source, secretes proteins that digest the food remotely, and the mycelium at that point retains the processed supplements (Rapior, 2006). There are exceptions to these generalizations; some mushrooms are enlisted into their respective kingdoms primarily based on the characteristics other than their eating habits. Mainly Mushrooms are freed from LDL cholesterol and contain small quantity of vital amino acids and B vitamins. However, they are really worth as a delicate food, diffused flavor and agreeable texture.(Khan & Tania, 2012)

Mushrooms, compared to plants, have an extraordinary potential due to possessing bioactive secondary metabolites and there is a huge potential for using them as drugs. Essential for a use as medication, nutraceutical or other reason for existing is the constant creation of mushrooms (fruiting bodies or on the other hand mycelium) in high sums and in a normalized quality. In any

case, the legitimate guidelines for approval as medication or as dietary enhancements or as food ought to get more consideration. Control of conceivable symptoms (i.e., Allergies) during wide use is important. (Devishree et al., 2017). While pharmaceuticals arranged by extraction of therapeutic plants establish a significant piece of proof-based medication additionally in the Western Hemisphere, restorative mushrooms are mainly utilized as dietary enhancements without announcement of a clinical sign. Logical examinations and contextual investigations from Asian medication show that growths have exceptionally encouraging pharmacological potential. The current status in regards to mushrooms is accounted for, with a point toward supporting the advancement of authorized pharmaceutical arrangements of therapeutic mushrooms in Europe. (Lindequist, 2013) So in Bangladesh we also have a huge chance to do research with mushrooms and to reveal its importance to the pharmacological, medical and nutritional sectors. In these review article of mine I would like to behold the pharmacological and nutritional importance of mushrooms.



Figure 1: Various types of Mushroom (Adapted from

https://baoquocte.vn/stores/news_dataimages/minhhoa/072016/24/02/021443_mushroom-group.jpg)

Habitat of mushrooms:

Mushrooms are discovered in a high-quality type of habitats, even though each species might also limit in the quantity of these it could occupy. For example, a mushroom that commonly grows on rotting logs in the forest is not going to be observed in sand dunes. Fungi may be located in almost each habitat, from seawater to sparkling water, in soil, to vegetation and animals, to human skin or even to develop in microscopic cracks in laptop CD-ROMs. Most of the fungus will locate in those places however very small and need a microscope or magnifying lens to see it. (Kumar Singh et al., 2018) Forests and grasslands are the pleasant place for fungal habitats. The wooded area is the first-rate area to see mushrooms, as extra as 80% of the fungus is related to the trees. Forests are a perfect habitat for fungi. Some mushrooms, inclusive of oyster mushrooms, button mushrooms, are fit for human consumption. Cultivated mushrooms, mushrooms that develop wild can also be eaten. (Banukie et al., 2014)

Geographically, mushrooms existed on the earth even before man showed up on it, as confirm from the fossil records of the lower cretaceous period. In this way regarding human sciences talking, there is each likelihood that man utilized the mushrooms as food when he was yet a food finder and tracker on the sequence of social advancement. (Kamal Perera & Li, 2011) Mushrooms offer massive applications as they can be utilized as food and medications other than their key biological jobs. They speak to as one of the universes most prominent undiscovered assets of nourishment and tasteful food of things to come. Mushrooms have been discovered influential against malignancy, cholesterol decrease, stress, a sleeping disorder, asthma, sensitivities, and diabetes (Mahajna et al., 2009). Because of high measure of proteins, they can be utilized to connect the protein hunger hole. Mushrooms as useful nourishments are utilized as supplement enhancements to upgrade insusceptibility as tablets. Because of low starch substance and low

cholesterol, they suit diabetic and heart patients. 33% of the iron in the mushrooms is in accessible structure. Their polysaccharide content is utilized as anticancer medication. Indeed, they have been utilized to battle HIV effectively (Nanba, 2013; King, 2013).

Types of Mushrooms:

Mushrooms establish at any rate 14,000 and maybe upwards of 22,000 known species. The quantity of mushroom species on the earth is evaluated to be 140 000, proposing that only 10% are known. Accepting that the extent of valuable mushrooms among the unfamiliar and unexamined mushrooms will be just 5%, which infers 7000 yet unfamiliar species will be of possible advantage to humanity. Indeed, even among the known species the extent of all around examined mushrooms is exceptionally low. The involvement with ethno medicinal utilization of mushrooms, the ecologic requirement for organisms to create bioactive auxiliary metabolites and the improved opportunities for genetic, pharmacological and concoction investigation let us accept that mushrooms have an incredible potential for effective bioprospecting.(Kumar Singh et al., 2018) There is a typical saying, "meds and nourishments have a typical root." Mushrooms are a perfect case of this in comprising both a healthfully useful food and a wellspring of physiologically helpful medication. There are numerous assortments of mushroom, which are nutraceuticals, for example, cordyceps mushroom, and *Prosopis cineraria*. (Cheung, 2010)A few assortments of mushroom are for treatment of malignant growth, for example, concentrate of Chaga (*Inonotus obliquus*) is utilized as enemies of tumors medication. The general biochemical mixes, which are acquired in mushrooms, are triterpenes, polysaccharides, germanium, adenosine, ganoderic quintessence, amino acids, nutrients, minerals, proteins and strands, beta-glycan, heteroglycan, proteoglycan, and nucleotides. This survey centers around different kinds of mushrooms and their

biochemical concentrates, which have more noteworthy nutraceutical esteem. Mushroom is a boundless wellspring of compound with hostile to tumor and immunostimulants. Mushroom consumption has been appeared to lessen the danger of disease, particularly in the bosom malignancy.(Khan & Tania, 2012)

The most common types of mushrooms are given below:

1. **Portobello Mushrooms:** These mushrooms are large in length and feature a rounded, flat cap that averages fifteen centimeters in diameter and is hooked up to a thick stem.



Figure 2: Portobello Mushrooms (Adapted from <https://www.gettyimages.com>)

2. **Cremini Mushrooms:** These mushrooms are mainly a meaty cultivated brown or tan mushroom this is of the equal sort of button mushroom as the bigger and greater mature Portobello.



Figure 3: Cremini Mushroom (Adapted from <https://www.gettyimages.com/detail/photo/five-crimini-mushrooms-on-wood-royalty-free-image/585831667>)

3. **Maitake Mushroom:** Maitake mushrooms range in size from small to very large, averaging 3-15 pounds, however can grow up to a hundred pounds. The fruiting frame has an underground, inedible base those transitions into a single branched stem with many clustered caps that resemble leaf-like fronds or rosettes.



Figure 4: Maitake Mushroom (Adapted from <https://www.gettyimages.co.nz/detail/photo/maitake-mushrooms-royalty-free-image/977206754>)

4. **Button Mushrooms:** These mushrooms are a generally small white mushroom (*Agaricus bisporus* synonym *A. Brunnescens*) wherein the pileus has no longer but expanded.



Figure 5: Button Mushroom (Adapted from <https://cdn.images.express.co.uk/img/dynamic/14/590x/secondary/portobello-pizza-recipe-mushroom-keto-friendly-ketogenic-2606856.jpg?r=1596727024627>)

5. **Hedgehog Mushroom:** The hedgehog, or sweet tooth, is possibly the most foolproof to become aware of all wild mushrooms. Its yellow to orange cap and fruity scent are reminiscent

of its summer-fruiting relative the golden chanterelle, but its tooth-protected underside distinguishes it from ability look-alikes.



Figure 6: Hedgehog Mushroom (Adapted from <https://storage.googleapis.com/plugbucket/pub/up/5/5bc/5bcdb6a733f3460fa0f3c9eca72ad7d4/img1.jpg>)

- 6. Morel Mushrooms:** Morel mushrooms are quite desired and especially unusual. They evolved from a yeast so recently that they've no longer received an excessive degree of structural complexity, cluster and they have no longer yet advanced the capability to measure gravity to decide vertical route. Whatever path they start developing in is the direction they hold in.



Figure 7: Morel Mushroom (Adapted from <https://indianapublicmedia.org/wpimages/eartheats/2012/04/morel.png>)

- 7. Shiitake Mushroom:** Shiitake mushrooms are small to medium in length with caps averaging 10-20 centimeters in diameter and are connected to thin stems. The caps variety in color from light to dark brown and feature a wide, umbrella form with a function curled rim. Inside, the cream-colored flesh is firm, chewy, and spongy.



Figure 8: Shiitake Mushroom (Adapted from <https://s3-us-west-1.amazonaws.com/contentlab.studiod/getty/7b897d4321724b46b4369ca45666c344.jpg>)

- 8. Porcini Mushrooms:** Porcini mushrooms are small to large in size with a very thick stem and a rounded cap that averages 7-30 centimeters in diameter. The red-brown to darkish brown caps are smooth, barely sticky, and are convex when young, pulling down out with age.



Figure 9: Porcini Mushroom (Adapted from <https://www.thespruceeats.com>)

- 9. Lobster Mushrooms:** The Lobster mushroom, *Hypomyces lactifluorum*, contrary to its not unusual name, isn't always a mushroom, however as an alternative a parasitic ascomycete fungus that grows on positive species of mushrooms, turning them a rosy orange shading that looks like the external shell of a cooked lobster.



Figure 10: Lobster Mushroom (Adapted from <https://cdn3.volusion.com/ezcwg.wmzwc/v/vspfiles/photos/1007-2.jpg>)

10. Enoki Mushroom: Cultivated Enoki mushrooms are very small and develop in bouquets of tightly packed, long stems crowned with petite, convex caps. The snow-white caps are tender, smooth, delicate, and are linked to matching white stems that can be thin and might grow as much as twelve centimeters in length.



Figure 11: Enoki Mushroom (Adapted from <https://hips.hearstapps.com/hmgprod.s3.amazonaws.com/images/enoki-mushroom>)

11. Chanterelle Mushrooms: Chanterelle mushrooms are small to medium in size with the ability to weigh up to two kilos and are convex in shape with a wavy cap connecting to a dense stem. The top cap is smooth, sensitive and gold-orange with irregular, uneven edges that are thick, blunt, and tighten.



Figure 12: Chanterelle Mushroom (Adapted from <https://i0.wp.com/health.veggieshake.com/wp-content/uploads/2018/10/Chanterelle-Mushrooms.jpeg?fit=640%2C360&ssl=1>)

12. Clamshell Mushrooms: These mushrooms are somewhat similar to white button mushroom. It grows in clusters and has a long, narrow, tapered stem and a hemispherical cap.

