Mushroom as a Source of Bioactive Polysaccharides: Review

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Abstract: *Mushrooms are highly valued for their nutritional values. But these contain large amounts of bioactive compounds like polysaccharides. Polysaccharides can be used for treating various incurable diseases like cancer, diabetes etc. The chemical structure of polysaccharides and its connection with their antitumor activity and immunomodulating effect are analysed in this paper.*

Keywords: *Mushrooms, Polysaccharides, Cancer, Anti-tumor activities, Immunomodulating effect*

Introduction

Mushrooms are well known for its nutritional and medicinal values [1]. Mushrooms are not only valued for their high nutritive value containing high quantities of protein, carbohydrate, minerals but also of their low fat content and low calorific value [2-6]. Large amount of bioactive compounds like lectins, polysaccharides, polysaccharide-peptides, polysaccharide-protein complexes have been isolated from mushrooms. Among this polysaccharide is a potent mushroom derived material having various bioactive properties [7-10]. Different polysaccharides from mushrooms showed their immunomodulation and antitumor properties. Mushroom polysaccharides are not only used to cure cancers of the stomach, esophagus, lungs, and colons but also act as anti-inflammatory, antiviral, hypoglycemic and antithrombotic agents [11-12]. Lentinan from *Lentinus edodes*, Schizophyllan from *Schizophyllum commune*, Agarican from *Agaricus blazei*, Lingzhi from *Ganoderma lucidum* and Maitake from *Grifola frondosa* have been used clinically as anti-tumor agents. The chemical structure of polysaccharides and its connection with their antitumor activity and immunomodulating effect are analysed. For determination of the exact structure of the polysaccharide it is of prime importance to purify the polysaccharide as much as possible.

Discussion

Mushroom is defined as a fleshy, aerial umbrella-shaped, fruiting body of macrofungi. According to Chang and Miles 'Mushroom' is "a macro fungus with a distinctive fruiting body which can be either hypogenous or epigeous, large enough to be seen with the naked eye and to be picked by Hand" [13]. Fungi are extraordinary organism, which are neither plants nor animals. Fungi occur in every environment on earth and play very important roles in most ecosystems.

About 1,40,000 mushrooms are reported to exist on Earth; 10 % of these mushrooms have been identified today, of which about 50 % are considered to possess varying degrees of edibility and more than 2000 are safely edible and about 700 species are known for possessing significant pharmacological properties [14-16]. The mushroom cell is encapsulated by an extra-cellular matrix, the cell wall, which protects it from osmotic pressure, environmental stress and determines cell shape. The cell wall has been described on one hand as a rigid layer of glycoproteins and polysaccharides, and on the other hand as a dynamic structure flexible enough to cope with cell growth.

Since differences in activity can all be correlated with ability of the polysaccharide molecule to solubilize in water, size of the molecules, branching rate and form, it is extremely important to determine the exact structure of the polysaccharides isolated either from mycelia or fruit bodies of medicinal mushrooms. Before performing structural analysis it is the prime job to purify the polysaccharide as much as possible, as the presence of other impurities in the polysaccharide will make it very difficult to establish the structure. Different biophysical techniques including chromatography, ultra centrifugation, dialysis, precipitation and re-precipitation with different solvent systems etc. are adapted for this purpose. The course of determination of structure of polysaccharides fundamentally stands on two kinds of methods; one is chemical method and another one is spectroscopic method comprising NMR [17] and Mass spectroscopic analyses.

Polysaccharides belong to a structurally diverse class of macromolecules, polymers of monosaccharide residues joined to each other by glycosidic linkages. It is noteworthy that, in comparison with other biopolymers such as proteins and nucleic acids, polysaccharides offer the highest capacity for carrying biological information because they have the greatest potential for structural variability. The nucleotides in nucleic acids and the amino acids in proteins can interconnect in only one way whereas the monosaccharide units in polysaccharides can interconnect at several points to form a wide variety of branched or linear structures. This enormous potential variability in polysaccharide structure gives the necessary flexibility to the precise regulatory mechanisms of various cell-cell interactions in higher organisms [18-20]. Mushroom polysaccharides are present mostly as glucans with different types of glycosidic linkages, such as (1→3), (1→6)-β-glucans and (1→3) - α, β-glucans, but some are true heteroglycans. The polysaccharides have linear or branched molecules in a backbone composed of α- or β-linked glucose units, and they contain side chains that are attached in different ways. Heteroglucan side chains contain glucuronic acid, xylose, galactose, mannose, arabinose, or ribose as a main component or in different combinations. Glycans, in general, are polysaccharides containing units other than glucose in their backbone. They are classified as galactans, fucans, xylans, and mannans by the individual sugar components in the backbone. A wide range of antitumor or immunostimulating polysaccharides of different chemical structure from mushrooms have been investigated.

Polysaccharides with antitumor action differ greatly in their chemical composition and configuration, as well as their physical properties. Antitumor activity is exhibited by a wide range of glycans extending from homopolymers to highly complex heteropolymers. Differences in activity can be correlated with solubility in water, size of the molecules, branching rate and form. Although it is difficult to correlate the structure and antitumor activity of complex polysaccharides, some relationships can be inferred. It is obvious that structural features such as β-(1→3) linkages in the main chain of the glucan and additional β-(1→6) branch points are needed for antitumor action. β-glucans containing mainly (1→6) linkages have less activity. High molecular weight glucans appear to be more effective than those of low molecular weight. However, obvious variations in antitumor polysaccharides have also been noted. Antititumor polysaccharides may have other chemical structures, such as hetero-β-glucans, β-glucan-protein, α-glucan-protein. Mushroom polysaccharides exert their antitumor action mostly via activation of the immune response of the host organism. These substances are regarded as biological response modifiers [21]; this basically means that:

(1) They cause no harm and place no additional stress on the body;

(2) They help the body to adapt to various environmental and biological stresses; and

(3) They exert a nonspecific action on the body, supporting some or all of the major systems, including nervous, hormonal, and immune systems, as well as regulatory functions.

Polysaccharides from mushrooms do not attack cancer cells directly, but produce their antitumor effects by activating different immune responses in the host. This has been verified in many experiments, such as the loss of the antitumor effect of polysaccharides in neonatal thymectomized mice or after administration of anti-lymphocyte serum. Such results suggest that the antitumor action of polysaccharides requires an intact T-cell component and that the activity is mediated through a thymus-dependent immune mechanism. Also, the antitumor activity of lentinan and other polysaccharides is inhibited by pre-treatment with antimacrophage agents. Thus, the various effects of polysaccharides are thought to be due to potentiation of the response of precursor T cells and macrophages to cytokines produced by lymphocytes after specific recognition of tumor cells. Mushroom polysaccharides are known to stimulate natural killer cells, T-cells, B-cells, and macrophage-dependent immune system responses.

Conclusion

A wide range of biologically active polysaccharides is found among mushrooms, and their practical application is dependent not only on their unique properties but also on biotechnological availability. Isolation and purification of polysaccharides from mushroom material is relatively simple and straightforward, and can be carried out with minimal effort. Determination of the structure of polysaccharide has been carried out mainly with the help of NMR spectroscopy. The relationship between the structure of polysaccharide and their biological activity is not clear.

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