

Review

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Review

The Influence of Monosaccharide Composition on the Bioactivity of Medicinal Plant Polysaccharides: A Review

Xinhui Fan ^{1,2,3}, Ke Li ^{1,2,4*}, Maohui Yang ^{1,2,5}, Xuemei Qin ^{1,2}, Zhenyu Li ^{1,2} and Yuguang Du ⁴

¹ Modern Research Center for Traditional Chinese Medicine, Shanxi University, Taiyuan 030006, China

² The Key Laboratory of Chemical Biology and Molecular Engineering of Ministry of Education, Shanxi University, Taiyuan 030006, China

³ Engineering Research Center of Glycoconjugates of Ministry of Education, School of Life Sciences, Northeast Normal University, Changchun 130024, China

⁴ State Key Laboratory of Biochemical Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing 100700, China

⁵ Institute of Chinese Materia Medica, China Academy of Chinese Medical Sciences, Beijing 100700, China

* Correspondence: like@sxu.edu.cn

Abstract

Polysaccharides are natural polymers widely found in medicinal plants. Structurally, polysaccharides are complex molecules composed of long chains of monosaccharide units linked by glycosidic bonds. Modern pharmacological research shows that the monosaccharide composition of polysaccharides is closely related to their bioactivity. This review systematically summarizes high-quality literature from recent years concerning the influence of monosaccharide composition on the biological activity of polysaccharides. The results are as follows: Glucans are vital for immune regulation, antioxidant effects and the regulation of gut microbiota. Similarly, galactans are important for antioxidant effects, immune regulation and the regulation of gut microbiota. Mannans play a critical role in immune regulation, anti-tumour effects and neuroprotection. Fructans play a critical role in regulating gut microbiota, immune regulation, and antioxidant effects. Pectin plays a critical role in immune regulation, antioxidant effects, and lowering blood sugar. Consequently, developing polysaccharides from medicinal plant resources based on their monosaccharide composition is expected to speed up the search for polysaccharides with high biological activity and provide a theoretical reference for polysaccharide research.

Keywords: bioactivity; medicinal plant polysaccharides; monosaccharide composition

1. Introduction

Polysaccharides are natural macromolecule polymers of long chains of monosaccharide units linked via glycosidic bonds, widely exist in medicinal plants [1]. Due to their non-toxicity and abundant availability, they have garnered increasing research attention in recent years [2].

Modern pharmacological studies have shown that medicinal plant polysaccharides have a variety of biological activities, including immune regulation, the protection of the liver, the protection of nerves, anti-oxidation, anti-fatigue, regulation of intestinal flora, and regulation of blood glucose [3].

Polysaccharides possess highly complex structural characteristics, including molecular weight, monosaccharide composition, glycosidic bond configuration and functional groups [4]. These structural features determine and influence the biological activity of polysaccharides. Among these, monosaccharides constitute the most fundamental units of the primary structure of polysaccharides and form the basis for other advanced structures [5]. They not only influence the physicochemical

properties of polysaccharides, such as functional group, electrification, chain length, and spatial conformation [6], but are also among the most easily detectable indicators.

Although various biological activities of medicinal plant polysaccharides have been extensively studied, a systematic review focusing on how monosaccharide composition influences their biological functions remains relatively scarce. A systematic analysis of the relationship between monosaccharide composition and specific biological activities is crucial for understanding the mechanisms of action of polysaccharides.

This review systematically summarizes high-quality literature from recent years concerning the influence of monosaccharide composition on the biological activity of polysaccharides. It is hoped that this will provide new perspectives for understanding the relationship between structure and function of medicinal plant polysaccharides.

2. Main Monosaccharides Description

The primary monosaccharide types in medicinal plant polysaccharides include glucose, galactose, arabinose, mannose, rhamnose, xylose, fucose, glucuronic acid, galacturonic acid and fructose. The monosaccharides can be classified as pentoses and hexoses based on the number of carbon atoms [7]. Xylose and arabinose are classified as pentoses. Meanwhile, glucose, galactose, mannose, rhamnose, fucose, glucuronic acid, galacturonic acid and fructose are classified as hexoses. Furthermore, uronic acids are a class of monosaccharide derivatives characterised by the structural oxidation of the hydroxyl group (typically at C6) to a carboxyl group (-COOH) [8]. The types of uronic acid that make up medicinal plant polysaccharides mainly include glucuronic acid and galacturonic acid. Their structures are shown in Figure 1.

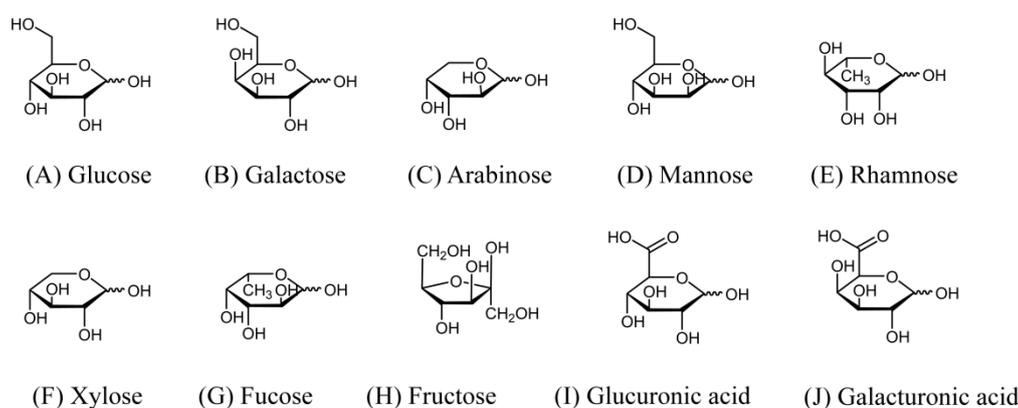


Figure 1. Main types of monosaccharides composed in medicinal plant polysaccharides.

