Nutritional and medicinal properties of edible mushrooms: A review

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Abstract : Wild edible mushrooms provide a significant source of nutritional as well as medicinal compounds and used for the development of drugs. Also their unique taste and flavour make them a demanding functional food for every man's plate. Nowadays mushroom have drawn the attention of chemists and immunobiologists due to their immunomodulatory, antimicrobial, antidiabetic, antitumor, anticancer, and antioxidant activities. This review focuses on the health implications, nutritional and medicinal importance of various edible mushroom species.

Key words: Edible Mushrooms, Nutrients, Medicine, antidiabetic, immunomodulatory, anticancer activity**.**

I. INTRODUCTION

Mushrooms are the fruiting bodies of higher fungi and worldwide distributed. Approximately, 140,000 types of mushrooms are present on the earth, out of which only around 10% are known. Meanwhile, about 50% of those ~14,000 species have varying degrees of edibility, more than 2,000 are safe, and about 700 species are known to possess significant pharmacological properties [1] (Reshetinikov, Wasser, & Tan, 2001). Edible mushrooms were called the "food of the gods" and the good sources of dietary protein, carbohydrate, fats, vitamins, fibre and minerals [2] (Mattila et al., 1994). From the ancient times mushroom are being used extensively as a functional food in many countries due to their good flavour, taste, high nutritive values and potential beneficial effects on human health [3,4] (Cheung, 2008; Wang et al., 2014). Hence, food industry is especially interested in both cultivated and wild edible mushrooms. They have recently become attractive for the development of several drugs [5,6] (Moradali, Mostafavi, Ghods, & Hedjaroude, 2007; Wasser & Weis, 1999a). PSK from *Coriolus (Trametes) versicolor*, lentinan from *Lentinus edodes* and sonifilan (SPG) from *Schizophyllum commune* have been recognized as anticancer drugs throughout the world [7-9] (Cui & Chisti, 2003; Fujimoto et al., 1983; Taguchi et al., 1983). Mushrooms have been found effective against diabetes, heart diseases, hypertension, cerebral stroke, asthma, allergies and cancer [10-12] (Mizuno et al., 1999; Tzianabos, 2000; Wasser, 2002). Mushrooms are also known to exhibit antifungal, anti inflammatory, antitumor, antiviral, antibacterial, hepatoprotective, anti diabetic, hypolipedemic, antithrombotic and hypotensive activities [5,13] (Moradali, Mostafavi, Ghods, & Hedjaroude, 2007; Wasser & Weis, 1999b). The objective of this review is to compile existing information about the nutritional composition and medicinal significance of edible mushrooms.

II. Chemical composition and nutritional value

The nutritional value of the mushroom originates from its chemical composition. The nutritional compositions of mushrooms as attractive, being good sources of dietary protein, carbohydrate, fats, vitamins, fibre and minerals [14] (Ghorai et al., 2009). Mushrooms possess ~ 90% water by weight. The remaining 10% consists of 10-40% protein, 2-8% fat, 3-28% carbohydrate, 3-32% fiber and 8-10% ash [15-19] (Manzi, Aguzzi, & Pizzoferrato, 2001; Manzi et al., 2004; Murugkar & Subbulakshmi, 2005; Sanme et al., 2003; Wang et al., 2014). Presence of high content of protein in mushrooms it is popularly called as "poor man's protein". Mushroom proteins contain all the essential amino acids, especially rich in lysine and leucine [20] (Mattaila et al., 2001) and considered as a good source of digestible proteins with protein content above most vegetables and somewhat less than most meats and milk [21] (Fitzpatrick, Esselen, & Weir, 1946). These are the good source of several vitamins such as A, B_1, B_2, B_3, B_{12}, C and D [22] (Breene, 1990), and mineral elements such as potassium, calcium, phosphorous, magnesium, iron, zinc and copper [23-25] (Horowitz, Schock, & Horowitz- Kisimova, 1994; Kalac, & Svoboda, 2000; Latiff, Mohd Daran, & Mohamed, 1996). The wild edible mushrooms contain higher quantities of mineral elements than cultivated ones [26] (Mattaila et al., 2000). Besides actual nutrients, mushrooms contain a wide variety of bioactive molecules including terpenoids, steroids, phenols, nucleotides, glycoproteins and polysaccharides. Thus mushrooms are good sources

of dietary supplements, functional foods, phyto-chemicals, and nutraceuticals [27] (Chang and Buswell, 1996). These dietary supplements are used for the enhancement of health, fitness, and prevention of various human diseases.

Nutritive value of Mushroom

Nutritive values of mushoom in 100 g [40]	
Energy	113 KJ (27 Kcal)
Carbohydrate	4.1 g.
Fat	0.1 g.
Protien	2.1 g.
Thiamine (vit. B_1)	0.1 g.
Riboflavin (vit. B_2)	0.5 g.
Niacin (vit. B_5)	3.8 g.
Pantothenic acid (vit. B_5)	1.5 g.
Vitamin C	5 mg.
Calcium	18 mg.
Phosphorus	120 mg.
Potassium	448 mg.
Sodium	6 mg.
Zinc	1.1 mg.

