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AN EXTENSIVE REVIEW ON THE MUSHROOM WORLD

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ABSTRACT

Mushroom is a macro-fungus with a unique fruiting body. It exhibits a saprophytic mode of nutrition. The body consists of mycelium, volva, stem, gill and cap. They are low in calories, carbohydrates, fats and sodium and high in water and fibre content which makes them a great diet food. The objective of this study is to evaluate the types and uses of different edible and poisonous mushrooms. Evidences prove that beneficial mushrooms help to prevent and treat diseases such as cancer, diabetes, hyperlipidemia, arteriosclerosis, and chronic hepatitis. Some of them may also help in the reduction of tumor growth. Some mushrooms also possess antimicrobial, antiviral, immunostimulatory and anti-allergy properties. In contrast, there are some poisonous mushroom which cause health hazards such as gastrointestinal problems, nausea, vomiting and abdominal pain when ingested. Some of them also exert neurological problems such as vertigo, fatigue, tremor and nystagmus.

KEYWORDS: *Mushroom, Saprophytes, Beneficial mushrooms, Poisonous mushrooms.*

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INTRODUCTION

DEFINITION AND CHARACTERISTICS

Mushroom is a macro-fungus with a unique fruiting body which can be epigeous or hypogenous in nature and conspicuous enough to be seen with the unaided eye. It describes a variety of gilled fungi, with or without stems, and the term is used even more generally, to describe both the fleshy fruiting bodies of some Ascomycota and the woody or leathery fruiting bodies of some Basidiomycota. Mushroom body consist of mycelium, volva, stem, gill and cap. It exhibit a saprophytic mode of nutrition which involves the production of a wide range of enzymes that can break down complex substances after which they are able to absorb the formed soluble substances.[1]

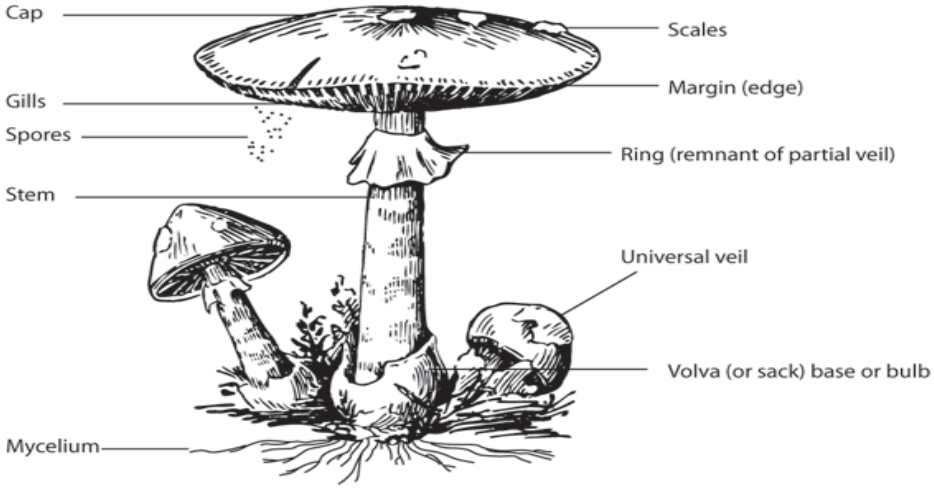

Figure 1
Different parts of a typical mushroom[52]

LIFE CYCLE

The reproductive part of mushroom releases spores by a process known as sporulation. The spores that land on their ideal environment (soil, dung or plant litter) begin to produce the mycelium under the ground. Growth of the mycelium at the soil surface produces a young, very small mushroom covered by the structure called the universal veil. The mushroom breaks through this veil and grows taller and wider. The adult mushroom produces spores and the process will start again.[2]

