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Review on Structural Characteristics and Biological Activities of Phellinus Polysaccharides

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Abstract. This paper reviewed the physicochemical properties and biological activities of Phellinus polysaccharides, covering the domestic and foreign research status quo articles in latest five years .We comprehensively compared the physicochemical properties, structural characteristics and biological activities of polysaccharides isolated from fruit bodies and mycelia of different Phellinus strains, which provides the underpinnings for exploition of Phellinus polysaccharidest.

Key words: Polysaccharides, structural characteristics, biological activities.

INTRODUCTION

The medicinal fungi Phellinus belongs to Basidiomycota, Hymenomycetes, Aphyllophorales, Hymenochaetaceae, usually grown, which normally grows in the Morus L. plants in south-central China, the sporophore is yellowish-brown, slightly bitter and cold, and it is used to treat dysentery, night sweat, metrorrhagia, bloody stranguria, navel and abdomen pain, and rectal prolapse bleed, morbid leucorrhea and amenorrhea in traditional Chinese medicine and so on. According to reports, the extracts of Phellinus has obvious anti-tumor, immune-enhancing, blood fat-lowering, blood sugar-reducimg, antioxidant, anti-inflammatory and other pharmacological effects [2-4], meanwhile Phellinus is considered to be a good medicine in the field of biological anti-cancer, which has become a hot spot in research and development of medicinal fungi in recent years. Phellinus polysaccharide is the main biological active substance of Phellinus igniarius, which exists in sporophore, mycelium and fermentation broth, and its blood sugar lowering, anti-oxidation, liver protection and immune regulation and biological activities are the research hotspots for its development and utilization [5].

At present, various Phellinus fungi have been used for medicines, during the research process; the phenomenon of "same objects with different names" and "different objects wit same name" frequently appeared. The taxonomist Dai Yucheng [6] systematically verified the names of medicinal fungus in China, and revised all the names according to the latest name rules, the Latin names of Phellinus are Phellinus baumii Pilát and Phellinus igniarius (L.: Fr.) Quél. sensu lato), Phellinus baumii Pilate has been mistakenly used in China as "P. linteus". Xie Liyuan [7] and others used rDNA ITS sequence analysis technology carry out molecular identification and genetic diversity analysis of Phellinus fungus. Calculating genetic distance and constructing phylogenetic tree based on rDNA ITS sequence; clearly there are 3 independent bacterial species groups, at present, the research on Phellinus at home and abroad is concentrated in these three major populations, this paper summarizes the polysaccharide structure characteristics and biological activities from several species of Phellinus reported in the past five years, and provide reference for the development and utilization of Phellinus polysaccharide.

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PHYSICOCHEMICAL PROPERTIES AND STRUCTURAL CHARACTERISTICS OF PHELLINUS POLYSACCHARIDES

Physicochemical Properties of Phellinus Polysaccharide

The polysaccharide substances in Phellinus exist mainly in the form of polysaccharides, glycoproteins and glucosides, according to the existing parts, they are divided into: intracellular polysaccharides, extracellular polysaccharides and sporophore polysaccharides a. Table 1 lists the monosaccharide composition and molecular weight distribution of homogeneous polysaccharide component isolated from sporophores and myceliums of different Phellinus igniarius species (mainly P. igniarius, P. linteus and P. baumii).

TABLE 1. Physicochemical property of homogeneous Phellinus polysaccharides

		mycelium polysaccharide					sporophore polysaccharide			
reported species of Phellinus		P.igniarius [8]	P.igniarius [9]	P.igniarius [10]	P.linteus [11]	P.baumii [12]	P.igniarius [13]	P.linteus [14]	P.linteus [15]	P.baumii [16]
homogeneous polysaccharide(Da)		PI11	PIE	PIP1	PLP	PBMP	P60wl	DOP-1	proteoglycan	PBF2
molecular weight		65k	--	17k	153k	--	17.1k	533k	150k	2000k
monosaccharide composition ratio	Fucose	10.2	--	--	--	1	1.12	--	--	1
	Rhamnose	--	--	--	--	0.22	--	--	--	--
	Arabinose	--	--	--	1.89	--	--	0.01	--	--
	Galactose	30.1	19.83	4.06	5.70	1.39	2.26	0.02	--	--
	Glucose	9.24	22.1	3.70	6.51	12.74	1	1.34	--	10.7
	Xylose	5.2	2.3	--	1	--		--	--	--
	Mannose	1	1	1	11.94	1.92	1.03	3.13	--	2.3
	Fructose	--	6.4	--	--	--		--	--	--
	3-O-Me-D-galactose	--	--	--	--	--	1.11	--	--	--
main chain configuration		--	--	β	--	--	α and β	--	α and β	β

Note: -- indicates that no detected or reported.