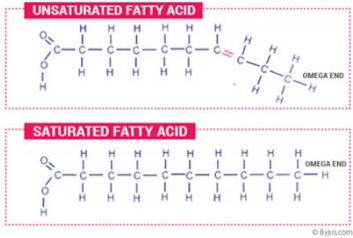
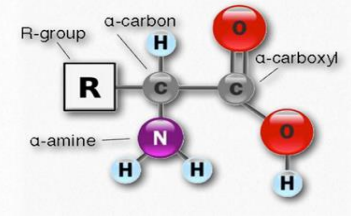
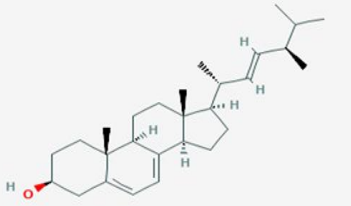



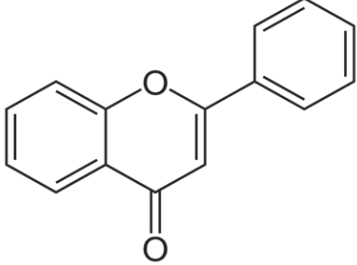
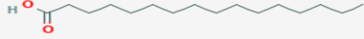
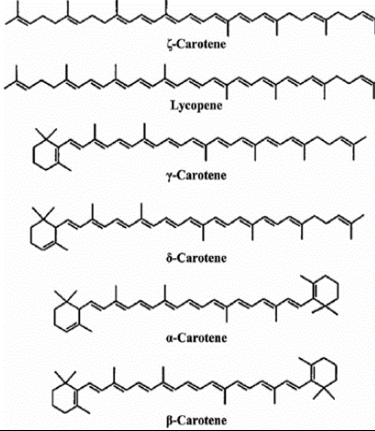
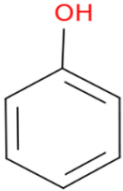
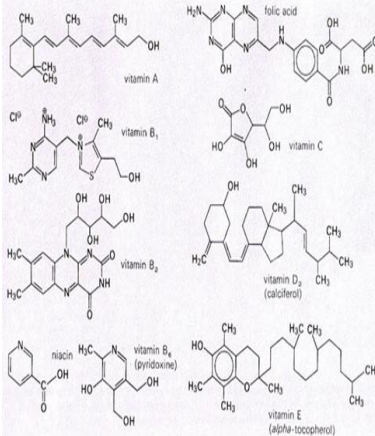
Figure 13: Clamshell mushroom (Adapted from <https://media.istockphoto.com/photos/bunashimeji-picture>)

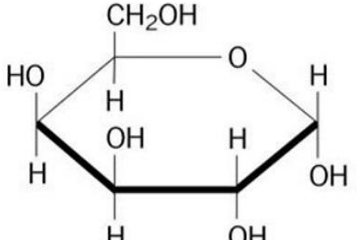
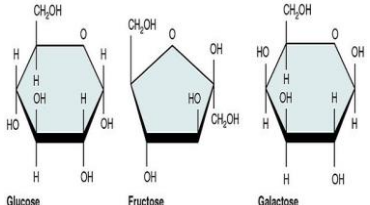
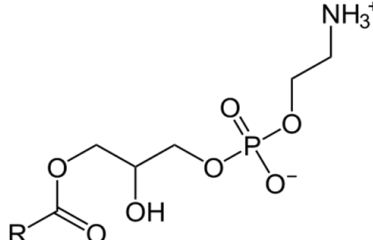
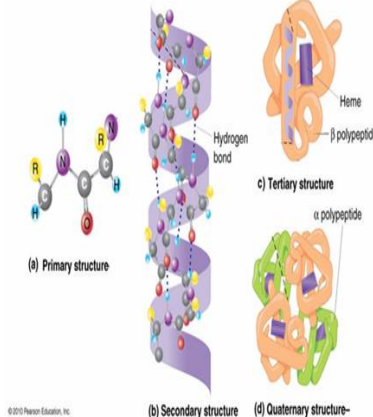
Chemical constituents of mushrooms:

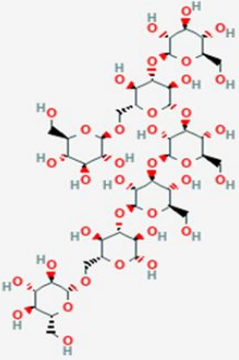
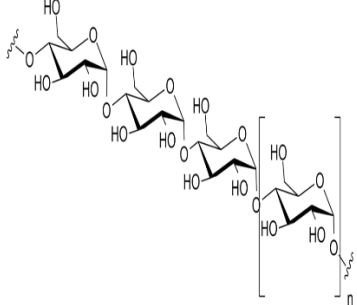
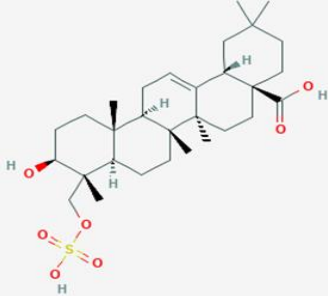
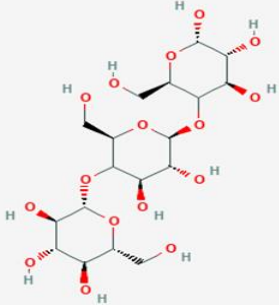
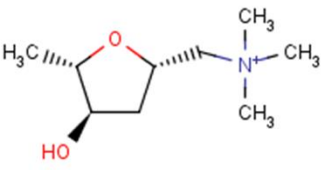
The simple composition (moisture, overall carbohydrates, nutritional fiber, crude fat, ash, nitrogen, and protein) and amino acid contents had been determined in the cultivated mushrooms in several experiments. Mainly amino acids, fatty acids, sterol (mostly ergosterol), linoleic acid, palmitic acid were determined to be present in mushrooms.

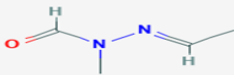
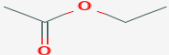
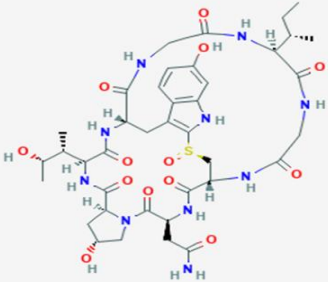
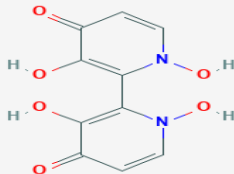
Table 1: Chemical constituents of mushrooms

Name of the chemical constituents	Structure	Mushrooms
1. Fatty acid		<p><i>Agrocybe cylindracea</i>, <i>Coprinus comatus</i>, <i>Lactarius deliciosus</i>, <i>Suillus collinitus</i>, <i>Tricholoma myomyces</i></p>
2. Amino acid		<p><i>Pleurotus ostreatus</i>, <i>Pleurotus eryngii</i>.</p>
3. Ergosterol		<p><i>Agaricus bisporus</i>, <i>Hygrophorus marzuolus</i>, <i>Pleurotus ostreatus</i>, <i>Calocybe gambosa</i>, <i>Lentinus edodes</i>, <i>Boletus edulis</i>.</p>
4. Linoleic acid		<p><i>Boletus reticulatus</i>, <i>Lactarius salmonicolor</i>, <i>Pleurotus ostreatus</i>, <i>Polyporus squamosus</i>, <i>Russula anthracina</i></p>

5. Flavonoid		<i>Pleurotus florida</i> , <i>Pleurotus eous</i> .
6. Palmitic acid		<i>Lepiota excoriata</i> , <i>Agaricus biterquis</i> , <i>Cantharallus cibarius</i> , <i>Pholiota sp</i>
7. Carotenoids		<i>Cantharellus cinnabarinus</i> , <i>Agaricus bisporus</i> , <i>Pleurotus ostreatus</i> , <i>Boletus edulis</i> , <i>Suillus bovinus</i> <i>Tricholoma equestre</i> .
8. Phenol		<i>Agaricus bisporus</i> , <i>Boletus edulis</i> , <i>Calocybe gambosa</i> , <i>Craterellus cornucopioides</i> , <i>Lactarius deliciosus</i> and <i>Pleurotus ostreatus</i> .
9. Vitamins		<i>Pleurotus ostreatus</i> , <i>Lentinula edodes</i> , <i>Pleurotus cystidis</i>

<p>10. Methanol</p>	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{O}-\text{H} \\ \\ \text{H} \end{array} $	<p><i>Pleurotus florida, Pleurotus ostreatus, Agaricus bisporus.</i></p>
<p>11. Carbohydrate</p>		<p><i>Caripia montagnei, Coprinus Atramentarius, Agaricus bisporus</i></p>
<p>12. Reducing sugar</p>	 <p>Glucose Fructose Galactose</p>	<p><i>Pleurotus sajor-caju, Cortinarius glaucopus, Russula delica, Suillus mediterraneensis</i></p>
<p>13. Lipid</p>		<p><i>Lentinula edodes, Volvariella volvacea, Flammulina velutipes, Agaricus bisporus.</i></p>
<p>14. Protein</p>	 <p>(a) Primary structure (b) Secondary structure (c) Tertiary structure (d) Quaternary structure-</p> <p>Hydrogen bond</p> <p>Heme</p> <p>β polypeptide</p> <p>α polypeptide</p> <p>© 2010 Pearson Education, Inc.</p>	<p><i>Agaricus arvensis, Calocybe indica, Volvariella volvacea, Agaricus campestris.</i></p>

<p>15. Lentinan</p>		<p><i>Lentinus edodes</i></p>
<p>16. Polysaccharide</p>		<p><i>Hericium erinaceus, Agaricus bisporus, Antrodia cinnamomea, Pleurotus ostreatus.</i></p>
<p>17. Triterpenoid</p>		<p><i>Ganoderma lucidum, Ganoderma japonicum, Antrodia cinnamomea.</i></p>
<p>18. Beta glucan</p>		<p><i>Ganoderma lucidum, Grifola frondosa, Flammulina velutipes, Trametes versicolor.</i></p>
<p>19. Muscarine</p>		<p><i>Entoloma rhodopolium, Boletus calopus, Boletus luridus</i></p>

<p>20. Gyromitrin</p>		<p><i>Gyromitra esculenta</i>, <i>Gyromitra californica</i>, <i>Gyromitra caroliniana</i>.</p>
<p>21. Ethyl acetate</p>		<p><i>Coprinus comatus</i>, <i>Grifola frondosa</i>, <i>Hypsizygus marmoreus</i>, <i>Phellinus igniarius</i>.</p>
<p>22. Amatoxin</p>		<p><i>Amanita phalloides</i>, <i>Lepiota chlorophyllum</i>, <i>Galerina autumnalis</i></p>
<p>23. Orellanine</p>		<p><i>Cortinarius orellanus</i>, <i>Cortinarius armillatus</i>, <i>Cortinarius rubellus</i></p>

1.5 Rationale of the study

Mushrooms were introduced to mankind a long time ago and they have been progressively explored and utilized for their significant medical advantages, with various collections having distinctive therapeutic properties. Mushrooms are low in energy and fat yet high in protein, sugar, and dietary fibre. Mushrooms contain a wide number of minerals and minor components, for example, potassium, and copper and nutrients, riboflavin, niacin, and folates. They have been utilized as food item for quite a long time due to their extraordinary taste. Aside from being perceived as a nutritious food, certain mushrooms are likewise a significant wellspring of naturally dynamic mixes with possible extra restorative encouragement in Chinese medication. Bioactive secondary metabolites are found in mushrooms such as phenolic compounds, sterols and triterpenes. In vitro and in vivo studies with mushrooms and isolated bioactive constituents have indicated numerous pharmacological impacts, for example, anti-tumour, cell reinforcement, antiviral, hypocholesterolemic and hypoglycemic activity. Daily dietary intake of mushrooms or mushroom items can provide us with huge medicinal advantages. For the stated reasons, this review was an attempt to highlight several pharmacological and nutritional properties of mushrooms.