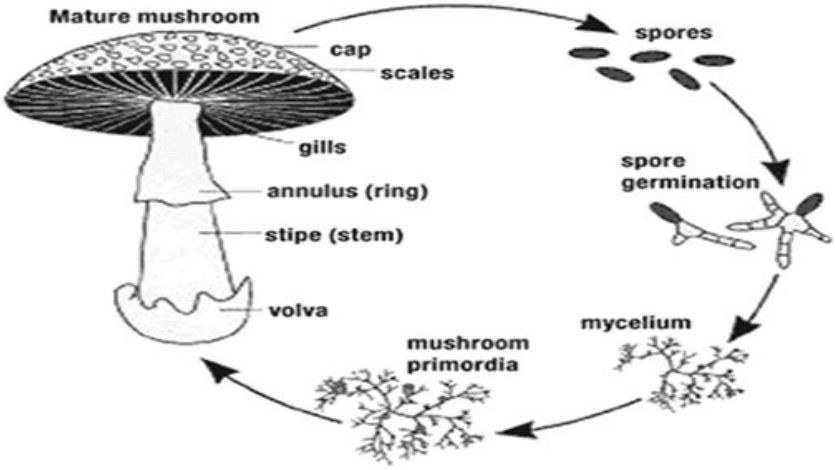

Figure 2
Life cycle of mushroom

MUSHROOM GROUPING AND CLASSIFICATION

Mushroom grouping and classification can be done by two ways.[3]

Table 1
Mushrooms are grouped into four categories[3]

	TYPES	EXAMPLES
A.	Edible Mushrooms	Agaricus bisporous (button mushroom), Lentinus edodes, Volvariella volvacea, Auricularia auricular, Pluerotus squarrosullus,
B.	Poisonous mushrooms	Amanita phalloides, A. verna, A. virosa, A. muscaria, etc.
C.	Medicinal mushrooms	Pleurotus tuberregium, Lentinus edodes, Schizophylum cummune
D.	Miscellaneous mushrooms	Stereum hirsutum, Phallus indusiatus, Earthstars

These groups are not water tight in the sense that there are mushrooms that could be in more than one category. For example there are edible species that are equally medicinal

Figure 3
A. Agaricus bisporus, edible mushroom
B. Amanita muscaria, poisonous mushroom
C. Lentinus edodes, medicinal mushroom
D. Phallus indusiatus, miscellaneous mushroom

ECOLOGICAL CLASSIFICATION OF MUSHROOM

Ecologically, mushrooms can be classified into three groups: the saprophytes, the parasites and the symbiotic (which include mycorrhizal) species. Saprophytes obtain nutrients from dead organic materials; parasites derive food substances from living plants and animals and causing harm to the hosts; and mycorrhiza live in a close physiological association with host plants and animals – thereby forming a special partnership where each partner enjoys some vital benefits from the other.However, some mushrooms do not fall neatly within these man-made categories and can share two of these categories. For example, some *Ganoderma* spp. including *G. lucidum* are common saprophytes, however they can be pathogenic too. *Tricholoma matsutake*,while initially appearing to be mycorrhizal on young roots, soon becomes pathogenic and finally exhibits some saprobic ability.[4]

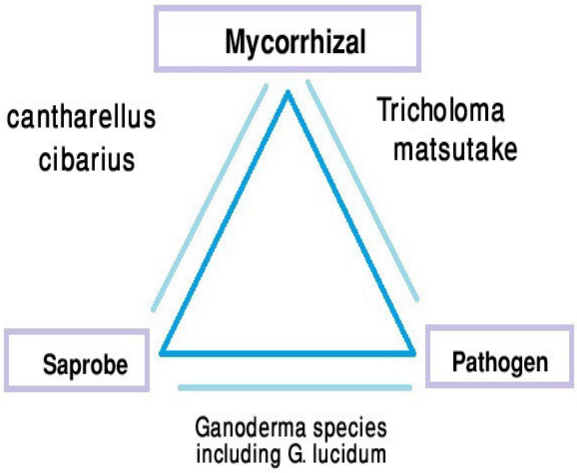

Figure 4
Ecological classification of mushrooms

IDENTIFICATION

Identifying mushrooms requires a basic understanding of their macroscopic structure. Most are Basidiomycetes and gilled. Their spores, called basidiospores, are produced on the gills under the caps.[5]

THE MUSHROOMS ARE IDENTIFIED

- **By the shape of the cap**

Mushroom caps come in many different shapes. The mushroom's cap should be carefully viewed during various stages of development. Some young mushroom caps may be conical or convex, later become plane or depressed.[6]