3. Classification of Medicinal Plant Polysaccharides

This article systematically summarises the monosaccharide composition of 210 polysaccharides from 72 medicinal plants. These are listed in Table 1 and Figure 2. Polysaccharides in medicinal plants may be classified as neutral polysaccharides or acidic polysaccharides based on whether their monosaccharide composition includes uronic acids. Neutral polysaccharides are primarily classified into six categories: glucans, galactans, arabinans, mannans, fructans, and xylans (Figure 2A). In the classification of galactans, arabinogalactan constitutes the primary component, whereas the proportion of pure galactans (gal > 90%) is comparatively low (Figure 2B). In the classification of mannans, glucomannan constitutes the primary component, whereas the proportion of pure mannans (man > 90%) is comparatively low (Figure 2C). Acidic polysaccharides are primarily pectins, which are categorised into two main types (Figure 2D) based on their monosaccharide composition:

homogalacturonan (HG) and rhamnogalacturonan-I (RG I). Their structures of 10 polysaccharides are shown in Figure 3.

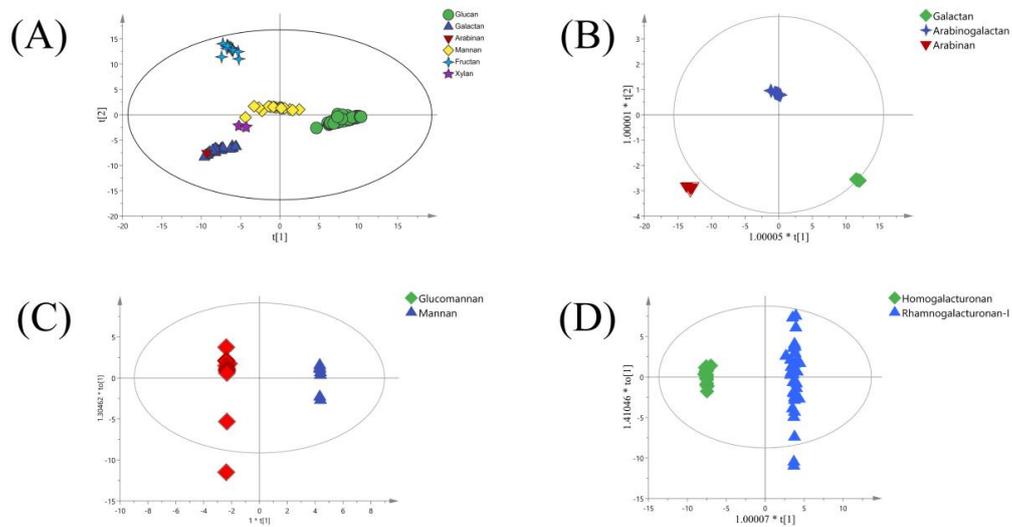


Figure 2. PCA scatter plots of monosaccharide composition of medicinal plant polysaccharides. (A): neutral polysaccharides; (B): galactans; (C): mannans; (D): acidic polysaccharides.

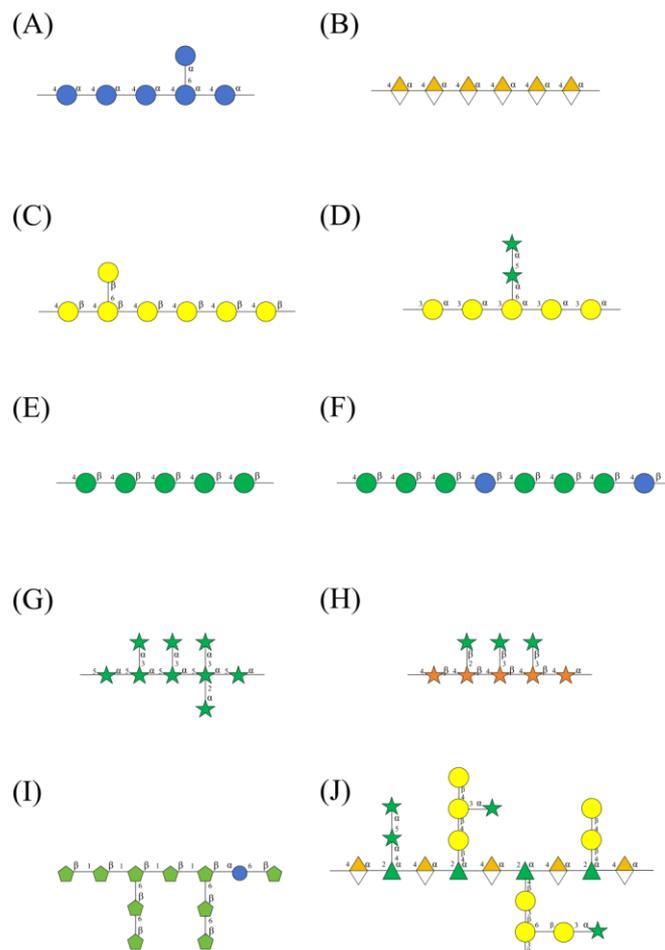


Figure 3. The hypothetical chemical structure of 10 polysaccharides. (A): glucans; (B): homogalacturonan; (C): galactans; (D): arabinogalactans; (E): mannans; (F): glucomannan; (G): arabinans; (H): xylans; (I): fructans; (J): rhamnogalacturonan-I.

Table 1. Monosaccharide composition and the bioactivity of medicinal plant polysaccharides.