III. Medicinal properties

However, mushrooms are used as tasty, edible, and dietetic miracle foods worldwide. Also, they have been used in folk medicine throughout the world and considered to be one of the most useful antitumor agents for clinical uses[28,10] (Brochers et al., 1999; Mizuno et al., 1999). For medical purposes, mushrooms have been consumed to prevent cancer and cardiac diseases, to improve blood circulation and to reduce blood cholesterol level (Ooi & Liu, 2000; Wasser, 2002). Several mushroom polysaccharides are widely used and commercialized[29,12] worldwide as anti cancer agents for therapeutic purposes. Ikekawa and coworkers [30,31] reported that hot water extracts obtained from the fruiting bodies of some edible wild-growing higher basidiomycetes showed a marked antitumor activity against Sarcoma 180 in Swiss albino mice. Several mushroom polysaccharides such as Lentinan (from *Lentinus edodes*, Japan), Schizophyllan (from *Schizophyllum commune)*, Krestin (from turkey tail mushroom *Trametes versicolor*), Agarican (from *Agaricus blazei*, USA), and Grifron-D (from *Grifola frondosa*, Japan) have been established as pharmaceutical agents and used as anticancer drugs [32-34] (Chihara et al., 1969; Taguchi et al., 1983; Zhuang et al., 1994). All these polysaccharides exhibit anticancer activity and are used in cosmetics products [35] (Wu et al., 2016). Lentinan was shown to induce apoptosis in gastric cancer cells and could be used for the treatment of gastric cancer [36,37] (Furue & Kitoh, 1981; Taguchi et al., 1985). Schizophyllan has great importance in the pharmaceutical and food industries [38] (Reyes, Brabl, & Rau, 2009). Moreover, Schizophyllan (SPG) is found to be effective in the therapy of uterine cervix cancers [39] (Okamura et al., 1989). PSK has an accepted anti-tumor activity in various types of cancers, including colorectal, gastric, breast, liver, pancreatic, and lung cancer [40,41] (Rai, Tidke, & Wasser, 2005; Tsang et al., 2003). It is also useful for hepatitis B and chronic active hepatites [42] (Ying et al. 1987). Agarican has been commercialized and used clinically as antitumor agents [43,44] (Ebina & Fujimiya, 1998; Kawagishi et al., 1990). It is also used to prevent various diseases including chronic hepatitis, allergies, and asthma[45,46] (Biedron, Tangen, Maresz, & Hetland, 2012; Grinde, Hetland, & Johnson, 2006). Grifron-D has been shown to have a cytotoxic affect on human prostate cancer cells (PC9) in vitro, possibly acting through oxidative stress, and causing 95% cell death by an apoptosis [47] (Fulleroton & Samadi, 2000). Several β-D-glucans [48-50] (Miura et al., 1996; Morikawa et al., 1985; Wasser & Weis, 1999b) and α-D-glucans [51] (Whistler et al., 1976) are widely used as antitumor and immunomodulating agents. The important bioactive carbohydrate moiety α-L-fucose is essential for novel treatment approaches in human breast cancer [52] (Jay, Gene, & Catherine, 2011). Different parts of the mushroom are being used for the treatment of blood sugar, high blood pressure, as a preventive of ageing as well as for the beauty treatment.

3.1. Anti-hyperglycemic activities:

A nimber of mushrooms, including *Agaricus subrufescens*, *Grifola frondosa*, *Pleurotus ostreatus* and *Cordyceps* have demonstrated antihyperglycemic activities. Researchers reported *Grifola frondosa* [53] contain α-glycosidase inhibitors-Ternatin is an antihyperglycemic cyclic heptapeptide isolated Trametes versicolor.

3.2. Asthma:

A *Cordycepes* extract [54] has recently been evaluated in asthamatic children during remission stage. The *Cordycepes* extract inhibited the proliferation and differntitaion of Th2 cells and reduced the expression of related cytokines by down regulating the expression of GATA-3 mRNA and up-regulating the expression of Foxp3 mRNA in peripheral blood mononuclear cells. The extract was able to alleviate the chronic allergic inflammation by increasing the level of interleukin-10.

3.3. Hepatitis:

Clinical effects and safety evaluation of *A.blazei* condensed liquid (*Agaricus* Mushroom Extract; ABCL) [55] administreted to human volunteers (10 male, 10 female) with chronic C-type hepatitis orally twice per day for 8 weeks repeted no toxicological or other side effects. A series of trials have evaluated G. licidium on cancer, Type II dibetes, coronary heart disease, chronic hepatitis b, and neurasthenia.

3.4. Constipation:

Constipation is one of the most prevalent gastrointestinal complaints and high fiber intake is recommended as an initial therapy for constipation. Ear mushrooms (*Auricularia polytricha*) [56] are known to have higher fiber contents (50%) than other mushroom varieties.

Mechanism of action of mushroom polysaccharide

Possible mode of action of β-D-glucan as biological response modifier (BRM) was established by Mizuno T. [57] and is shown in the schematic diagram.