1.6 Aim of the study

The aim of this review is to compile all possible information on pharmacological and nutritional properties of mushrooms.

1.7 Objectives

The main objectives of this study are given below:

- To overview general information about different kinds of mushrooms
- To compile all possible information on pharmacological and nutritional properties of mushrooms
- To create references for researchers for further investigation.

Chapter 2:

METHODOLOGY

This review has been done by thoroughly reading a wide number of scholarly articles related to the topic and these all are from authentic sources. In addition, these articles were taken from various reliable sources like online database, books, reviewed articles, conference papers according to need. Then, overall information of this review work was taken from those sources and organized in a good manner as it is required. Also, some web pages of some professionals were used as reference here. Some of searching webpages such as PubMed, chem-med, science direct, goggle scholars etc. were used during reviewing this project work. Moreover, citation of this review paper was done in Mendeley by Elsevier as required.

Chapter 3:

OVERVIEW ON PHARMACOLOGICAL AND NUTRITIONAL PROPERTIES OF MUSHROOMS

Pharmacological properties of mushroom:

1.1 Anticancer properties:

More than 2000 types of palatable and additionally therapeutic mushrooms have been distinguished to date, a significant number of which are broadly devoured, animating a lot of exploration on their wellbeing advancing properties. Regardless of the way that β -glucans (homopolysaccharides) are acknowledged to be the major bioactive polysaccharides of mushrooms, various types of mushroom polysaccharides (heteropolysaccharides) also have normal properties. (Rapior, 2006)



Figure 14: Tiger milk mushroom benefits (Adapted from <https://1.bp.blogspot.com>)

Tiger milk mushrooms have gotten a lot of enthusiasm for ongoing years, attributable to its wide-extending ethnobotanical utilizes, and the accomplishment in training of the mushroom. A few

examinations have been started to look at its security and bio pharmacological viability so as to approve its ethnobotanical claims. Exploration discoveries have uncovered that moonshine mushroom sclerotia to contain different organically dynamic substances, for example, polysaccharides, polysaccharides-protein edifices, and β -glucan, which exhibit mitigating, cancer prevention agent, hostile to proliferative and immuno-adjusting impacts

The well-known palatable mushroom *Ganoderma lucidum* (Reishi) has been broadly utilized for the overall advancement of wellbeing and life span in Asian nations. The dried powder of *Ganoderma lucidum* was mainstream as a disease chemotherapy specialist in old China. The creators as of late exhibited that *Ganoderma lucidum* represses constitutively dynamic record factors atomic factor kappa B (NF-kappaB) and AP-1, which brought about the hindrance of articulation of urokinase-type plasminogen activator (uPA) and its receptor uPAR. *Ganoderma lucidum* likewise stifled cell grip and cell relocation of profoundly obtrusive bosom and prostate malignant growth cells, proposing its power to decrease tumor intrusiveness.(Bisen et al., 2010) Subsequently, *Ganoderma lucidum* plainly exhibits anticancer action in tries different things with malignant growth cells and has conceivable remedial potential as a dietary enhancement for an elective treatment for breast and prostate cancer. Be that as it may, as a result of the accessibility of *Ganoderma lucidum* from various sources, it is prudent to test its biologic action.

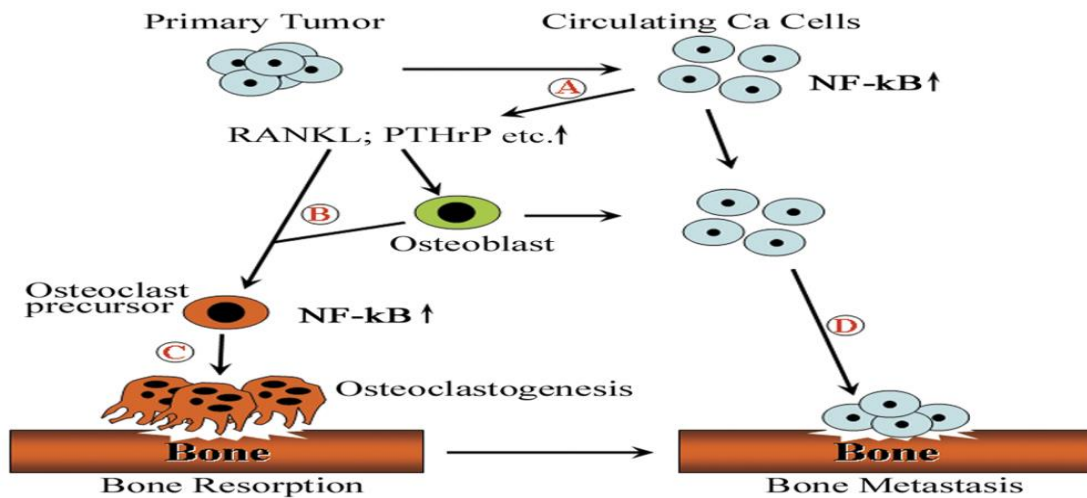


Figure 15: Activation of NF-kappa B Signaling Promotes Growth of Prostate Cancer Cells in Bone (Adapted from <https://journals.plos.org/plosone/article>)

Biochemical and cell biomarkers related with diabetes and weight are additionally employable against various kinds of tumors and contaminations, recommending the likelihood that mushrooms and their polysaccharides may simultaneously ensure against different human ailments. Such biomarkers incorporate antiradical, cancer prevention agent, hostile to glycation, calming, and against α -glucosidase, exercises and improvement of the invulnerable framework.(Friedman, 2016) To animate enthusiasm for this chance, here we will quickly specify chosen concentrates on the anticarcinogenic and anti-infection properties of mushrooms(Kamal Perera & Li, 2011)

A meta-investigation of 8009 patients from randomized controlled preliminaries uncovered that expansion of the immunopotentiator polysaccharide K (PSK) from *Coriolis versicolor* mushrooms to standard chemotherapy expanded the endurance of patients after healing gastric malignancy resection over chemotherapy alone. This investigation affirms the capacity of polysaccharides to incite apoptosis and different types of disease cell demise through immunological components .(Devishree et al., 2017) It is additionally essential that day by day utilization of *Lentinula edodes* improved invulnerability in solid youthful grown-ups and that oral utilization of solvent β -glucans was sheltered in old sound grown-ups and appeared to actuate an expansion in the quantity of circling β -cells .(Badshah et al., 2014)

More than 50 species present immunological potential that display anticancer action in vitro or in creature models, and some of them have been explored in human malignant growths. Malignant growth is a significant reason for death everywhere throughout the world, advancing durable impacts all through the lifetime of the patient. Mushrooms are a wellspring of ergothioneine, selenium, fiber, and a few different nutrients and minerals. They have bioactive mixes utilized in malignant growth treatment due to their antitumor and anticarcinogenic impacts. They have β -glucans, β -proteoglycans, lectins, triterpenes, ergosterol, glutamine, and arginine.(Bisen et al., 2010)

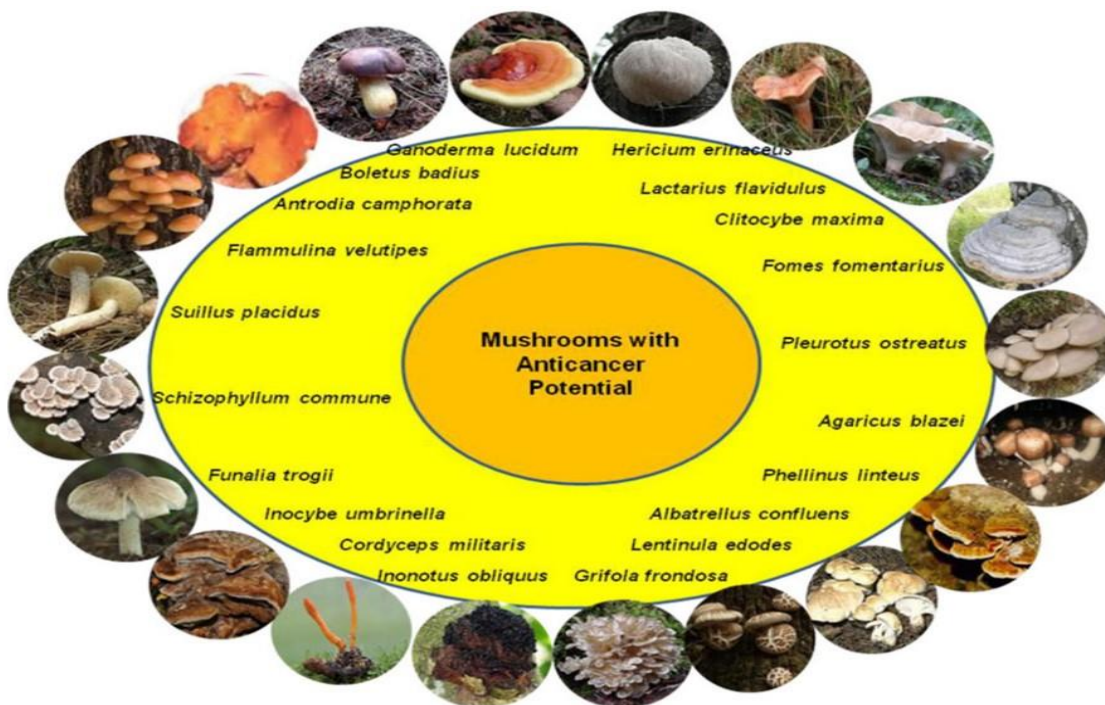


Figure 16: Some medicinal mushrooms with anti-cancer potential (Adapted from <https://www.intechopen.com/media/chapter/70347/media/F3.png>)