No.	Source	Types of polysaccharides	Glucose	Galactose	Arabinose	Mannose	Rhamnose	Xylose	Fucose	Glucuronic acid	Galacturonic acid	Fructose	Bioactivity	Reference
1	<i>Astragalus membranaceus</i>	Glucans	89.00	3.00	3.50	1.00	-	-	-	-	-	-	Immunomodulatory activity	[9]
2	<i>Astragalus membranaceus</i>	Glucans	95.76	1.83	2.41	-	-	-	-	-	-	-	Immunomodulatory activity	[10]
3	<i>Astragalus membranaceus</i>	Glucans	95.76	1.83	2.41	-	-	-	-	-	-	-	Immunomodulatory activity	[11]
4	<i>Astragalus membranaceus</i>	Glucans	91.69	4.18	4.13	-	-	-	-	-	-	-	Immunomodulatory activity	[12]
5	<i>Panax ginseng</i>	Glucans	88.60	3.80	3.70	0.70	0.60	-	-	0.80	1.80	-	Immunomodulatory activity	[13]
6	<i>Sagittaria sagittifolia</i>	Glucans	91.76	7.72	0.27	-	-	-	-	-	-	-	Immunomodulatory activity	[14]
7	<i>Panax ginseng</i>	Glucans	95.30	3.30	1.30	-	-	-	-	-	-	-	Immunomodulatory activity	[15]
8	<i>Dendrobium huoshanense</i>	Glucans	95.46	-	-	4.54	-	-	-	-	-	-	Immunomodulatory activity	[16]
9	<i>Dendrobium officinale</i>	Glucans	94.17	-	-	-	-	-	-	5.82	-	-	Immunomodulatory activity	[17]
10	<i>Angelica dahurica</i>	Glucans	97.50	0.41	-	0.82	-	1.15	-	-	-	-	Immunomodulatory activity	[18]
11	<i>Angelica sinensis</i>	Glucans	97.83	-	-	1.19	-	-	-	-	-	-	Immunomodulatory activity	[19]
12	<i>Polygonum multiflorum</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Immunomodulatory activity	[20]
13	<i>Radix Aconiti Lateralis Preparata</i>	Glucans	92.50	-	7.50	-	-	-	-	-	-	-	Immunomodulatory activity	[21]
14	<i>Schisandra chinensis</i>	Glucans	89.10	-	-	-	-	-	-	-	10.90	-	Immunomodulatory activity	[22]
15	<i>Schisandra chinensis</i>	Glucans	89.80	10.20	-	-	-	-	-	-	-	-	Immunomodulatory activity	[23]
16	<i>Gastrodia elata</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Immunomodulatory activity	[24]
17	<i>Pueraria lobata</i>	Glucans	95.74	2.19	1.25	0.30	-	0.43	0.09	-	-	-	Immunomodulatory activity	[25]
18	<i>Pueraria lobata</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Immunomodulatory activity	[26]
19	<i>Glehnia littoralis</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Immunomodulatory activity	[27]
20	<i>Astragalus membranaceus</i>	Glucans	96.43	1.40	2.17	-	-	-	-	-	-	-	Regulation of intestinal flora	[28]
21	<i>Astragalus membranaceus</i>	Glucans	85.30	7.70	7.00	-	-	-	-	-	-	-	Regulation of intestinal flora	[29]

2	<i>Astragalus membranaceus</i>	Glucans	85.96	-	4.45	0.83	-	6.15	-	2.52	-	-	Regulation of intestinal flora	[30]
2	<i>Astragalus membranaceus</i>	Glucans	79.07	6.63	8.56	0.79	1.70	-	-	-	3.28	-	Regulation of intestinal flora	[31]
2	<i>Panax ginseng</i>	Glucans	96.64	3.20	-	-	-	-	-	-	-	-	Regulation of intestinal flora	[32]
2	<i>Crataegus pinnatifida</i>	Glucans	95.37	0.42	0.79	0.15	0.70	-	-	-	2.34	-	Regulation of intestinal flora	[33]
2	<i>Lycium barbarum</i>	Glucans	98.10	-	-	-	-	-	-	-	-	-	Regulation of intestinal flora	[34]
2	<i>Atractylodis macrocephalae</i>	Glucans	84.16	6.51	9.33	-	-	-	-	-	-	-	Regulation of intestinal flora	[35]
2	<i>Lycium barbarum</i>	Glucans	81.83	2.02	3.46	6.52	6.06	-	-	-	-	-	Neuroprotective activity	[36]
2	<i>Schisandra chinensis</i>	Glucans	87.80	12.30	-	-	-	-	-	-	-	-	Neuroprotective activity	[37]
3	<i>Gastrodia elata</i>	Glucans	99.10	0.90	-	-	-	-	-	-	-	-	Neuroprotective activity	[38]
3	<i>Gastrodia elata</i>	Glucans	97.90	-	2.10	-	-	-	-	-	-	-	Neuroprotective activity	[39]
3	<i>Gastrodia elata</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Neuroprotective activity	[40]
3	<i>Lonicera japonica</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Neuroprotective activity	[41]
3	<i>Corydalis yanhusuo</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Neuroprotective activity	[42]
3	<i>Dendrobium officinale</i>	Glucans	77.87	-	-	22.12	-	-	-	-	-	-	Antioxidant activity	[43]
3	<i>Angelica sinensis</i>	Glucans	76.34	14.81	2.63	5.78	-	-	-	-	-	-	Antioxidant activity	[44]
3	<i>Polygonum multiflorum</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Antioxidant activity	[45]
3	<i>Glycyrrhiza inflata</i>	Glucans	79.08	10.50	10.42	-	-	-	-	-	-	-	Antioxidant activity	[46]
3	<i>Glycyrrhiza glabra</i>	Glucans	98.03	-	-	-	-	-	-	-	-	-	Antioxidant activity	[47]
4	<i>Pouteria campechiana</i>	Glucans	86.65	-	-	4.62	-	-	-	-	-	-	Antioxidant activity	[48]
4	<i>Taraxacum officinale</i>	Glucans	79.30	10.00	8.80	-	1.50	-	-	-	-	-	Antioxidant activity	[49]
4	<i>Sophora flavescens</i>	Glucans	78.75	9.17	8.34	2.49	0.30	0.95	-	-	-	-	Antioxidant activity	[50]
4	<i>Fallopia multiflora</i>	Glucans	100.00	-	-	-	-	-	-	-	-	-	Antioxidant activity	[51]
4	<i>Astragalus membranaceus</i>	Glucans	97.51	1.56	0.93	-	-	-	-	-	-	-	Hypoglycemic activity	[52]
4	<i>Angelica sinensis</i>	Glucans	84.59	8.90	-	-	6.36	-	-	-	-	-	Hypoglycemic activity	[53]
4	<i>Codonopsis pilosula</i>	Glucans	71.38	24.98	3.60	-	-	-	-	-	-	-	Hypoglycemic activity	[54]
4	<i>Glycyrrhiza uralensis</i>	Glucans	78.38	7.51	5.55	2.82	0.65	3.96	0.65	-	0.48	-	Hypoglycemic activity	[55]
4	<i>Lycium barbarum</i>	Glucans	81.83	2.02	3.46	6.52	6.06	-	-	-	-	-	Hepatoprotective activity	[56]
4	<i>Polygonatum sibiricum</i>	Glucans	98.10	-	-	-	-	-	-	-	-	-	Hepatoprotective activity	[57]
5	<i>Schisandra chinensis</i>	Glucans	77.80	4.10	7.74	-	-	-	-	-	8.98	-	Hepatoprotective activity	[58]