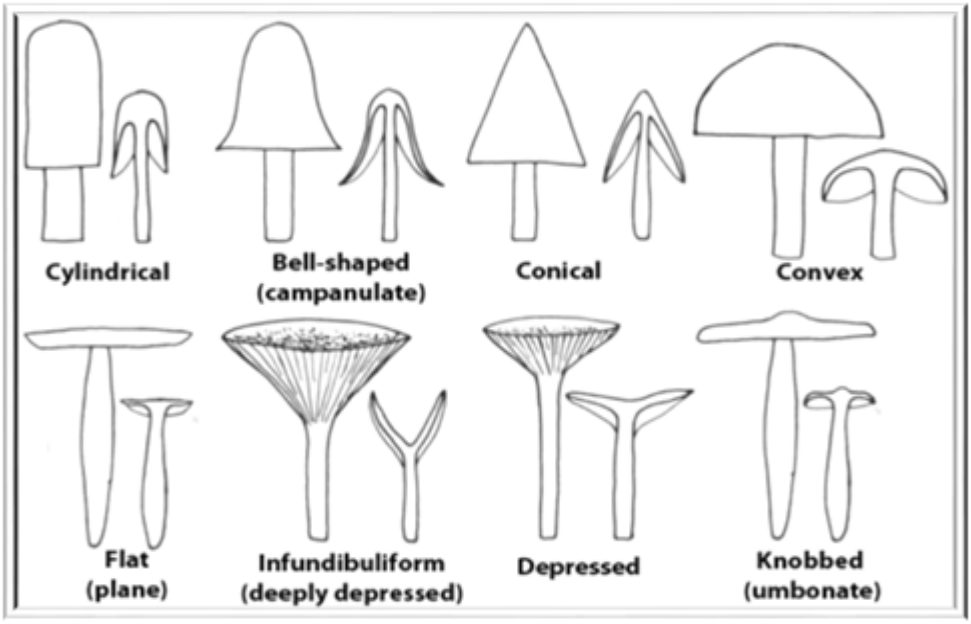

Figure 5
Identification of mushroom by cap morphology

- ***BY UNDERSTANDING HOW GILLS ATTACHED TO THE CAP***

A mushroom's gills, if it has gills, attach to the stem in several ways. Some gills are not attached to the stem at all. These are called "free" gills. Others are decurrent, running down the stem. It can sometimes be difficult to determine exactly how the gills attach to the stem without looking at specimens of varying ages. [6]

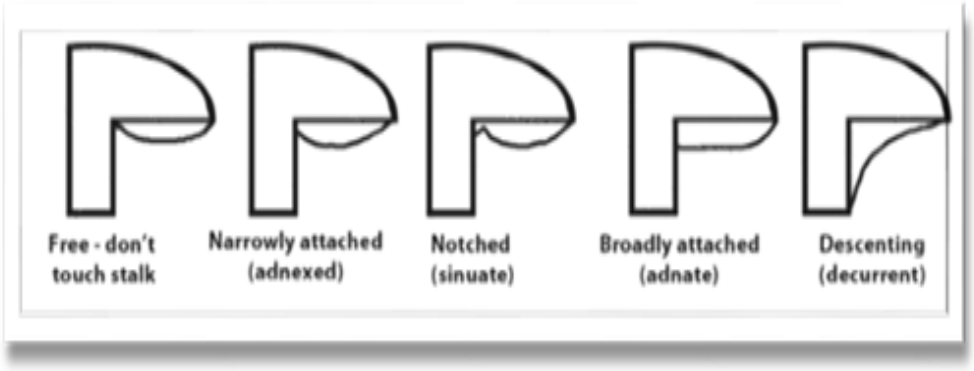

Figure 6
Identification of mushroom by gill attachment

- ***BY SPORE PRINT***

At the microscopic level the basidiospores are shot off basidia and then fall between the gills in the dead air space. As a result, for most mushrooms, if the cap is cut off and placed gill-side-down overnight, a powdery impression reflecting the shape of the gills (or pores, or spines, etc.) is formed (when the fruit body is sporulating). The color of the powdery print, called a spore print, is used to help classify mushrooms and can help to identify them. Spore print colors include white (*Flammulina velutipes, Grifola frondosa*), brown(*Ganoderma lucidum*), black (*Coprinus comatus*), pink (*Pleurotus ostreatus*), yellow(*Craterellus cornucopiodes*), and dark greenish brown (*Boletus edulis*), but almost never blue, green, or red.[6]