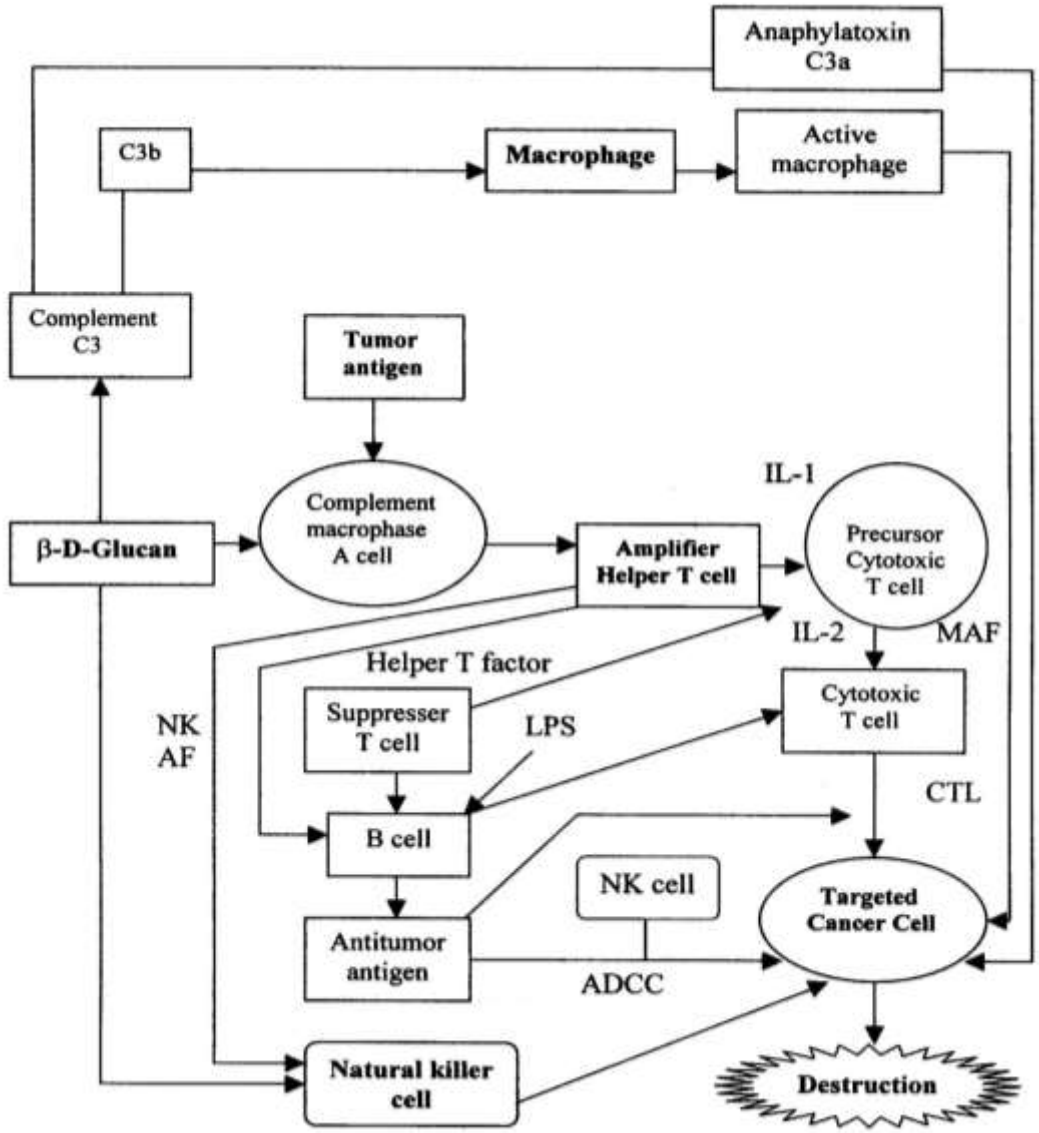

Figure 1: Schematic representation showing the mode of action of polysaccharide, β-glucan as biological response modifier to target cancer cell. NK: Natural Killer cell; AF: Antibody Formation; LPS: Liver Protein Serum; ADCC: Antibody Dependent Cell mediated Cytotoxicity; CTL: Cytotoxic T-Lymphocyte; MAF: Macrophage Activating Factor; IL-1: Interlukine 1; IL-2: Interlukine 2.

IV. Conclusion

Mushrooms are the important natural renewable source of bioactive polysaccharides that exhibit immunostimulating and antitumor properties. Various structures of β-D-glucans show distinct affinities toward receptors to trigger different host responses. So, they are regarded as biological response modifiers, BRM. β-D-glucans are useful to recover the impaired immune systems of humans and particularly against cancer and infectious diseases. The commercial pharmaceutical products such as schizophyllan, lentinan, grifolan, PSP and PSK have shown potential clinical applications in cancer therapy. Hence, they have a great role for future application as drugs for immune and cancer therapy.

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