5	<i>Puerariae lobatae</i>	Glucans	10 0.0	-	-	-	-	-	-	-	-	-	-	Hepatoprotective activity	[59]
5	<i>Puerariae thomsonii</i>	Glucans	10 0.0	-	-	-	-	-	-	-	-	-	-	Hepatoprotective activity	[60]
5	<i>Puerariae thomsonii</i>	Glucans	10 0.0	-	-	-	-	-	-	-	-	-	-	Hepatoprotective activity	[61]
5	<i>Cyathulae officinalis</i>	Glucans	93.34	6.65	-	-	-	-	-	-	-	-	-	Hepatoprotective activity	[62]
5	<i>Ginkgo biloba</i>	Glucans	98.12	1.10	0.80	-	-	-	-	-	-	-	-	Hepatoprotective activity	[63]
5	<i>Dendrobium officinale</i>	Glucans	81.80	-	-	18.20	-	-	-	-	-	-	-	Antitumor activity	[64]
5	<i>Angelica sinensis</i>	Glucans	93.15	-	6.75	-	-	-	-	-	-	-	-	Antitumor activity	[65]
5	<i>Platycodon grandiflorus</i>	Glucans	92.80	2.85	1.11	0.26	-	-	-	1.14	1.83	-	-	Antitumor activity	[66]
5	<i>Atractylodes macrocephala</i>	Glucans	82.10	-	17.90	-	-	-	-	-	-	-	-	Antitumor activity	[67]
6	<i>Glehnia littoralis</i>	Glucans	92.10	5.30	2.60	-	-	-	-	-	-	-	-	Antitumor activity	[68]
6	<i>Pseudostellaria heterophylla</i>	Glucans	93.10	1.00	0.90	-	-	-	-	2.50	0.50	-	-	Antitumor activity	[69]
6	<i>Angelica pubescens</i>	Glucans	85.10	4.50	3.20	7.30	-	-	-	-	-	-	-	Anti-inflammatory activity	[70]
6	<i>Dioscorea opposita</i>	Glucans	79.72	3.03	1.45	14.90	0.22	0.42	-	-	-	-	-	Anti-inflammatory activity	[71]
6	<i>Gastrodia elata</i>	Glucans	99.30	0.20	-	-	-	-	-	-	0.40	-	-	Anti-inflammatory activity	[72]
6	<i>Gastrodia elata</i>	Glucans	100.0	-	-	-	-	-	-	-	-	-	-	Anti-inflammatory activity	[73]
6	<i>Lycium ruthenicum</i>	Arabinogalactans	-	39.52	56.62	-	3.80	-	-	-	-	-	-	Immunomodulatory activity	[74]
6	<i>Lycium barbarum</i>	Arabinogalactans	-	31.07	63.79	-	1.23	-	-	-	3.89	-	-	Immunomodulatory activity	[75]
6	<i>Scutellaria baicalensis</i>	Arabinogalactans	-	22.20	67.10	-	4.40	-	-	1.20	6.30	-	-	Immunomodulatory activity	[76]
6	<i>Rehmannia glutinosa</i>	Arabinogalactans	0.05	56.60	38.10	-	-	-	-	-	-	-	-	Immunomodulatory activity	[77]
7	<i>Atractylodes lancea</i>	Arabinogalactans	-	35.00	50.00	-	14.50	4.00	-	-	-	-	-	Immunomodulatory activity	[78]
7	<i>Astragalus membranaceus</i>	Arabinogalactans	6.34	27.39	48.39	1.61	6.05	-	-	-	10.21	-	-	Immunomodulatory activity	[79]
7	<i>Astragalus membranaceus</i>	Arabinogalactans	13.77	18.36	51.00	-	1.53	-	-	-	15.30	-	-	Immunomodulatory activity	[80]
7	<i>Atractylodes lancea</i>	Arabinogalactans	3.01	11.21	70.82	-	8.84	1.84	-	-	4.28	-	-	Immunomodulatory activity	[81]
7	<i>Dendrobium officinale</i>	Arabinogalactans	-	46.79	29.79	-	11.68	-	-	-	11.80	-	-	Regulation of intestinal flora	[82]
7	<i>Lycium barbarum</i>	Arabinogalactans	-	35.50	55.60	-	8.00	-	-	-	-	-	-	Regulation of intestinal flora	[83]
7	<i>Lycium barbarum</i>	Arabinogalactans	2.15	39.67	40.66	-	-	-	-	5.12	12.40	-	-	Regulation of intestinal flora	[84]
7	<i>Lycium barbarum</i>	Arabinogalactans	8.26	33.49	45.87	-	-	-	-	3.21	9.17	-	-	Regulation of intestinal flora	[85]