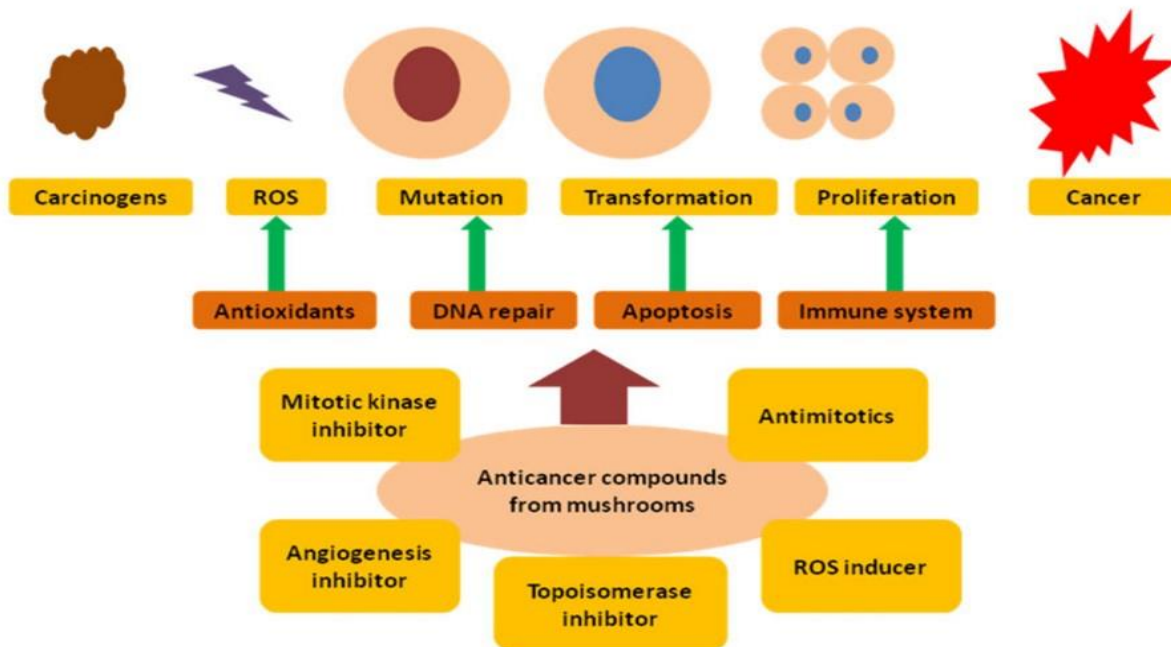


Figure 17: Anti-cancer mechanism of mushroom bioactive compounds (Adapted from <https://media.springernature.com>)

1.2 Anti-oxidant properties:

Cancer prevention agents are intensifying that restrain oxidation. Oxidation is a compound response that can deliver free radicals, in this manner prompting chain responses that may harm the cells of life forms. Cancer prevention agents, for example, thiols or ascorbic corrosive (nutrient C) end these chain responses. Oxidation is basic to many living beings for the creation of vitality to fuel natural procedures. In any case, oxygen-focused free radicals and other reactive oxygen species, that are consistently delivered in vivo, bring about cell demise and tissue harm. Oxidative harm brought about by free radicals might be identified with maturing and maladies, for example, atherosclerosis, diabetes, disease and cirrhosis (Halliwell and Gutteridge, 2009). Albeit practically all creatures have cell reinforcement resistance and fix frameworks that have advanced to secure them against oxidative harm, these frameworks are deficient to prevent the harm altogether (Simic, 2008). Be that as it may, against oxidant enhancements, or nourishments containing cancer prevention agents, might be utilized to support the human body lessen oxidative harm.

Table 2: Some popular mushrooms with their anti-oxidant activity

Mushrooms	Bioactive Compounds	Antioxidant Activity
<i>Agaricus brasiliensis</i>	Crude Se polysaccharide and total soluble Se protein hydroxyl radicals	Scavenging of DPPH and hydroxyl radicals
<i>Cortinarius purpurascens</i>	Rufoolivacin, rufoolivacin C, rufoolivacin D and leucorufoolivacin	Scavenging of DPPH radicals
<i>Ramaria flava</i>	Phenolic compounds	Scavenging of DPPH and OH radicals
<i>Phellinus baumii</i> Pilat	Polysaccharides	Scavenging of hydroxyl, superoxide and DPPH radicals

<i>Pleurotus abalonus</i>	Polysaccharide-peptide complex LB-1b	Exhibition of antioxidant activity erythrocyte hemolysis
<i>Cordyceps taii</i>	Polysaccharides	Scavenging of DPPH, hydroxyl, and superoxide anion radicals, and enhancement of antioxidant enzyme activities
<i>Agaricus bisporus</i>	Polysaccharides, phenolics	Scavenging of superoxide, hydroxyl and DPPH radicals and hydrogen peroxide, enhancement of the activities of antioxidant enzymes in sera, liver, and heart of mice

Table 3: Extraction yields and antioxidant activity values of wild edible mushrooms

Mushroom Species	Extract concentration (mg mL)	Extraction yields (%)	RSA (%)
<i>Pobpotus sguamosus</i>	3.46	17.3	95.35±0.10
<i>Pleurotus ostreatus</i>	2.72	13.6	96.16±0.42
<i>Amanita ceciliae</i>	4.65	23.2	95.35±0.10
<i>Lactarius salmonicolor</i>	2.90	14.5	94.17±0.31
<i>F. relutipes</i> var. <i>relutipes</i>	4.45	22.2	95.27±0.00
<i>Russula anthracina</i>	2.31	11.5	90.62±0.73
<i>Agrocybe cylindracea</i>	2.82	14.1	95.79±0.10
<i>Boletus reticulatus</i>	3.17	15.8	94.83±0.84
<i>Tricholoma myomyces</i>	2.97	14.8	84.93±0.42

Cantharellus cibarius	3.34	16.7	95.64±0.10
Armillaria mellea	4.51	22.5	96.16±0.00
Suillus collinitus	2.91	14.5	71.94±1.04
Lactarius deliciosus	2.56	12.7	92.02±0.21
Rhizopogon roseolus	2.61	13.0	88.11±0.52
Coprinus comatus	5.09	25.4	94.61±0.10
Chlorophyllum rhacode	2.35	11.7	70.46±0.21
BHT	3.00		98.24

RSA: Radical scavenging activity

Mushrooms accumulate an assortment of auxiliary metabolites, counting phenolic mixes, polyketides, terpenes and steroids. Among the cancer prevention agent mixes, polyphenols have picked up significance because of their huge exhibit of natural activities that incorporate free radical searching, metal chelation protein balance exercises and hindrance of LDL oxidation, among others.(Yang et al., 2002) The term polyphenol alludes to a mind-boggling gathering of exacerbates that remembers for their structure a sweet-smelling ring bearing at least one hydroxyl gatherings. They include straightforward phenols, for example, phenolic acids and subordinates, just as mind-boggling structures, for example, flavones, flavonoids or anthocyanins, among others. Some normal consumable mushrooms have as of now been found to have cancer prevention agent action, which is all around connected with their all-out phenolic content. (Sánchez, 2017)Additionally, over the most recent couple of years, an expanding enthusiasm for the utilization of mushrooms has emerged, because of their raised polyphenol focus, which connects with a raised cancer prevention agent action. A few investigations breaking down the absolute phenols and cell reinforcement action of new and cooked wild and business mushrooms have been distributed.(Bisen et al., 2010)

1.3 Anti -bacterial properties

During a time where we are getting progressively worried about bacterial advancement and the adequacy of anti-infection agents, there is an on-going requirement for novel antimicrobial mixes to outmaneuver microscopic organisms and different microbes.

A group of specialists from the University of Auckland and Dr Peter Buchanan from Manaaki Whenua – Landcare Research have as of late indicated that few assortments of eatable mushrooms, five of which are local and were gathered from New Zealand woodlands and parks, have antibacterial and cancer prevention agent properties. (Ren et al., 2014)

In late exploration, the earthy colored clam mushroom (*Pleurotus australis*), has been appeared to repress the development of five regular bacterial strains. Eight types of mushroom were chosen for testing. Four of the mushroom species referred to early Māori as eatable mushrooms: *Auricularia cornea* Ehrenb.; *Calvatia gigantea*; *Hericium coralloides*; and *Pleurotus australis*. Of the eight assortments tried for their capacity to repress the development of five basic bacterial strains, one of the best end up being the New Zealand local earthy colored clam mushroom (*Pleurotus australis*). The earthy colored shellfish mushroom likewise had the most elevated cell reinforcement movement. (Rapior, 2006)

Mushrooms, the fruiting body of a macro fungus, have been utilized since the beginning for therapeutic purposes. For sure, in present day times, a few anti-toxins have just been segregated from different mushrooms and micro fungi (counting penicillin and griseofulvin, which are disconnected from micro fungi). Nonetheless, there are a huge number of mushroom assortments just as other organisms, just a bunch of which have been contemplated, that can possibly have anti-infection, antifungal, antiviral and additionally antiprotozoal properties, just as other medical advantages. (Alves et al., 2012)

In this examination, the analysts utilized paper circle dissemination and microdilution strategies to gauge antibacterial action. They likewise contrasted the two procedures with figure out which technique was predominant and discovered that the microdilution strategy was more dependable than the plate dissemination technique in recognizing antibacterial movement. (Alves et al., 2012)

The concentrates they expelled from the test mushrooms are called polysaccharides. Polysaccharides are answerable for the unbending nature and morphological properties of the parasitic cell divider. Many present powerful movements against regular strains of microscopic organisms. Organisms produce polysaccharides, phenolics and different metabolites that speak to

expected wellsprings of novel common cancer prevention agents," compose the scientists in their distributed paper. (Rezaeian & Pourianfar, 2016)

The analysts found that the polysaccharides separated from the mushroom *Cordyceps sinensis* hindered the development of the microscopic organisms *Bacillus subtilis* and *Streptococcus epidermidis*, and the mushroom *P. australis* separate confined the development of *S. epidermidis*. The cell reinforcement movement of the mushroom removes was evaluated by estimating their radical searching action. (Hatvani, 2001) The polysaccharides for every one of the eight mushroom species indicated radical rummaging exercises. Nonetheless, *P. australis* displayed the most noteworthy cell reinforcement action. The scientists clarify that weight on the body because of maturing, corpulence and adverse way of life decisions is a critical medical problem, which frequently appears as oxidative harm to tissues by free radicals. Cell reinforcements are intensifying that can ensure natural frameworks against the conceivably destructive impacts of these free radicals.