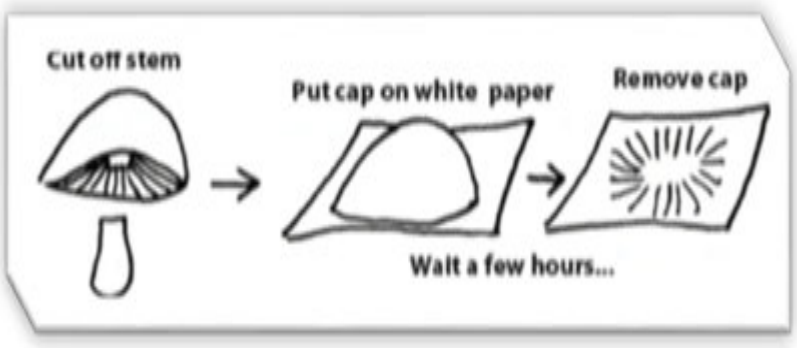

Figure 7
Identification of mushroom by spore print

COMPOSITION

A large variety of mushrooms have been utilized traditionally in many different cultures for the maintenance of health, as well as in the prevention and treatment of diseases.[7]

Table 2
Proximal composition of some edible mushrooms (dry basis)
Adapted from Carneiro et al. 2013[8]; Kalač 2013[9]; Phan et al. 2012[10]; Reis et al. 2012[11].

SPECIES	PROTEIN %	FAT %	ASH %	CARBOHYDRATE %	CALORIES Kcal/kg
Agaricus bisporus	14.1	2.2	9.7	74.0	325
Lentinus edodes	4.5	1.73	6.7	87.1	772
Pleurotus ostreatus	7.0	1.4	5.7	85.9	416
Pleurotus eryngii	11.0	1.5	6.2	81.4	421
Pleurotus sajor-caju	37.4	1.0	6.3	55.3	380
Pleurotus giganteus	17.7	4.3	-	78.0	364
Dry powder formulations					
Agaricus blazei	31.3	1.8	7.5	59.4	379
Lentinus edodes	12.8	1.0	4.3	81.9	388

NUTRITIONAL VALUE

The nutritional value of edible mushrooms is due to their high protein, fiber, vitamin and mineral contents, and low-fat levels.[8, 12] They provide all the essential amino acids for adult requirements. Besides, edible mushrooms contain many different bioactive compounds associated with health benefits.[12, 13]

- ***CARBOHYDRATE***

Polysaccharides are the best known and most potent mushroom derived substances with antitumor and immunomodulating properties. β-glucans are the main polysaccharides found in mushrooms and around half of the fungal cell wall mass is constituted by β-glucans.[14]

- ***PROTEIN***

Mushroom produces a large number of protein and peptides with interesting biological activities such as lectins, Fungal immunomodulatory proteins (These are small molecule protein which are important bioactive component with immune regulating activity. They play a significant role in immunomodulating), ribosome inactivating proteins, antimicrobial proteins, ribonucleases, and laccases. [15]

- ***FAT***

Polyunsaturated fatty acids are mostly contained in edible mushrooms; thus, they may contribute to the reduction of serum cholesterol.[16, 17] The major sterol produced by edible mushrooms is ergosterol, which shows antioxidant properties. [16]

- ***VITAMINS***

Mushrooms are also a good source of vitamins with high levels of riboflavin (vitamin B2), niacin, folates, and traces of vitamin C, B1, B12, D and E. Mushrooms are the only non-animal food source that contains vitamin D. Wild mushrooms are generally excellent sources of vitamin D2 unlike cultivated ones.[16, 18, 9-22]

Table 3

Nutritional composition of White Button Mushroom (Agaricus bisporus) Adapted from USDA Nutrient Database