7	<i>Lycium</i>	Arabinogalac	2.1	39.6	40.6	-	-	-	-	5.12	12.40	-	Regulation	[86]
8	<i>barbarum</i>	tans	5	7	6	-	-	-	-	-	-	-	of intestinal	
7	<i>Angelica</i>	Arabinogalac	-	62.0	30.3	-	-	-	-	-	7.57	-	Regulation	[87]
9	<i>sinensis</i>	tans	-	8	6	-	-	-	-	-	-	-	of intestinal	
8	<i>Atractylodes</i>	Arabinogalac	-	44.1	55.9	-	-	-	-	-	-	-	Regulation	[88]
0	<i>chinensis</i>	tans	-	0	0	-	-	-	-	-	-	-	of intestinal	
8	<i>Angelica</i>	Arabinogalac	17.	52.4	19.3	-	-	-	-	10.44	-	-	Antioxidant	[89]
1	<i>sinensis</i>	tans	75	1	1	-	-	-	-	-	-	-	activity	
8	<i>Angelica</i>	Arabinogalac	17.	52.4	19.3	-	-	-	-	10.44	-	-	Antioxidant	[90]
2	<i>sinensis</i>	tans	75	0	1	-	-	-	-	-	-	-	activity	
8	<i>Angelica</i>	Arabinogalac	17.	52.4	19.3	-	-	-	-	10.44	-	-	Antioxidant	[91]
3	<i>sinensis</i>	tans	75	0	1	-	-	-	-	-	-	-	activity	
8	<i>Bupleurum</i>	Arabinogalac	17.	44.5	37.3	-	-	-	-	-	-	-	Antioxidant	[92]
4	<i>chinense</i>	tans	80	0	8	-	-	-	-	-	-	-	activity	
8	<i>Zizyphus</i>	Arabinogalac	3.4	55.4	33.3	2.4	4.0	-	-	-	1.42	-	Antioxidant	[93]
5	<i>Jujuba</i>	tans	1	0	0	4	6	-	-	-	-	-	activity	
8	<i>Pueraria</i>	Arabinogalac	4.5	58.5	27.8	0.6	7.4	-	-	0.80	0.20	-	Antioxidant	[94]
6	<i>mirifica</i>	tans	0	0	0	0	0	-	-	-	-	-	activity	
8	<i>Taraxacum</i>	Arabinogalac	9.4	42.2	43.8	2.3	2.0	-	-	-	-	-	Antioxidant	[95]
7	<i>officinale</i>	tans	3	4	4	5	7	-	-	-	-	-	activity	
8	<i>Taraxacum</i>	Arabinogalac	8.0	52.9	25.9	7.3	1.8	-	-	1.47	2.40	-	Antioxidant	[96]
8	<i>officinale</i>	tans	7	4	5	3	4	-	-	-	-	-	activity	
8	<i>Ginkgo biloba</i>	Arabinogalac	5.9	54.0	17.2	4.3	6.4	-	-	8.64	3.24	-	Antioxidant	[97]
9		tans	4	0	8	2	8	-	-	-	-	-	activity	
9	<i>Panax ginseng</i>	Arabinogalac	-	22.4	53.8	-	10.	-	-	-	13.20	-	Antioxidant	[98]
0		tans	-	0	0	-	30	-	-	-	-	-	activity	
9	<i>Polygonatum</i>	Arabinogalac	-	73.6	21.0	-	5.2	-	-	-	-	-	Antioxidant	[99]
1	<i>sibiricum</i>	tans	-	4	4	-	6	-	-	-	-	-	activity	
9	<i>Lycium</i>	Arabinogalac	6.4	40.8	44.9	1.0	2.9	3.	-	-	-	-	Anti-aging	[100]
2	<i>barbarum</i>	tans	8	5	9	6	7	65	-	-	-	-	activity	
9	<i>Lycium</i>	Arabinogalac	-	45.9	46.1	-	-	-	-	-	-	-	Anti-aging	[101]
3	<i>barbarum</i>	tans	-	0	0	-	-	-	-	-	-	-	activity	
9	<i>Rehmannia</i>	Arabinogalac	6.6	37.8	55.4	-	-	-	-	-	-	-	Anti-aging	[102]
4	<i>glutinosa</i>	tans	8	3	9	-	-	-	-	-	-	-	activity	
9	<i>Rehmannia</i>	Arabinogalac	15.	61.3	18.1	0.8	3.3	-	-	-	0.96	-	Anti-aging	[103]
5	<i>glutinosa</i>	tans	39	6	9	0	1	-	-	-	-	-	activity	
9	<i>Lycium</i>	Arabinogalac	-	60.9	39.0	-	-	-	-	-	-	-	Neuroprote	[104]
6	<i>barbarum</i>	tans	-	3	6	-	-	-	-	-	-	-	ctive	
9	<i>Lycium</i>	Arabinogalac	6.8	37.6	34.8	1.0	3.6	2.	-	0.73	12.67	-	Neuroprote	[105]
7	<i>barbarum</i>	tans	9	4	8	3	8	46	-	-	-	-	ctive	
9	<i>Lycium</i>	Arabinogalac	1.4	49.8	47.8	-	1.2	-	-	-	-	-	Neuroprote	[106]
8	<i>barbarum</i>	tans	0	0	0	-	0	-	-	-	-	-	ctive	
9	<i>Ginkgo biloba</i>	Arabinogalac	3.0	5.00	82.0	5.0	-	-	-	-	-	-	Neuroprote	[107]
9		tans	0	-	0	0	-	-	-	-	-	-	ctive	
1	<i>Lycium</i>	Arabinogalac	-	44.4	48.1	-	-	-	-	-	-	-	Antitumor	[108]
0	<i>barbarum</i>	tans	-	4	5	-	-	-	-	-	-	-	activity	
1	<i>Lycium</i>	Arabinogalac	4.0	46.2	40.2	1.7	5.1	-	-	2.30	0.50	-	Antitumor	[109]
0	<i>ruthenicum</i>	tans	0	0	0	0	0	-	-	-	-	-	activity	
1	<i>Angelica</i>	Arabinogalac	17.	52.4	19.3	-	-	-	-	10.44	-	-	Antitumor	[110]
0	<i>sinensis</i>	tans	75	1	1	-	-	-	-	-	-	-	activity	
2	<i>Panax</i>	Arabinogalac	-	43.7	56.3	-	-	-	-	-	-	-	Antitumor	[111]
1	<i>notoginseng</i>	tans	-	0	0	-	-	-	-	-	-	-	activity	
3	<i>Ophiopogon</i>	Galactans	-	100.	-	-	-	-	-	-	-	-	Antitumor	[112]
1	<i>japonicus</i>		-	00	-	-	-	-	-	-	-	-	activity	
4	<i>Polygonatum</i>	Galactans	-	100.	-	-	-	-	-	-	-	-	Regulation	[113]
1	<i>cyrtonea</i>		-	00	-	-	-	-	-	-	-	-	of intestinal	
0	<i>Polygonatum</i>	Galactans	-	100.	-	-	-	-	-	-	-	-	Regulation	[114]
1	<i>cyrtonea</i>		-	00	-	-	-	-	-	-	-	-	of intestinal	
6	<i>Polygonatum</i>	Galactans	2.1	82.9	-	14.	-	-	-	-	-	-	Immunomo	[115]
1	<i>sibiricum</i>		3	1	-	96	-	-	-	-	-	-	dulatory	
0		Galactans	-	-	-	-	-	-	-	-	-	-	activity	
7			-	-	-	-	-	-	-	-	-	-		