The analysts finished up, the antibacterial and cell reinforcement exercises identified here warrant examination for their capability to improve human wellbeing, and application as dietary enhancements. (Alves et al., 2012)



Figure 18: Oyster mushroom which is enriched with antibacterial properties (Adapted from <https://live.staticflickr.com>)

1.4 Anti-inflammatory properties:

Mushroom *Inonotus obliquus* (*I. obliquus*) was a white-decay organism having a place with the group of Hymenochaetaceae Donk, habiting as a parasitism on birches vulnerable scopes of Europe and Asia (Hawksworth, Kirk, Sutton, and Pegler, 1995). In Russian, *I. obliquus* had been utilized as a conventional solution for fixing different illnesses, for example, malignancy, cerebrovascular infections, diabetes, gastrointestinal sicknesses since the sixteenth century (Choi et al., 2010; Sun, Ao, and Lu, 2008). Triterpenes, polysaccharides, polyphenols and melanin were found in *I. obliquus*, which were answerable for the anticancer and antitumor exercises (Handa, Yamada, and Tanaka, 2012; Song et al., 2008), calming capacity (Van et al., 2009), antioxidant impact (Ma, Chen, Zhang, Zhang, and Fu, 2012), hypoglycemic capacity (Lu, Chen, Dong, Fu, and Zhang, 2010), immunomodulatory action (Fan, Ding, Ai, and Deng, 2012) and against mutagenic legitimate ties (Ham et al., 2009). Nonetheless, the majority of the bioactive examinations were for the most part centered around the concentrates or divisions and the powerful constituents were not very much represented. Incessant aggravation was ensnared in the pathogenesis of arrangement of sicknesses including atherosclerosis, weight, metabolic syndrome, diabetes, neurodegenerative ailments, and even a few sorts of malignancies (Moro et al., 2012). Numerous sorts of normal items were examined on the mitigating properties utilizing the LPS-initiated macrophage model. *I. obliquus* was a conventional restorative mushroom and it had been accounted for to have calming potential on the concentrates. A few examinations on methanol concentrate and ethanol separate from *I. obliquus* had appeared to hinder macrophage capacities by diminishing the creation of provocative middle people, for example, NO, prostaglandins (PGE₂) and a few cytokines (Kim et al., 2007; Park et al., 2005; Van et al., 2009). In any case, there were no reports concerning the dynamic com-beats on the calming action. Steroids and triterpenes mixes had been accounted for to show fundamentally against inflammatory capacity in other regular assets (Chang, Wen, Wang, and Duh, 2008; Jiang and Dusting, 2003). Be that as it may, the counter inflame-conservative exercises of triterpenes mixes in *I. obliquus* were as yet obscure.



Figure 19: *Inonotus obliquus* mushroom (Adapted from <https://st4.depositphotos.com>)

Mushrooms are enriched with anti-inflammatory elements, for example, polysaccharides, phenolic and indolic compounds, myco-steroids, unsaturated fats, carotenoids, nutrients, and biometals. Metabolites from mushrooms of the Basidiomycota taxon have cell reinforcement, anticancer, and most essentially, mitigating properties. (Duru & Çayan, 2015)

1.5 Anti-diabetic properties

Mushrooms are significant dietary parts in certain societies, devoured in every day diet as advantageous food since former times (Soković et al., 2016). Mushroom separates are progressively devoured in view of their wellbeing gainful impacts, including the upgrade of invulnerable capacity and antitumor movement (Popović et al., 2013). It is affirmed that mushroom separates contain differing mixes, for example, alkaloids, filaments, lectins, protein, polyphenols and polysaccharides, which are adding to their organic exercises (Popović et al., 2013). Mushrooms are thought to apply numerous pharmacological functions, for example, antitumor, immunomodulatory, antigenotoxic, antioxidant, mitigating, hypocholesterolemia, antihypertensive, antiplatelet-conglomerating, antihyperglycemic, antimicrobial and different exercises (Lindequist, 2013; Paterson and Lima, 2014). Mushrooms as useful food and dietary enhancements can help in the intercession of sub-wellbeing states and may forestall the out and out results of hazardous sicknesses. An equilibrated diet connected with the mushroom utilization has a bit of leeway of the nourishing/restorative feature of mushrooms (Soković et al., 2016) and their pharmacological applications. The expression "mushroom" is utilized here for a

restorative/eatable fruiting group of higher parasites. Diabetes mellitus is a constant issue of metabolism followed by unusual ascent in plasma glucose levels, as a result of unequilibrated insulin creation or potentially lack of care toward the impact of this hormone in signal transduction of cell receptors. These metabolic changes are joined by alterations in sugar, lipid and protein metabolism. The greater part of the diabetes type 2 intricacies in patients are because of hyperglycemia as their primary driver (Ortiz et al., 2007; Shobana et al., 2009). One of the viable systems for diabetes type-2 oversee ment is the hindrance of complex polysaccharide hydrolysis by pancreatic α -amylase and ingestion confinement of glucose by hindering intestinal α -glucosidase protein. Acarbose, miglitol, voglibose are business drugs utilized for α -glucosidase hindrance in the control of the diabetic sickness (Saito et al., 1998). Incessant α -amylase and α -glucosidase restraints might be helpful in the administration of type-2 diabetes and heftiness (Melo et al., 1999; Koike, 2005). The medications must be utilized as reversible inhibitors of α -amylase and α -glucosidase for the treatment of diabetic patients show symptoms, for example, abdominal distension, meteorism, swelling, fart and potentially looseness of the bowels (Fujisawa et al., 2005).

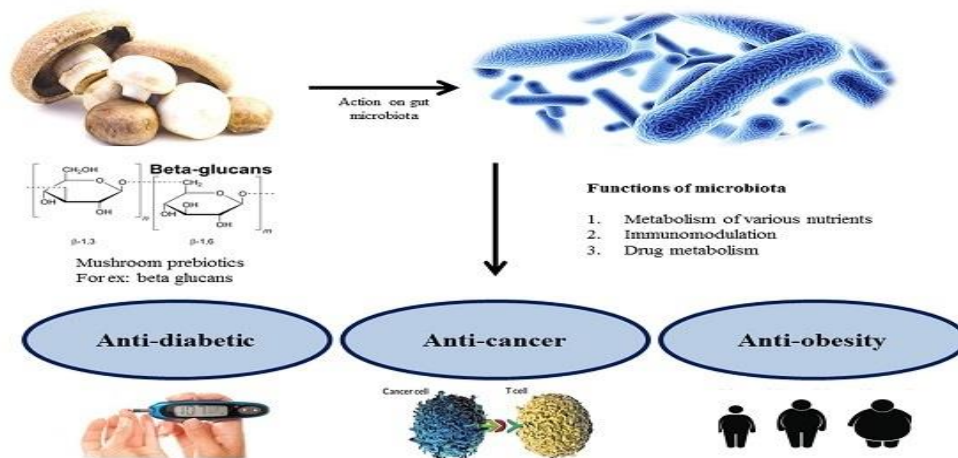


Figure 20: Activity and function of beta glucan (Adapted from <https://external-preview.redd.it>)

Table 4: Clinical studies carried out with mushrooms for management of DM

Biological source	Extract/ Fraction/ Isolated compound	Dose	Type of trial	Observations
<i>Agaricus sylvaticus</i> Schaeff. (Agaricaceae) Sun Mushroom	Fruiting bodies	30mg/kg; Dietary supplementation	Random-ized, double-blind, placebo-controlled clinical trial on 56 patients with colorectal cancer	Significant reduction of fasting plasma glucose, total cholesterol, creatinine, aspartate amino transferase, alanine amino transferase, systolic blood pressure
<i>Grifola frondosa</i> (Dicks.) Gray (Fomitopsidaceae) Hen of the woods, Maitake	<i>Grifola frondosa</i> polysacchande caplets (MFCs) containing active SX-fraction.		5 patients with type 2 diabetes	Improved glycemic levels. One patient showed complete glycemic control with MFCs; whereas others showed over 30% decline in their serum glucose levels with MFCs in 2 to 4 weeks
<i>Pleurotus ostreatus</i> (Jacq.) P. Kumm. (Pleurotaceae) Oyster mushroom	Powdered fruiting bodies	Dietary supplementation	120 patients with type 2 diabetes	Significant association between mushroom supplementation and gradual reduction in hyperglycemia in type 2 diabetic subjects

This table's data was collected from the article "An insight into antidiabetic properties of six medicinal and edible mushrooms: Inhibition of α -amylase and α -glucosidase linked to type- 2 diabetes"(Stojkovic et al., 2019)

1.6 Anti-allergic properties

For a considerable length of time, mushrooms have been viewed in the East as preeminent wellbeing tonics. In normal food stores, mushrooms are cutting out a specialty as interesting dietary enhancements separated from nutrients and botanicals. A huge number of logical examinations exhibit their unrivaled capacity to help invulnerability, cardiovascular wellbeing, glucose, sexual capacity and vitality. In various analyses and clinical preliminaries, mushrooms have likewise exhibited antiviral, antibacterial, calming and hostile to allergenic activities.

A few investigations even recommend that mushrooms containing psilocybin may have the option to help individuals living with psychological well-being conditions, for example, nervousness and gloom. With respect to the viability of treating psychological wellness conditions utilizing shrooms Canada and different nations have discovered that utilizing psychedelic drugs like enchantment mushrooms can assist patients with improving their passionate preparing. Additionally, through micro dosing enchantment mushrooms, patients have discovered that they can reconnect with their emotions and arrive at a feeling of viewpoint.

Subsequently, you may likewise be astounded to discover that specific mushrooms can be powerful medicines for sensitivities and other respiratory issues. Yet, when you take a gander at their various activities, it bodes well since mushrooms address a few basic elements engaged with the unfavorably susceptible reaction. In this way, knowing precisely what the substance contains

before devouring it, could end up being advantageous to your wellbeing. Something like an Ehrlich test unit can assist you with establishing the substance you're taking, just as its fixings so that on the off chance that you do have hypersensitivities, you'll have all the data you need in a lot of time. Allergy, originates from an extreme touchiness to substances in the condition that, in many people, cause no issue. These ecological substances, known as allergens, are breathed in or enter the skin. The most well-known allergens are earth, dust, dust, tobacco smoke and creature dander. The culpable substance, likewise called an antigen, triggers an invulnerable reaction known as an unfavorably susceptible or overly sensitive response. The most well-known unfavorably susceptible issues are roughage fever, asthma, skin inflammation and hives. The body's creation of histamine and other compound middle people in these responses may cause responses running from gentle to perilous.