Nutrients	***Unit***	***Amount/100gm***
Water	g	92.45
Energy	kcal	22
Protein	g	3.09
Total lipid (fat)	g	0.34
Carbohydrate, by difference	g	3.26
Fiber, total dietary	g	1.0
Sugars, total	g	1.98
Minerals		
Calcium, Ca	mg	3
Iron, Fe	mg	0.50
Magnesium, Mg	mg	9
Phosphorus, P	mg	86
Potassium, K	mg	318
Sodium, Na	mg	5
Zinc, Zn	mg	0.52
Vitamins		
Vitamin C, total ascorbic acid	mg	2.1
Thiamin	mg	0.081
Riboflavin	mg	0.402
Niacin	mg	3.607
Vitamin B-6	mg	0.104
Folate, DFE	µg	17
Vitamin B-12	µg	0.04
Vitamin A, RAE	µg	0
Vitamin A, IU	IU	0
Vitamin E (alpha-tocopherol)	mg	0.01
Vitamin D (D2 + D3)	µg	0.2
Vitamin D	IU	7
Vitamin K (phylloquinone)	µg	0.0
Lipids		
Fatty acids, total saturated	g	0.050
Fatty acids, total monounsaturated	g	0.000
Fatty acids, total polyunsaturated	g	0.160
Fatty acids, total trans	g	0.000
Cholesterol	mg	0
Other		
Caffeine	mg	0

MAIN EDIBLE AND POISONOUS MUSHROOMS WORLDWIDE

There are different edible and different poisonous mushrooms which are found in different parts of the world.[23, 24]

Table 4
Main Edible and Poisonous Mushrooms worldwide

EDIBLE MUSHROOMS	***POISONOUS MUSHROOMS***
Genus Agaricus	Genus Amanita
A.bisporus	*A .virosa*
A.blazei	*A. phalloides*
	A. pantherina
Genus Lentinus	*A. muscaria*
L.edodes	
	Genus Clitocybe
Genus Pleurotus	*C. amoenolens*
P. ostreatus	*C. acromelalga*
P. pulmunarius	*C. phyllophila*
P. sajor-caju	
P. eryngii	Genus Inocybe
	I. asterospora
Genus Ganoderma	*I. lilacina,*
Ganoderma lucidum	*I. rimosa*
Huitlacoche mushroom	Genus Cortinarius
	C. orellanus
Other mushrooms	*C. speciosissimus*
Trametes versicolor	
Grifola frondosa	Genus Gyromitra
Cordyceps militaris	*G. esculenta*
Cordyceps sinensis	
Antrodia cinnanomea	Genus Psilocybe
Panellus serotinus	*P. semilanceata,*
Auricularia. Polytricha	*P. Mexicana,*
Flammulina velutipes	*P. cubensis*

MEDICINAL PROPERTIES OF MUSHROOM

Some mushrooms or extracts are used or studied as possible treatments for diseases, such as cardiovascular disorders.[25] Some mushroom materials, including polysaccharides, glycoproteins and proteoglycans are under basic research for their potential to modulate immune system responses and inhibit tumor growth,[26] whereas other isolates show potential antiviral, antibacterial, antiparasitic, anti-inflammatory, and antidiabetic properties in preliminary studies.[27] Currently, several extracts have widespread use in Japan, Korea and China, as adjuncts to radiation treatments and chemotherapy, even though clinical evidence of efficacy in humans has not been confirmed.[28] The main aims and objectives of this review article is to investigate the characteristics, identification, life cycle and cultivation of different mushrooms. It also helps to identify the composition and nutritive value of different edible mushroom species. As there are both beneficial and poisonous mushrooms, so it helps to study the beneficial medicinal properties of edible mushrooms as well as the ill effects of different poisonous mushrooms on health.

REVIEW OF LITERATURE

NUTRIENT COMPOSITION IN MUSHROOM

Koyyalamudi *et al* (2013) conducted a study on the micronutrient mineral content of the fruiting bodies of Australian cultivated Agaricus bisporus (white button mushrooms) and concluded that (A. bisporus) can provide significant contribution to the daily requirements of several minerals from the point of view of human nutrition, and in particular, Cu, Se, Mo and B.[29] Kanagasabapathy *et al* (2011) conducted a study on the chemical composition and antioxidant properties of extracts of fresh fruiting bodies of Pleurotus sajor-caju and concluded that the regular consumption of P. sajor-caju as a part of human diet may render nutritional and nutraceuticals benefits for good health.[30] Koyyalamudi *et al* (2009) evaluated that Vitamin B12 is the active Corrinoid produced in cultivated white button mushrooms (Agaricus bisporus) and concluded that intake of this mushroom increases vitamin B12 .[31] Keegan *et al* (2013) conducted a study on the photobiology of vitamin D in mushrooms and its bioavailability in humans and concluded that mushrooms are a rich source of vitamin D2 that when consumed can increase and maintain blood levels of 25-hydroxyvitamin D in a healthy range. Ingestion of mushrooms may also provide the consumer with a source of vitamin D3 and vitamin D4.[32] Calvo *et al* (2014) conducted a study on the risk factor modification in pre-diabetic adults consuming white button mushrooms rich in the anti-oxidant, ergothioneine and concluded that WBM are bioavailable food sources for the antioxidant ergothioneine in older pre-diabetic adults & their consumption effectively modifies risk factors for T2D. [33]