From the comprehensive research report (Table 1), it can be found that the physicochemical properties of the Phellinus polysaccharides obtained from different strains and different cultivation methods vary greatly. The research reported homogeneous polysaccharide isolated from Phellinus, its monosaccharide mainly consists of glucose and galactose. From the monosaccharide composition of several homogeneous polysaccharides isolated from P. igniarius strain, galactose accounts for a large proportion of monosaccharide composition; the content of mannose in intracellular polysaccharides and sporophore polysaccharides of P. linteus species is very high, while the mannose of P.igniarius and P.baumii strains is low in composition ratio; the homogeneous polysaccharide isolated from P. baumii strain has a larger proportion of glucose.

For the same strain, the sporophore polysaccharide and mycelium polysaccharide differ greatly in sugar composition. The monosaccharide and polysaccharide composition of mycelium is more complex than sporophore, and the content of fucose and mannose in some mycelium polysaccharides are relatively high. The monosaccharide composition in the sporophore polysaccharide is relatively simple, there are mainly glucose, galactose and mannose, and the composition ratio is not much different.

From the molecular weight distribution, the molecular weight of homogenous polysaccharides of Phellinus sporophore has been reported from ten thousand to millions (Table 1). Yan Jingkun [17] and others have found that mass average molar mass in bacterial cell polysaccharides of Phellinus range from 5.7*103 to 6.1*106Da, but homogeneous polysaccharide with millions molecular weights in mycelium has not been reported.

Structural Characteristics of Phellinus Polysaccharide

The fungus polysaccharide structure can be divided into primary, secondary, tertiary and quaternary structure, at present, most structural studies are limited to the primary structure, and there are mainly the monosaccharide residue composition, glycosidic bond type, and the polysaccharide configuration. Composition of the main chain, branching degree and branched chain in the primary structure affect the biological activity of sugar. Many scholars at home and abroad have conducted in-depth research on the structure of Phellinus igniarius, but mainly focused on the polysaccharide structure of Phellinus igniarius sporophore.

Yang Wei [18 -19] separated and purified a single polysaccharide P60wl from P. igniarius fruiting body, and further analyzed with GC-MS after acetylation of P60wl, meanwhile the unknown monosaccharide components in P60wl were identified by DEPT-135 atlas of 13C NMR, It was first discovered that mulberry polysaccharide contains 3-O-methyl-galactose. Zhou Yong [8] separated three single polysaccharides PI11, PI21 and PI31 from the mycelium of Phellinus igniarius, it shows that there is no continuous α(1→4) glycosidic bond, and the spectrum shows that its configuration is β type. LIU Y H[20] et al. separated the water soluble polysaccharide PRP from the Phellinus ri1 bis sporophore, PRP was identified as a β-D-glucan with 8.59 kDa molecular weight, its main chain is linked by (→4) and (1→6) two forms, branched chain is linked by (1→3). WU M J [9] etc. separated the homogeneous polysaccharide PIP1 from P. igniarius liquid submerged fermentation mycelium, The molecular weight is 17k Da, glycome become: Glucose, galactose and mannose, the ratio is 3.70: 4.06: 1.00, GC-MS analysis identified its glycosidic bond as β configuration, and the main chain is composed of (1→3)-glucose and (1→4)-mannose, The side chain is composed of (1→3, 6)-glucose and (1→4, 6)-mannose.

BIOACTIVITY OF PHELLINUS POLYSACCHARIDE

Anti-tumor and Immunoregulation Effect of Phellinus Polysaccharide

Many fungus polysaccharides have anti-tumor and immunoregulation functions [21]. In recent years, studies have shown that Phellinus polysaccharides act as a biological response regulator or immunologic stimulant, by activating immune cells in vivo (T cells, B cells, dendritic cells (DC), macrophages (M), and natural killer cells (NK), etc., multiple layers play an all-round role in promoting the immune system, thereby enhancing the host immunoregulation function to achieve anti-tumor activity, and almost no toxicity to normal cells [22-23].