Royal Sun Mushroom

This organism has been concentrated as a controller of the safe framework and it has been viable in instances of hypersensitivity, invulnerability issues and irresistible procedures. It is utilized as a wholesome enhancement in oncological integrative medication

Sensitivities

- Equalizations the insusceptible reaction
- Lifts the normal insusceptible reaction
- It's rich assortment of polysaccharides act by preferring the body's safe reaction.
- Fortifies the body's first safeguard hindrance



Figure 21: Royal Sun Mushrooms (Adapted from <https://hifasdaterra.com>)

Reishi

It is a ground-breaking calming and regular cancer prevention agent. The Reishi mixes make it an extraordinary mitigating and one of the most remarkable regular cell reinforcements that exist. Therapeutic organism concentrated in instances of a sleeping disorder, stress, tension and gloom.

Oxidation

It is known as the organism of unceasing youth for its capacity to battle free radicals that cause cell oxidation and maturing.

Rest issues

It advances passionate parity, smoothness and causes you nod off.



Figure 22: Reishi mushrooms (Adapted from <https://hifasdaterra.com>)

1.7 Anti - viral properties

Therapeutic mushrooms are everywhere nowadays, from colors and pills to espresso and lotions. While they're certainly having a second, mushrooms are the same old thing; many have been utilized in antiquated medication for centuries. There are many types of mushrooms, and their indicated benefits run from supporting liver and heart wellbeing to improving vitality.

One of the most powerful impacts of numerous therapeutic mushrooms is their solid antiviral and invulnerable upgrading properties. A few mushrooms, truth be told, have been demonstrated to be successful against forestalling and treating respiratory infections like the basic cold and even the influenza infection, which is noteworthy considering the exceptionally irresistible nature of infections and that they are famously hard to forestall and treat because of their capacity to effectively change. (Dhar et al., n.d.)

As an Asian culinary staple, shiitake mushrooms are effortlessly found in nearby markets. One of their most critical qualities is their antiviral exercises, said to battle the hepatitis C infection, human immunodeficiency infection, the herpes simplex infection, and flu.



Figure 23: Shiitake Mushrooms (Adapted from <https://ucarecdn.com>)

The kingdom of Fungi speaks to a rich wellspring of different naturally active compounds. Here is a table of Fungal orders with positive antiviral activities on the next page.

Table 5: Fungal orders with positive antiviral activities

Phylum	Order	Virus*
Ascomycota	Amphisplaaeriales	EV711, HIV-I1
	Capnodiales	H1N11
	Chaetothyriales	HIV-I4
	Diaporthales	HIV-14, HSV-11
	Dothideales	HSV-15
	Eurotiales	EV712, DENV3, H1N12, HIV-14, H3N22, JEV1, Zika 2 virus
	Glomerellales	HIV-14

	Helotiales	HSV-11
	Hypocreales	EV712, HIV-14, HSV-11, H1N11'4, H3N21'4
	Microascales	HIV-14
	Ophiostomatales	HIV-14
	Pezizales	HIV-14
	Pleosporales	HIV-14, HSV-

Basidiomycota	Agaricales	BoHV-11,3, H1N12, HCV5, HBV4'5, HCV5, HIV-12, HSV-11'2'3, HSV-1 2 - 2 ' , influenza 2 2 A , poho, Rsv1,2, vaccinia1 , VS1 , VZV2, WEE2
	Boletales	HIV-14, HSV-5 1 1 , vaccinia, VS1
	Cantharellales	HIV-14, vaccinia1
	Gomphales	vaccinia1
	Hymenochaetales	influenza A and B4
	Polyporales	BoHV-11, EBV-A3, EV712,

1.8 Lipid lowering properties

Examination recommends a potential relationship exists between a compound in mushrooms called eritadenine and lower cholesterol esteems. Nonetheless, research is as yet continuous and should be assessed in human subjects. The investigations use shiitake mushrooms since they are known to be high in eritadenine. Sadly, it is hazy if other mushroom assortments contain this valuable compound. In any case, mushrooms can be a piece of a solid eating regimen. By subbing mushrooms in plans that call for meat, you can diminish your complete cholesterol consumption. Regardless of whether you can supplant half of the meat in a dish with mushrooms, this will incredibly decrease your utilization of cholesterol.(Friedman, 2016)

Sadly, a large portion of the investigations used to inspect the utilization of mushrooms in bringing down elevated cholesterol or fatty oils have been performed on creatures, for example, rodents, hares, and mice. The vast majority of these examinations just inspected shiitake (*Lentinus edodes*), Portobello (*Agaricus bisporus*), or shellfish mushrooms (*Pleurotus ostreatus*) — a portion of the more well-known mushrooms found in markets and cafés. These creatures were taken care of a level of dried mushrooms in their eating routine over a time of one to two months. In a portion of these investigations, it created the impression that:

- I. Absolute cholesterol levels were decreased between 10 percent and 65 percent.
- II. Fatty oil levels were brought by up down to 70 percent.

III. LDL cholesterol levels were brought down somewhere in the range of 5 and 54 percent.

IV. HDL cholesterol levels didn't have all the earmarks of being influenced in many investigations.

It's essential to take note of that lone two or three investigations took a gander at HDL, LDL, and fatty substance levels, while most examinations took a gander at the impact of mushrooms on all out-cholesterol levels.

If we look at the results of mushrooms seemed, by all accounts, to be portion reliant, which means the higher measure of mushrooms devoured would bring about the biggest decrease in lipids. Moreover, the most reductions in lipids were noted in creatures likewise expending an eating routine that was high in fat or cholesterol. (Ibrahium, 2014)

There are not many human examinations analyzing the impact of mushrooms on cholesterol and fatty substance levels. These investigations are little and clashing:

In one examination, five individuals ingested 10 to 15 grams of dried clam mushrooms day by day over a time of a month. This brought about a normal reduction in complete cholesterol levels by up to 30 percent. (Dhuldhaj, 2018)

In another little investigation, 20 HIV-positive people with high lipid levels brought about by antiretroviral treatment expended 15 grams of freeze-dried shellfish mushrooms every day for two

months. Toward the finish of the examination, there was no critical impact on cholesterol levels notwithstanding, fatty substance levels diminished by a normal of right around 19 percent.(Dhuldhaj, 2018)

There have all the earmarks of being a couple of fixings found in mushrooms that may add to their lipid-bringing down impacts:

- I. Beta-glucan, a type of solvent fiber, are found in different focuses in mushrooms. It is imagined that beta-glucan may meddle with the assimilation of cholesterol into the circulatory system.
- II. Eritadenine is thought to bring down lipid levels by adjusting the manner in which certain lipids are made in the liver.
- III. Mevinolin, another fixing found in certain mushrooms, capacities by restraining HMG CoA reductase, a key compound used to make cholesterol in the body.

These cholesterol-bringing down synthetics fluctuate in sums between various types of mushrooms and are as of now being researched as likely medicines for forestalling coronary illness.

1.9 Neuroprotective properties

Hericium erinaceus, a palatable and restorative mushroom, shows different pharmacological exercises in the anticipation of dementia in conditions, for example, Parkinson's and Alzheimer's

infection. The current examination investigated the neuroprotective impacts of *H. erinaceus* mycelium polysaccharide-improved watery concentrate (HE) on a l-glutamic corrosive (l-Glu)-instigated separated PC12 (DPC12) cell apoptosis model and an AlCl₃ joined with d-galactose-prompted Alzheimer's infection mouse model. The information uncovered that HE effectively initiated PC12 cell separation. A 3 h HE brooding at dosages of 50 and 100 µg/mL before 25 mM of l-Glu adequately turned around the decrease of cell practicality and the upgrade of the atomic apoptosis rate in DPC12 cells.(Sajon et al., n.d.) Contrasted and l-Glu-harmed cells, in PC12 cells, HE smothered intracellular receptive oxygen species collection, blocked Ca²⁺ over-burden and forestalled mitochondrial layer potential (MMP) depolarization. In the Alzheimer's sickness mouse model, HE organization upgraded the flat and vertical developments in the autonomic movement test, improved the perseverance time in the rotarod test, and diminished the departure inertness time in the water labyrinth test. It additionally improved the focal cholinergic framework work in the Alzheimer's mice, exhibited by the way that it portions conditionally upgraded the acetylcholine (Ach) and choline acetyltransferase (ChAT) fixations in both the serum and the nerve center. Our discoveries give trial proof that HE may give neuroprotective contender to treating or forestalling neurodegenerative ailments.

Neuro-protective benefits of mushrooms:

1. Protects against dementia
2. Helps to relieve mild symptoms of depression and anxiety
3. May Speed Recovery from Nervous System Injuries
4. Reduces Inflammation and Oxidative Stress
5. Boosts the Immune System
6. Reduces Heart Disease Risk

The sensory system comprises of the cerebrum, spinal line and different nerves that movement all through the body. These parts cooperate to impart and communicate signs that control pretty much every substantial capacity.

Wounds to the cerebrum or spinal rope can be destroying. They frequently cause loss of motion or loss of mental capacities and can set aside a long effort to mend.

In any case, research has discovered that lion's mane mushroom concentrate may help speed recuperation from these sorts of wounds by invigorating the development and fix of nerve cells.

Truth be told, lion's mane mushroom remove has been appeared to decrease recuperation time by 23–41% when given to rodents with sensory system wounds. (Neifar et al., n.d.)

Lion's mane concentrate may likewise help lessen the seriousness of mind harm after a stroke.

In one investigation, high dosages of lion's mane mushroom separate given to rodents following a stroke helped decline irritation and lessen the size of stroke-related cerebrum injury by 44%.



Figure 24: *Lion's mane mushroom* (Adapted from <https://thewickedgoodfarm.com>)

1.10 Sedative properties

Tasty, exquisite mushrooms support our lay down with elevated levels of nutrient D, selenium and potassium. One-half cup of cooked mushrooms gives around 1/3 of your everyday selenium consumption, just as high measures of nutrients B2 and B3.

Button (otherwise known as Portobello/Crimini) mushrooms have additionally been found to control aggravation and to give defensive advantages to your insusceptible and cardiovascular frameworks.(Singha et al., 2017) Oyster and shiitake mushrooms additionally show significant levels of resistance boosting beta-glucans.