MEDICINAL PROPERTIES OF MUSHROOMS PREVENTS CANCER

Arora *et al* (2013) conducted a study on the enhanced antiproliferative effects of aqueous extracts of threemedicinal mushrooms (Auricularia polytricha,

Macrolepiota procera, and Pleurotus ostreatus) on colon cancer cells and concluded that among all the extracts, the aqueous extract of P. ostreatus and the ethanolic extract of M. procera showed the highest cytotoxic effect on all 3 cancer cell lines, especially COLO-205.[34] Ina *et al* (2013) conducted a study on the use of lentinan for treating gastric cancer and concluded that lentinan containing natural compounds such as β-glucan have been used to improve general health in China and Japan and has been approved as a biological response modifier for the treatment of gastric cancer in Japan.[35] Yan *et al* (2012) conducted a study on the antioxidant and antitumor activities of selenium- and zinc-enriched oyster mushroom (SZMs) in mice and concluded that SZMs may be effective for improving antioxidant capacity and preventing tumors.[36] Fan *et al* (2011) conducted a study on the crude extracts of Agaricus brasiliensis induce apoptosis in human oral cancer CAL 27 cells through a mitochondria-dependent pathway and concluded that 50% ethanol crude extract and hot water extracts of *Agaricus brasiliensis* were able to induce apoptotic cell death in CAL 27 cells via the release of cytochrome c from mitochondria into the cytoplasm and activation of caspase-3 in vitro.[37] Zhang *et al* (2009) conducted a case study in which they provide joint effect of mushrooms and green tea on 1,009 female patients aged 20-87 years in southeast China and concluded that higher dietary intake of mushrooms decreased risk of breast cancer in pre- and postmenopausal Chinese women and an additional decreased risk of breast cancer from joint effect of mushrooms and green tea was observed.[38]

PREVENTS DIABETES

Marsales *et al* (2014) conducted a study on the effect of mushroom intake on modulating post-prandial glycemic response and concluded that Portabella Mushroom powder reduced postprandial hypoglycemia, rapid insulin decrease and elevated hunger in women compared to glucose alone. Mushrooms may moderate postprandial glucose related responses.[39] Jeong *et al* (2010) conducted a study on the white button mushroom (Agaricus bisporus) lowers blood glucose and cholesterol levels in diabetic and hypercholesterolemic rats and observed a significant decrease in hepatic cholesterol and triglyceride concentrations and concluded that A bisporus mushroom had both hypoglycemic and hypolipidemic activity in rats.[40] Khatun *et al* (2007) evaluated that oyster mushroom reduced blood glucose and cholesterol in diabetic subjects and concluded that the mushroom significantly reduced blood glucose, blood pressure, TG and cholesterol of diabetic subjects without any deleterious effect on liver and kidney.[41]

PROMOTES WEIGHT MANAGEMENT

Poddar *et al* (2013) conducted a 1-year randomized clinical trial on the positive effect of mushrooms substituted for meat on body weight, body composition, and health parameters and at the end of the 1-year trial, participants on the mushroom diet reported lower intakes of energy and fat, lost more pounds and percentage body weight, achieved lower body mass index, waist circumference and percent total body fat, and had lower systolic and diastolic pressure; their lipid profile and inflammatory markers also improved.[42]

HELPS TO IMPROVE IMMUNITY

Dai *et al* (2014) conducted a Randomized Dietary Intervention in Healthy Young Adults Consuming Lentinula edodes (Shiitake) Mushrooms and concluded that regular L. edodes consumption resulted in improved immunity, as seen by improved cell proliferation and activation and increased sIgA production.[43] Wu *et al* (2007) evaluated the dietary supplementation with white button mushroom which enhances natural killer cell activity in C57BL/6 Mice and concluded that the increased intake of white button mushrooms may promote innate immunity against tumors and viruses through the enhancement of a key component, NK activity. This effect might be mediated through increased IFNγ and TNFα production.[44]