1	<i>Polygonatum</i>	Galactans	-	78.7	-	5.5	-	-	-	-	13.84	-	Immunomodulatory activity	[116]
0	<i>sibiricum</i>			7		0								
8														
1	<i>Rehmannia</i>	Arabinans	-	-	100.	-	-	-	-	-	-	-	Immunomodulatory activity	[117]
0	<i>glutinosa</i>				00									
9														
1	<i>Glehnia</i>	Arabinans	-	-	100.	-	-	-	-	-	-	-	Antitumor activity	[118]
1	<i>littoralis</i>				00									
0														
1	<i>Akebia</i>	Arabinans	-	-	100.	-	-	-	-	-	-	-	Immunomodulatory activity	[119]
1	<i>quinata</i>				00									
1														
1	<i>Dendrobium</i>	Glucomannans	33.	1.00	-	59.	0.5	-	-	-	-	-	Immunomodulatory activity	[120]
1	<i>officinale</i>		31			31	1							
2														
1	<i>Dendrobium</i>	Glucomannans	20.	-	-	80.	-	-	-	-	-	-	Immunomodulatory activity	[121]
1	<i>officinale</i>		00			00								
3														
1	<i>Dendrobium</i>	Glucomannans	25.	-	-	74.	-	-	-	-	-	-	Immunomodulatory activity	[122]
1	<i>huoshanense</i>		78			22								
4														
1	<i>Dendrobium</i>	Glucomannans	14.	-	-	85.	-	-	-	-	-	-	Immunomodulatory activity	[123]
1	<i>officinale</i>		50			50								
5														
1	<i>Anemarrhena</i>	Glucomannans	10.	2.60	7.30	79.	0.	-	-	-	-	-	Immunomodulatory activity	[124]
1	<i>asphodeloides</i>		90			00	20							
6														
1	<i>Dendrobium</i>	Glucomannans	22.	-	-	76.	-	-	-	-	-	-	Antitumor activity	[125]
1	<i>wardianum</i>		85			66								
7														
1	<i>Dendrobium</i>	Glucomannans	12.	-	-	87.	-	-	-	-	-	-	Antitumor activity	[126]
1	<i>officinale</i>		65			34								
8														
1	<i>Platycodon</i>	Glucomannans	42.	-	-	57.	-	-	-	-	-	-	Antitumor activity	[127]
1	<i>grandiflorum</i>		00			96								
9														
1	<i>Dendrobium</i>	Glucomannans	17.	-	-	82.	-	-	-	-	-	-	Neuroprotective activity	[128]
1	<i>officinale</i>		92			08								
2														
1	<i>Dendrobium</i>	Glucomannans	24.	-	-	75.	-	-	-	-	-	-	Neuroprotective activity	[129]
1	<i>huoshanense</i>		19			81								
2														
1	<i>Dendrobium</i>	Glucomannans	33.	0.48	0.26	65.	-	-	-	-	-	-	Gastroprotective activity	[130]
1	<i>huoshanense</i>		47			79								
2														
2	<i>Dendrobium</i>	Glucomannans	24.	-	-	75.	-	-	-	-	-	-	Gastroprotective activity	[131]
1	<i>huoshanense</i>		75			25								
3														
1	<i>Dendrobium</i>	Glucomannans	24.	-	-	76.	-	-	-	-	-	-	Hepatoprotective activity	[132]
1	<i>officinale</i>		00			00								
2														
1	<i>Dendrobium</i>	Glucomannans	17.	-	-	82.	-	-	-	-	-	-	Renal protective activity	[133]
1	<i>officinale</i>		24			76								
2														
5	<i>Dendrobium</i>	Glucomannans	28.	-	-	71.	-	-	-	-	-	-	Regulation of intestinal flora	[134]
1	<i>officinale</i>		17			83								
2														
6	<i>Dendrobium</i>	Glucomannans	36.	1.65	-	62.	-	-	-	-	-	-	Anti-osteoporosis activity	[135]
1	<i>huoshanense</i>		07			25								
2														
7														
1	<i>Bletilla</i>	Glucomannans	25.	-	-	75.	-	-	-	-	-	-	Antioxidant activity	[136]
1	<i>striata</i>		00			00								
8														
1	<i>Dendrobium</i>	Mannans	5.0	2.29	1.46	91.	-	-	-	-	-	-	Immunomodulatory activity	[137]
1	<i>officinale</i>		9			15								
2														
3	<i>Ginkgo</i>	Mannans	-	2.91	-	97.	-	-	-	-	-	-	Antioxidant activity	[138]
1	<i>biloba</i>					08								
0														
1	<i>Codonopsis</i>	Fructans	3.4	-	-	-	-	-	-	-	-	96.	Regulation of intestinal flora	[139]
1	<i>pilosula</i>		0									60		
3														
1	<i>Codonopsis</i>	Fructans	2.7	-	-	-	-	-	-	-	-	97.	Regulation of intestinal flora	[140]
1	<i>pilosula</i>		2									28		
3														
2														

1	<i>Ophiopogon japonicus</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Regulation of intestinal flora	[141]
3	<i>Ophiopogon japonicus</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Regulation of intestinal flora	[142]
3	<i>Ophiopogon japonicus</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Regulation of intestinal flora	[143]
3	<i>Ophiopogon japonicus</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Regulation of intestinal flora	[144]
3	<i>Polygonatum kingianum</i>	Fructans	6.90	-	-	0.90	-	-	-	-	-	91.30	Regulation of intestinal flora	[145]
3	<i>Polygonatum kingianum</i>	Fructans	6.44	-	-	-	-	-	-	-	-	93.56	Regulation of intestinal flora	[146]
3	<i>Polygonatum cyrtoneura</i>	Fructans	3.44	-	-	-	-	-	-	-	-	96.32	Regulation of intestinal flora	[147]
4	<i>Polygonatum cyrtoneura</i>	Fructans	7.50	-	-	7.40	-	-	-	-	-	77.40	Regulation of intestinal flora	[148]
4	<i>Polygonatum kingianum</i>	Fructans	7.10	-	-	-	-	-	-	-	-	92.90	Regulation of intestinal flora	[149]
4	<i>Polygonatum cyrtoneura</i>	Fructans	5.84	-	-	3.18	-	-	-	-	-	89.48	Regulation of intestinal flora	[150]
4	<i>Atractylodes lancea</i>	Fructans	5.52	-	-	-	-	-	-	-	-	94.48	Regulation of intestinal flora	[151]
4	<i>Codonopsis pilosula</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Immunomodulatory activity	[152]
4	<i>Polygonatum kingianum</i>	Fructans	4.98	-	-	-	-	-	-	-	-	95.01	Immunomodulatory activity	[153]
4	<i>Polygonatum odoratum</i>	Fructans	3.30	-	-	-	-	-	-	-	-	96.70	Immunomodulatory activity	[154]
4	<i>Atractylodes Macrocephalae</i>	Fructans	11.00	-	-	-	-	-	-	-	-	89.00	Immunomodulatory activity	[155]
4	<i>Anemarrhena asphodeloides</i>	Fructans	5.50	-	-	-	-	-	-	-	-	94.50	Immunomodulatory activity	[156]
4	<i>Polygonatum cyrtoneura</i>	Fructans	3.44	-	-	-	-	-	-	-	-	96.32	Antioxidant activity	[157]
5	<i>Polygonatum sibiricum</i>	Fructans	5.40	-	-	3.60	-	-	-	-	-	91.00	Antioxidant activity	[158]
5	<i>Polygonatum cyrtoneura</i>	Fructans	3.85	-	-	-	-	-	-	-	-	95.89	Antioxidant activity	[159]
5	<i>Polygonatum kingianum</i>	Fructans	7.20	0.80	-	-	-	-	-	-	-	92.00	Antioxidant activity	[160]
5	<i>Liriope spicata</i>	Fructans	3.33	-	-	-	-	-	-	-	-	96.57	Hypoglycemic activity	[161]
5	<i>Ophiopogon japonicus</i>	Fructans	-	-	-	-	-	-	-	-	-	100.00	Hypoglycemic activity	[162]
5	<i>Polygonatum kingianum</i>	Fructans	-	11.20	-	1.10	-	-	-	-	-	87.70	Hypoglycemic activity	[163]
5	<i>Codonopsis pilosula</i>	Fructans	3.17	-	2.40	-	-	-	-	-	-	94.21	Hepatoprotective activity	[164]
5	<i>Ophiopogon japonicus</i>	Fructans	3.13	-	-	-	-	-	-	-	-	96.86	Hepatoprotective activity	[165]