Figure 25: Mushrooms with sedative properties (Adapted from <https://i0.wp.com/www.groceryuncle.com>)

Mushrooms will help in giving us strength. Mushrooms are plentiful in B nutrients: riboflavin [B2], folate [B9], thiamine [B1], pantothenic corrosive [B5], and niacin [B3]. These helps the body use strength from the food we expend and produce red platelets, which convey oxygen all through the body.

1.11 Immune function properties

Mushrooms contain incredible exacerbates that improve and balance your body's capacity to battle malady and remain solid. These extravagant organisms are jam-pressed with mending cancer

prevention agents and calming parts that obliterate contaminations, hinder maturing, and recover nerve cells.

Prestigious for its enemy of histamine and mitigating properties, reishi mushroom has additionally indicated the capacity to invigorate macrophages (a kind of white platelet) to create more tumor corruption factor (TNF-alpha) to bring about enemy of tumor movement.

Mushrooms are plentiful in the B nutrients: riboflavin, niacin, and pantothenic corrosive. The mix secures heart wellbeing. Riboflavin is useful for red platelets. Niacin is useful for the stomach related framework and for keeping up solid skin.

Exploration shows that mixes in chaga mushroom show natural activity against a few sorts of infections, and furthermore forestall replication of different infection types. It even blocked strains of herpes from entering cells.



Figure 26: *Different immune function properties of mushrooms (Adopted from <https://www.google.com>)*

Maitake is a culinary and therapeutic mushroom that has demonstrated enemy of malignancy movement on bosom disease, melanoma, and hepatoma cells in creature examines. Proteoglycan, a segment of maitake, has been related with the resistant invigorating impacts of the mushroom. In mouse models, proteoglycan has been appeared to diminish mammary tumor cell behavior. Further, in-vitro and creature contemplate, polysaccharides found in maitake have been appeared

to apply hostile to viral movement against hepatitis B and human immunodeficiency infection (HIV). (Carvalho et al., n.d.)

The turkey tail mushroom gets its name from the tan and earthy colored rings on its surface, comparable in appearance to the tail plumes of a turkey. In conventional medication, turkey tail has been utilized remedially for contagious diseases, malignancy, and AIDS (AIDS). Contemporary research in creature models of bosom malignancy proposes that *C. versicolor* applies an enemy of tumor and hostile to metastasis impact, demonstrating that it might diminish the danger of creating optional dangerous developments. Polysaccharide-K (PSK), a restrictive detailing of turkey tail, is affirmed in Japan as an integral malignant growth treatment.(Deepalakshmi & Mirunalini, 2014)

Hericium erinaceus is generally known as lion's mane mushroom because of its white, hide like appearance. Creature models have exhibited that lion's mane may advance valuable gut microbiota development and be related with decreased colon tissue harm in instances of provocative gut illness (IBD). The analysts propose that lion's mane may help control the safe framework and improve the strength of people with IBD, notwithstanding, clinical preliminaries are expected to affirm this in people.



Figure 27: Mushrooms with immune function properties (Adapted from <https://cdn.drweil.com>)

2. Nutritional properties of mushroom:

Mushrooms are edible fungus which could offer numerous crucial nutrients. There are many types of mushroom which have various compositions and dietary profiles. Edible mushrooms are a tremendous supply of proteins, minerals, polysaccharides, unsaturated fatty acids, and secondary metabolites.(Verma & Singh, n.d.) Numerous researches have supplied proof for the protecting outcomes of fit to be eaten mushrooms towards diverse continual diseases. Mushrooms are an

incredible supply of nutrients, e.g. B nutrients and nutrition D, and minerals, e.g. phosphorus, magnesium, selenium, copper, and potassium, and also are wealthy in nutritional fiber, chitin and β -glucans.(Ergönül et al., n.d.) Humans have, for centuries, fed on mushrooms now no longer simplest for vitamins and flavoring however additionally for his or her restoration properties. Numerous researches have proven that mushrooms are a wealthy supply of bioactive compounds, e.g. phenolic and flavonoid compounds, that exert antioxidant properties, and those may be useful to human health. Mushrooms should assist in decreasing the danger of diseases, which includes Parkinson’s, Alzheimer’s, hypertension, stroke, and cancer, in addition to act as an antibacterial, immune device enhancer, and cholesterol-decreasing agents. Here some nutritional properties of mushrooms are discussed below:

Table 6: Quantity of nutritional elements present in mushrooms

Nutrient	Quantity of nutrient in 1 cup of mushrooms	Recommended daily intake
Energy (calories)	21.1	1600-3200
Protein (g)	3	46-56
Carbohydrate (g)	3.1	130
Calcium (mg)	2.9	1000-1300
Iron (mg)	0.5	8-18
Magnesium (mg)	8.6	310-420
Phosphorus (mg)	82.6	700-1250
Potassium (mg)	305	4700
Sodium (mg)	4.8	2300
Zinc (mg)	0.5	8-11
Copper (mcg)	305	890-900
Selenium (mcg)	8.9	55
Vitamin C (mg)	2	65-90
Vitamin D (mg)	0.2	15
Folate (mcg DFE)	16.3	400
Choline (mg)	16.6	400-450

2.1 Source of Vitamin B:

Mushrooms additionally incorporate some of B nutrients, such as thiamine, riboflavin, B-6, and B-12. Mushrooms are wealthy withinside the B nutrients: riboflavin, niacin, and pantothenic acid. The combination facilitates defend coronary heart health. Riboflavin is ideal for erythrocytes. Niacin is true for the digestive device and for keeping wholesome skin. B nutrients assist to offer power with the aid of using breaking down proteins, fat and carbohydrates. B nutrients additionally play a crucial function withinside the anxious device.(Souilem et al., 2017) Mushrooms are wealthy in B nutrients that at once effect power levels, mind feature, and cell health, for that reason gambling a crucial function in right immune feature and well-being. Thiamine (B1) and riboflavin (B2) permit the frame to use carbohydrates as power. Niacin (B3) is ideal for the digestive device while pantothenic acid (B5) is an important nutrient for the anxious device. Folate(B9) assists in forming red blood cells and cobalamin (B12) facilitates make DNA and promotes wholesome body cells. (Scuto et al., n.d.)As it turns out, mushrooms are one of the few certainly taking place non-animal nutritional of B12. On the other hand, researchers have discovered that dried shiitake mushrooms as well as black trumpet mushrooms, golden chanterelle mushrooms, and lion's mane mushrooms have appreciably excessive quantities of B12.

2.2 Source of Zinc:

Mushrooms are rich source of zinc. Zinc is observed in cells for the duration of the body. It plays most important role for the body's defensive (immune) machine to nicely work. It acts in the capacity in cell division, cell development, wound mending, and the breakdown of sugars. Zinc is likewise wanted for the senses of odor and taste. Zinc content of some mushrooms per 100 gm are given below:

Table 7: Zinc content in different types of mushrooms

Mushrooms	Content of Zinc (mg)
Maitake (dried)	6.9
Shiro-kikurage (dried)	3.6
Shiitake, Hoshi-shiitake (dried)	2.3
Kikurage (dried)	2.1
Oyster mushroom (boiled)	1.4
Common mushroom (canned in brine, solids)	1
Oyster mushroom (raw)	1
Usuhiratake (raw)	0.9
Matsutake (raw)	0.8
Maitake (raw)	0.8
Honshimeji (raw)	0.8
Arage-kikurage (dried)	0.8
Matsutake (canned in water)	0.7
Maitake (boiled)	0.7
Eringii (raw)	0.7
Kuroawabitate (raw)	0.7
Yanagimatsutake (raw)	0.6
Common mushroom (boiled)	0.6
Tamogitake (raw)	0.6
Winter mushroom (bottled in seasoning)	0.6
Winter mushroom (boiled)	0.6
Winter mushroom (raw)	0.6
Nameko (canned in brine)	0.5
Nameko (raw)	0.5
Bunashimeji (boiled)	0.5
Bunashimeji (raw)	0.5
Shiitake, Nama-shiitake (boiled)	0.5

Common mushroom (raw)	0.4
Numerisugitake (raw)	0.4
Nameko (boiled)	0.4
Hatakeshimeji (raw)	0.4
Shiitake, Hoshi-shiitake (boiled)	0.4
Shiitake, Nama-shiitake (raw)	0.4
Shiro-kikurage (boiled)	0.3
Kikurage (boiled)	0.2
Arage-kikurage (boiled)	0.1

2.3 Source of Copper:

Mushroom is a good source of copper. Copper enables our body to produce erythrocytes that are used to supply oxygen all around the body. The mineral is likewise crucial to different tactics withinside the body, like retaining wholesome bones and nerves.(Cheung, 2010) Even after being cooked, a 1-cup serving of mushrooms can offer approximately one third of the everyday endorsed quantity of copper. Copper content in 100g of mushrooms are given below:

Table 8: Copper content in different types of mushrooms

Mushrooms	Content of Copper (mg)
Shiitake (dried)	5.165
Shiitake (cooked)	0.896
Morel (raw)	0.625
Italian, or Crimini (raw)	0.5
Portabella	0.389
Chanterelle (raw)	0.353
Portabella (exposed to ultraviolet light, raw)	0.286

Maitake (raw)	0.252
Oyster (raw)	0.244
Shiitake (raw)	0.142
Enoki (raw)	0.107

2.4 Source of Potassium:

Intaking mushroom is a good choice for getting a great amount of potassium. Potassium is extraordinarily essential in terms of heart, muscle, and nerve feature. There is approximately as plenty potassium in 2 third cup of cooked Portobello mushroom as there may be in a medium-sized banana. Potassium aids withinside the upkeep of regular fluid and mineral balance, which facilitates manipulate blood pressure. It additionally performs a function in ensuring nerves and muscles, which include the heart, feature properly.

Table 9: Potassium content in different types of mushrooms

Mushrooms	Content of Potassium (mg)
Shiitake (dried)	1534
Chanterelle (raw)	506
Italian, or Crimini (raw)	448
Portabella (grilled)	437
Oyster (raw)	420
Morel (raw)	411
Portabella (exposed to ultraviolet light, raw)	364

2.5 Low fat:

Mushroom is mainly a fat free and low carbohydrate food. It has simplest a minuscule quantity of fat, maximum of that is polyunsaturated fat. As a result, mushrooms are taken into consideration as a heart-healthy meals choice. It is a good choice for the people who are health conscious.