LI G [24] and others separated proteoglycans from Phellinus linteus, it was found that by studying its cell cytotoxic mechanism; this proteoglycan can cause G2/M phase block and induce apoptosis of human rectal tumor cells. Park [25] and others' studies have shown that the acidic polysaccharides of Phellinus igniarius can also promote the maturation of functional dendritic cells in surface of rats, and induce migration to lymphocytes. Sang-Bae Han[26] purified an acid protein proteoglycan PL that can significantly inhibit mouse melanoma from Phellinus linteus mycelium, it was found that PL does not directly inhibit cancer cell growth, but inhibits adhesion of cancer cells and prevent cancer cells from invading the extracellular stroma, and significantly increased the release of NO from macrophages. Therefore, PL acts as an immunopotentiator and an inhibitor of cancer cell adhesion to achieve an anti-tumor effect.

Hypoglycemic Effect of Phellinus Polysaccharide

Insulin-dependent diabetes mellitus (IDDM) is a disease caused by own immunodeficiency and is dominant diabetes characterized by lymphocytes infiltrating islet beta cells [27]. Hwan Mook Kim [28] and others establish non-obese diabetic (NOD) models to study the pathogeny of IDDM, usually 80% of NOD rats will have IDDM at 24 weeks, and rats which take Phellinus linteus polysaccharide (PLP), none has diabetes, and blood glucose level is 110 mg/dl; NOD rats control without taking PLP, its blood sugar level is 499 mg/dl. Histological examination of islet cells show that compared to the NOD rats control, there is only a small amount of islet lymphocytic infiltration in rats that have taken PLP, and there is no adaptive diabetes characterization. The results indicate that Phellinus polysaccharide inhibits the expression of inflammatory factors including IFN-γ, IL-2, and TNF-α through Th cells and macrophages, thereby inhibiting insulin-dependent diabetes mellitus in non-obese rats.

Antioxidant Effect of Phellinus Polysaccharide

Free radical is a normal metabolite result in the human body, the free radicals are in a dynamic equilibrium in the human body under normal conditions, but once the balance is broken, it will cause damage to the body, thus leading to a series of related diseases [29]. Studies have found that Phellinus polysaccharide has the functions of scavenging free radicals, inhibiting lipid peroxidation and increasing antioxidant enzyme activity, and can effectively slow down aging. Yan Jingkun [17] and others studies external antioxidant activity of intracellular polysaccharides from liquid fermentation of Phellinus elegans, found that intracellular polysaccharides of Phellinus bacteria can better remove • OH, O2-• and chelate Fe2+, and have obvious scavenging action for O2-•. Song [30] and others found that P. linteus sporophore polysaccharide can directly remove stable DPPH free radicals, but also inhibit the production of lipid

peroxide (LPO). LUO JG [35] and others induced rat oxidative models through D-galactose-, found that P. baumii polysaccharide significantly increased antioxidant enzyme activity, enhanced total antioxidant capacity, and reduced lipid peroxide MDA levels in rats' serum and liver.

PROSPECT AND OUTLOOK OF RESEARCH ON PHELLINUS POLYSACCHARIDES

In recent years, scholars at home and abroad have continued to deepen their research on Phellinus, people have begun to become familiar with the medicinal value of Phellinus, especially for its anti-cancer function. Due to the large export demand and high price of Phellinus, the domestic production sites are subject to predatory mining, and the rare medicinal fungi resources of Phellinus are facing exhaustion. Recent studies have shown that although there are some differences in physicochemical properties and structural characteristics between mycelium polysaccharides and sporophore polysaccharides, mycelium polysaccharides show good bioactivity in animal experiments and the cellular level.

It takes only one week for the fermentation of Phellinus mycelium, and the growth of Phellinus sporophore takes at least 1-2 years. The mycelium of Phellinus igniarius is obtained by fermentation, and the active polysaccharide in the Phellinus mycelium is extracted, and it has a broad prospect for the development and utilization of sporophore polysaccharides. However, the research on the structure and activity of polysaccharides structure of Phellinus mycelium is not enough, whether the homogeneous polysaccharide of macromolecules exists in the Phellinus mycelium, and how to separate and purify it remains to be further studied. The industrial production of Phellinus mycelium and the extraction technology of mycelium polysaccharides need to be continuously studied.

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