1	<i>Plantago</i>	Araboxylans	-	-	32.2	-	-	61	-	-	-	-	Regulation	[166
5	<i>asiatica</i>				0			.1					of intestinal]
8								0					flora	
1	<i>Plantago</i>	Araboxylans	-	-	32.2	-	-	61	-	-	-	-	Hypoglyce	[167
5	<i>asiatica</i>				0			0					mic activity]
9														
1	<i>Prunella</i>	Araboxylans	8.3	9.70	24.2	1.9	-	55	-	-	-	-	Immunomo	[168
6	<i>vulgaris</i>		0		0	0		.9					dulatory]
0								0					activity	
1	<i>Panax</i>	Pectins	18.	19.4	7.90	-	5.2	-	-	-	49.30	-	Immunomo	[169
6	<i>ginseng</i>		20	0			0						dulatory]
1													activity	
1	<i>Panax</i>	Pectins	4.4	33.0	14.2	-	-	-	-	-	48.21	-	Immunomo	[170
6	<i>ginseng</i>		6	3	8								dulatory]
2													activity	
1	<i>Panax</i>	Pectins	2.0	5.90	-	-	-	-	-	-	92.10	-	Immunomo	[171
6	<i>ginseng</i>		0										dulatory]
3													activity	
1	<i>Panax</i>	Pectins	3.0	19.5	9.20	0.4	21.	-	-	2.20	33.80	-	Immunomo	[172
6	<i>ginseng</i>		0	0		0	80						dulatory]
4													activity	
1	<i>Panax</i>	Pectins	12.	14.5	15.5	-	9.8	-	-	-	47.74	-	Immunomo	[173
6	<i>ginseng</i>		28	8	3		6						dulatory]
5													activity	
1	<i>Panax</i>	Pectins	3.0	19.5	9.20	-	21.	-	-	-	33.80	-	Immunomo	[174
6	<i>ginseng</i>		0	0			80						dulatory]
6													activity	
1	<i>Codonopsis</i>	Pectins	-	-	3.50	-	5.7	-	-	-	90.80	-	Immunomo	[175
6	<i>pilosula</i>						0						dulatory]
7													activity	
1	<i>Codonopsis</i>	Pectins	-	4.92	2.92	-	7.5	-	-	-	84.55	-	Immunomo	[176
6	<i>pilosula</i>						9						dulatory]
8													activity	
1	<i>Angelica</i>	Pectins	4.3	21.6	22.4	7.5	3.5	-	-	-	39.00	-	Immunomo	[177
6	<i>sinensis</i>		0	0	0	0	0						dulatory]
9													activity	
1	<i>Panax</i>	Pectins	4.5	33.3	25.2	-	15.	-	-	-	17.10	-	Immunomo	[178
7	<i>notoginseng</i>		0	0	0		50						dulatory]
0													activity	
1	<i>Plantago</i>	Pectins	5.6	24.0	15.8	3.7	17.	7.	1.	1.86	22.68	-	Immunomo	[179
7	<i>asiatica</i>		7	0	9	9	89	12	11				dulatory]
1													activity	
1	<i>Panax</i>	Pectins	11.	15.2	19.2	12.	2.1	9.	-	4.10	26.30	-	Immunomo	[180
7	<i>quinquefolius</i>		50	0	0	00	0	60					dulatory]
2													activity	
1	<i>Pueraria</i>	Pectins	4.0	16.6	16.5	0.4	6.1	4.	2.	1.47	47.44	-	Immunomo	[181
7	<i>lobata</i>		5	0	2	8	4	75	54				dulatory]
3													activity	
1	<i>Atractylodis</i>	Pectins	-	4.20	6.80	-	11.	-	-	-	77.90	-	Immunomo	[182
7	<i>Macrocephalae</i>						00						dulatory]
4													activity	
1	<i>Gardenia</i>	Pectins	6.0	18.5	20.3	-	5.0	-	-	-	50.14	-	Immunomo	[183
7	<i>jasminoides</i>		3	2	0		2						dulatory]
5													activity	
1	<i>Ginkgo</i>	Pectins	1.9	6.00	7.86	0.4	6.9	0.	0.	2.43	73.18	-	Immunomo	[184
7	<i>biloba</i>		7			4	5	57	61				dulatory]
6													activity	
1	<i>Saposhnikovia</i>	Pectins	-	5.80	7.60	-	1.6	-	-	-	85.60	-	Immunomo	[185
7	<i>divaricata</i>						0						dulatory]
7													activity	
1	<i>Saposhnikovia</i>	Pectins	-	43.0	35.0	-	2.0	-	-	-	20.00	-	Immunomo	[186
7	<i>divaricata</i>			0	0		0						dulatory]
8													activity	
1	<i>Lycium</i>	Pectins	-	7.60	26.6	-	20.	1.	-	-	43.10	-	Antioxidant	[187
7	<i>barbarum</i>				0		80	90					activity]
9														
1	<i>Lycium</i>	Pectins	7.3	9.95	8.93	2.4	7.0	1.	-	-	60.55	-	Antioxidant	[188
8	<i>barbarum</i>		7			7	0	16					activity]
0														
1	<i>Codonopsis</i>	Pectins	-	11.0	8.90	-	9.3	-	-	-	70.10	-	Antioxidant	[189
8	<i>pilosula</i>			0			0						activity]
1														
1	<i>Bupleurum</i>	Pectins	2.5	16.7	12.9	-	14.	1.	-	-	49.20	-	Antioxidant	[190
8	<i>chinense</i>		0	0	0		20	60					activity]
2														