OTHER USES OF CONSUMING MUSHROOM

Handayani *et al* (2012) conducted a study on the Dietary Shiitake Mushroom (Lentinus edodes) which Prevents Fat Deposition and Lowers Triglyceride in Rats Fed a High-Fat Diet and concluded that the rats on the HD-M diet had the lowest body weight gain compared to MD-M and LD-M groups. The total fat deposition was significantly lower (-35%, $P < 0.05$) in rats fed an HD-M diet than that of HFD group. Interestingly, plasma triacylglycerol (TAG) level was significantly lower (-55%, $P < 0.05$) in rats on HD-M than HFD.[45] Chang *et al* (1996) conducted a study on the functional properties of edible mushrooms [Lentinus (shiitake), Pleurotus (oyster), Auricularia (mu-er), Flammulina (enokitake), Tremella (yin-er), Hericium, and Grifola (maitake)] and concluded that they are useful in preventing or treating serious health conditions such as cancer, acquired immune deficiency syndrome (AIDS), and hypercholesterolemia.[46]

MUSHROOM POISONING

Avci *et al* (2014) conducted a study on the elevated cardiac enzymes due to mushroom poisoning and concluded that amatoxin with the elevated troponin-I have the cardio toxic effect.[47] Muller *et al* (2014) conducted a case study on the suicide under the influence of "magic mushrooms" and concluded that Psilocybin causes hallucinogenic effects and it has been observed that a man committed suicide by self-inflicted cut and stab injuries. A causal connection between suicidal behaviour and previous ingestion of psychoactive mushrooms is discussed.[48] George *et al* (2013) conducted a study on the muscarinic toxicity among family members after accidental consumption of poisonous mushrooms on four members of a family and concluded that the Clitocybe species of mushrooms caused muscarinic toxicity. Patients with muscarinic mushroom toxicity have early onset of symptoms (Systemic muscarinic manifestations such as exhaustion, irritability, muscular cramps, salivation, frothing from mouth, sweating, lacrimation, blurring of vision, miosis, ptosis, bronchorrhea, cough, wheeze, tachypnea, rhonchi, bradycardia, hypotension, abdominal cramps, vomiting, and diarrhea were

observed) and they respond well to atropine and symptomatic supportive care.[49] Agerlund Petersen *et al* (2013) conducted a study on the two accidental cases admitted 12 and 17 hours after ingestion of Death Cap mushroom and presenting the symptom of gastroenteritis and decline in liver function. The patient who arrived after 12 hours responded well to intensive treatment. The other patient who arrived after 17 hours deteriorated in spite of intensive treatment and underwent liver transplantation.[50] Magdalan *et al* (2007) conducted a case of a 72-year-old female who ingested panther cap (Amanita pantherina) and developed short-time diarrhea and severe transient neurological disorders; short-term hallucination followed by deep coma, skeletal muscle flaccidity with hyporeflexia. The sporological test revealed numerous spores of panther cap in patient's vomit. Finally it was concluded that patient's symptoms and signs were most probably a result of panther cap poisoning complicated with transient ischaemia of the brain..[51]

CONCLUSION

- Extensive review showed that mushrooms are saprophytes. They are low in calories, carbohydrates, fats and sodium, and high in protein, water and fiber content. They naturally contains Vitamin-B_{12} and vitamin-D. They also contains essential antioxidant, selenium and ergothioneine, which makes them a highly nutritious food.
- Mushrooms are the major sources of glucans, polysaccharides and antioxidants, hence they shows a protective action against cancer, diabetes, improves immunity and maintains body weight.
- They are also beneficial for arthritis management, hypertension, hypercholesterolemia and acquired immune deficiency syndrome (AIDS).
- Apart from its beneficial effects, there are some mushrooms which are poisonous for health and causes serious health hazards.

Awareness of poisonous mushrooms among the population is essential. It can be concluded that except some poisonous mushrooms, all edible mushrooms are beneficial for human health. Mushrooms are rich in many nutrients. Intake of mushrooms can treat and prevent different diseases without any side effect. We should consume mushrooms to live a healthy and long life.

CONFLICT OF INTEREST

Conflict of interest declared none.

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