Table 10: Low fat content in different types of mushrooms

Mushrooms	Content of Low fat (g)
Shiitake (dried)	0.99
Portabella (grilled)	0.58
Morel (raw)	0.57
Chanterelle (raw)	0.53
Shiitake (raw)	0.49
Oyster (raw)	0.41

2.6 Source of polysaccharide:

Polysaccharides are one of the most important components of mushroom. It is mainly found in medicinal mushrooms and that they are normally indexed on many medicinal mushroom products. Fungi can contain little amounts of polysaccharide. However, the first polysaccharides are beta-D-glucans. Beta-glucans are available in numerous forms, however the most one in fungi have what's referred to as 1-3,1-6 branching conjointly noted as (1-3) (1-6) beta-d-glucans.(Garbi et al., 2011) These are specific to fungi and yeast. Beta-glucans' immunity-stimulating effects contribute to resistance against allergies and will participate in physiological processes regarding the metabolism of fats and sugars within the anatomy.(Carvalho et al., n.d.) The beta-glucans

contained in oyster, shiitake mushroom and split gill mushrooms are considered to be the foremost effective.

2.7 Source of Protein:

Mushrooms offer a small quantity of protein: 2.2 grams per cup. This is most effective 4% of your everyday needs, so that you need to make sure to eat protein-wealthy foods, which includes legumes, nuts, dairy, meat, or fish, as a part of a balanced diet. Mushrooms do not have as a good deal protein as meat or fish; however, they do have a comparable (and now and again better) quantity than many common vegetables.

Clinical trials additionally display that a mushroom diet is a powerful technique for weight reduction and weight management. Not handiest do mushrooms offer the identical degree of hunger pleasure that meat offers especially people with a chewy meat-like texture which includes portobello mushrooms. Protein content in some mushrooms is given below:

Table 11: Protein content in different types of mushrooms

Mushrooms	Content of Protein
Oyster	7%
White button	6%
Morel	6%
Enoki	5%

2.8 Source of Selenium:

Selenium works as an antioxidant to shield our body cells from harm that would possibly result in coronary heart disease, a few cancers and different illnesses of aging. Also located to be vital for the immune device and fertility in men. The selenium contents of eighty- three species of untamed mushrooms have been decided through oxygen combustion of the sample, observed through conversion of selenite to bromopiazselenol and final estimation through electron seize gas-liquid chromatography. Selenium attention have been located to variety from 0.012-20.0 mg/kg dry weight.(Wasser, 2011) Selenium content material changed into species-dependent. High concentrations have been located in Agaricaceae and in positive in Boletaceae of the genus Tubiporus, while in Russulaceae, Amanitaceae and Cantharellaceae selenium-wealthy species have been absent or rare. Ascomycetes and all mushrooms developing on timber had a totally low selenium content material. The maximum selenium concentrations (up to twenty ppm) have been located in Boletus (Tubiporus) edulis, a maximum famous fit to be eaten mushroom. Analyzing diverse parts of carpophores of B. edulis, Suillus luteus and Amanita muscaria, it has been found that these three species consists of much less selenium than the fleshy element of the cap.(Cohen et al., 2002) In Boletus and Suillus the best selenium content material changed into located in the tubes. Selenium content in mushroom is given below:

Table 12: Selenium content in different types of mushrooms

Mushrooms	Content of Selenium (mcg)
Shiitake (dried)	46.1
Italian, or Crimini (raw)	26

Shiitake (cooked)	24.8
Portabella (grilled)	21.9
Portabella (exposed to ultraviolet light, grilled)	21.9
Portabella (raw)	18.6

2.9 Source of Vitamin D:

Mushrooms are stated to be the handiest vegetarian meals from which we can get dietary Vitamin D. Unlike plants, mushrooms do not have chlorophyll that’s why it does not require daylight to grow. However, whilst mushrooms are uncovered to UV rays both via herbal or synthetic daylight, they have got better quantities of diet D, mainly D2. (Altaf et al., 2020)

Some industrial mushroom growers now provide mushrooms with UV light-caused vitamin D, however wild mushrooms which includes chanterelles and morels are better in vitamin D due to the fact they may be grown and harvested with herbal solar exposure.(Wani et al., 2010) While the "sunshine nutrition" has constantly been related to sturdy bones, current developments display that diet D in mushrooms also can inhibit the manufacturing of most cancers cells via way of means of supporting to modify molecular growth. Vitamin D content in 100 gm in some mushrooms are given below:

Table 13: Vitamin D content in different types of mushrooms

Mushrooms	Content of Vitamin D (IU)
Maitake (raw)	1123
Mportabella (exposed to ultraviolet light, raw)	446
Chanterelle (raw)	212
Morel (raw)	206
Shiitake (dried)	154

Oyster (raw)	29
Shiitake (cooked)	28
Shiitake (stir-fried)	21

2.10 Source of Triterpenes:

Triterpenes are rather oxidized lanostanes. Triterpenes are broadly suggested in Ganoderma species. Zhou had reviewed that triterpene is one of the primary additives accountable for the claimed healing efficacy of Ganoderma.(Ao & Deb, 2019) In fact, the ability of Ganoderma triterpenoids towards diverse cancer goals were properly documented. Although ganoderic acids are famous for their anticancer properties, their useful outcomes at the apprehensive device are broadly pursued with the aid of using researchers. Triterpenes content in mushroom are given below in a table:

Table 14: Triterpene acid content in different type of mushrooms

Triterpene Acids	Contents (mg/g)
Ganoderic acids	
Mf	3.0 ± 0.2
T	69.2 ± 5.4
Me	41.6 ± 3.4
A	6.7 ± 0.4
B	3.3 ± 0.2
S	3.5 ± 0.2
Lucidenic acid F	0.19 ± 0.0

Note: Mf, T, Me, A, B, S are different types of Ganoderic acid

2.11 Source of Magnesium:

Essential to suitable health, magnesium enables to hold ordinary muscle and nerve function, maintains coronary heart rhythm steady, helps a wholesome immune device and maintains bones strong. Mushrooms are a Wonderful supply of Magnesium. Magnesium content in various mushrooms is given below:

Table 15: Magnesium content in different type of mushrooms

Mushrooms	Content of Magnesium (mg)
Shiitake (dried)	132
Shiitake (raw)	20
Morel (raw)	19
Shiitake (stir-fried)	19
Oyster (raw)	18
Enoki (raw)	16
Shiitake (cooked)	14
Chanterelle (raw)	13

2.12 Few Calories:

Mushrooms have very much less energy and include about eighty to ninety percentage water. At the identical time, they have got low sodium, carbohydrate and fats content material and excessive fiber content material. This is the purpose why mushrooms are taken into consideration suitable for the ones aiming for weight loss. Calory content in mushrooms are given below:

Table 16: Calorie content in different types of mushrooms

Mushrooms	Content of Few calories (kcal)
Shiitake (dried)	296

Shiitake (cooked)	56
Shiitake (stir-fried)	39
Chanterelle (raw)	38
Enoki (raw)	37
Shiitake (raw)	34
Oyster (raw)	33
Morel (raw)	31

2.13 Source of Phosphorus:

Mushrooms are a great supply of phosphorus. Eating a 100-gram serving, that is barely greater than 1 cup, of uncooked white mushrooms will offer you with 86 milligrams of phosphorus, that is nine percentage of each day value. Portobello mushrooms incorporate 108 milligrams of phosphorus in step with 100-gram serving, shiitake mushrooms incorporate 112 milligrams and oyster mushrooms incorporate a hundred and twenty milligrams in step with serving, that is 12 percentage of the DV.(Lindequist, 2013) Phosphorus is pivotal for transforming the sugars and fats you eat up into vitality, nerve and muscle work, holding your bones and lacquer solid, controlling your pulse, integrating protein for developing new tissues for your body, sifting waste from your kidneys and developing DNA and RNA. Phosphorus content in a few mushrooms are given underneath:

Table 17: Phosphorus content in different types of mushrooms

Mushrooms	Content of Phosphorus (mg)
Shiitake (dried)	294
Morel (raw)	194

Portabella (grilled)	135
Italian, or Crimini (raw)	120
Oyster (raw)	120
Shiitake (raw)	112
Shiitake (stir-fried)	111
Portabella (raw)	108

2.14 Source of Fiber:

Compared to different traditional reassess of DF, which includes cereals, fruits, legumes and vegetables, mushrooms or fungi are underutilized. In fact, safe to eat mushrooms or macro fungi are a wealthy supply of a few novel DFs which have numerous useful fitness outcomes to humans. Mushrooms are described as fungi which have one-of-a-kind and seen fruiting our bodies and that they encompass safe to eat and medicinal ones. The fruiting our bodies of safe to eat mushrooms (e.g., *Lentinus edodes*) are in particular ate up of their flesh or dried form, whilst medicinal mushrooms (e.g., *Ganoderma lucidum*) are non-safe to eat fungi which have biopharmaceutical packages because of the bioactive additives which includes polysaccharides and triterpenoids that they contain. Fiber content of several mushrooms are given below:

Table 18: Fiber content in different types of mushrooms

Mushroom Name	Content of Fiber (g)
Shiitake (dried)	11.5
Chanterelle (raw)	3.8
Shiitake (stir-fried)	3.6
Morel (raw)	2.8
Enoki (raw)	2.7
Maitake (raw)	2.7
Shiitake (raw)	2.5

Chapter 4:

CONCLUSION & FUTURE RECOMMENDATIONS

Conclusion:

Nowadays, mushrooms are valuable ingredients due to the fact that they are low in calories, carbohydrates, fat, and sodium: also, they are LDL cholesterol-free. In addition, mushrooms contain crucial nutrients, vitamins and minerals, such as selenium, potassium, riboflavin, niacin, diet D, proteins, and fiber. Many nutraceuticals present in mushrooms, used for the prevention or remedy of Parkinson disease, Alzheimer disease, hypertension, and excessive risk of stroke. They also are applied to lessen the probability of most cancers' invasion and metastasis because of their antitumor properties. Mushrooms act as antibacterial, immunity enhancer, and LDL cholesterol decreasing agents. Due to possessing different secondary metabolites with distinct bioactivity they have the potential to prevent and treat various diseases. Bioactive components of mushroom extracts are used to give human fitness and are used as nutritional supplements as well. Thus, the benefits of mushrooms are undefined and usage of mushrooms for various purposes are approaching over for centuries.

Future Recommendation:

This review has been written with a view to facilitate the work of future researchers who wants to conduct lab-based work with different types of mushrooms. It will help them to understand about the pharmacological and nutritional importance of these mushrooms. Besides, the information

about different types of mushrooms mentioned in this paper will lead them to write a more informative research paper and the unknown beneficial facts of mushrooms will be revealed to the people of the world. Moreover, it will serve as a future documentation for other researchers.

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