1														
8	<i>Salvia</i>	Pectins	4.0	5.60	5.60	-	5.2	-	-	-	78.80	-	Antioxidant	[191
3	<i>miltiorrhiza</i>		0				0						activity]
1														
8	<i>Ziziphus</i>	Pectins	-	4.26	8.52	-	7.4	-	-	-	79.61	-	Antioxidant	[192
4	<i>jujuba</i>						1						activity]
1														
8	<i>Polygonatum</i>	Pectins	-	10.9	6.10	-	4.4	1.	-	1.00	76.50	-	Antioxidant	[193
5	<i>odoratum</i>						0	10					activity]
1														
8	<i>Morus</i>	Pectins	-	12.7	8.90	-	15.	-	-	2.00	61.00	-	Antioxidant	[194
6	<i>alba</i>						70						activity]
1														
8	<i>Sophorae</i>	Pectins	1.2	9.70	7.30	2.0	18.	0.	-	-	60.40	-	Antioxidant	[195
7	<i>Tonkinensis</i>		0			0	40	90					activity]
1														
8	<i>Codonopsis</i>	Pectins	-	4.16	4.16	-	8.3	-	-	-	83.20	-	Antitumor	[196
8	<i>pilosula</i>						2						activity]
1														
8	<i>Bupieurum</i>	Pectins	-	4.42	11.5	-	7.1	-	-	-	76.89	-	Antitumor	[197
9	<i>chinense</i>						8						activity]
1														
9	<i>Lycium</i>	Pectins	15.	14.6	27.9	4.1	3.1	-	-	-	34.62	-	Antitumor	[198
0	<i>barbarum</i>		47	7	5	0	9						activity]
1														
9	<i>Lycium</i>	Pectins	-	26.6	24.9	-	14.	16	-	-	17.70	-	Antitumor	[199
1	<i>ruthenicum</i>						40	.4					activity]
1								0						
9	<i>Polygonum</i>	Pectins	-	29.6	24.6	-	26.	-	-	-	20.00	-	Antitumor	[200
2	<i>multiflorum</i>						40						activity]
1														
9	<i>Polygala</i>	Pectins	-	18.9	65.6	-	7.3	-	-	-	8.20	-	Antitumor	[201
3	<i>tenuifolia</i>						0						activity]
1														
9	<i>Panax</i>	Pectins	12.	11.2	23.6	-	9.9	-	7.	-	35.47	-	Hypoglyce	[202
4	<i>ginseng</i>		30	4	8		2		38				mic activity]
1														
9	<i>Lycium</i>	Pectins	5.2	19.5	23.1	3.4	2.7	3.	-	-	42.33	-	Hypoglyce	[203
5	<i>barbarum</i>		9	3	0	9	7	46					mic activity]
1														
9	<i>Lycium</i>	Pectins	-	3.09	37.2	14.	4.7	1.	-	-	38.76	-	Hypoglyce	[204
6	<i>barbarum</i>					30	5	76					mic activity]
1														
9	<i>Ziziphus</i>	Pectins	4.0	9.48	3.29	-	9.1	-	-	-	68.71	-	Hypoglyce	[205
7	<i>jujuba</i>		5				3						mic activity]
1														
9	<i>Schisandra</i>	Pectins	1.1	1.29	0.89	0.7	0.8	-	-	2.56	90.06	-	Hypoglyce	[206
8	<i>chinensis</i>		0			1	8						mic activity]
1														
9	<i>Pseudostellaria</i>	Pectins	-	7.00	20.5	-	5.1	-	-	-	63.20	-	Hypoglyce	[207
9	<i>heterophylla</i>						0						mic activity]
2														
0	<i>Lycium</i>	Pectins	3.1	17.9	19.9	-	8.7	-	-	-	50.29	-	Regulation	[208
0	<i>barbarum</i>		3	2	6		1						of intestinal]
2													flora	
0	<i>Gardenia</i>	Pectins	3.1	4.16	4.72	-	5.9	-	-	-	82.03	-	Regulation	[209
1	<i>jasminoides</i>		8				1						of intestinal]
2													flora	
0	<i>Lycium</i>	Pectins	3.9	20.4	43.8	0.9	6.2	-	-	-	24.67	-	Regulation	[210
2	<i>barbarum</i>		0	2	4	7	0						of intestinal]
2													flora	
0	<i>Morus</i>	Pectins	5.7	17.2	24.1	-	23.	1.	-	4.12	24.60	-	Regulation	[211
3	<i>alba</i>		4	8	3		00	12					of intestinal]
2													flora	
0	<i>Dendrobium</i>	Pectins	0.4	3.55	4.47	-	2.3	17	0.	1.26	69.80	-	Hepatoprote	[212
4	<i>nobile</i>		3				8	.8	26				ctive]
2								4					activity	
0	<i>Panax</i>	Pectins	1.6	3.00	4.50	0.2	3.8	-	-	-	86.80	-	Hepatoprote	[213
5	<i>notoginseng</i>		0			0	0						ctive]
2													activity	
0	<i>Crataegus</i>	Pectins	-	3.98	-	4.5	-	-	-	-	85.10	-	Hepatoprote	[214
6	<i>pinatifida</i>					0							ctive]
2													activity	
0	<i>Gardenia</i>	Pectins	-	3.22	4.14	-	5.7	-	-	-	86.87	-	Hepatoprote	[215
7	<i>jasminoides</i>						7						ctive]
													activity	

208	<i>scrophularia ningpoensis</i>	Pectins	-	24.0	13.5	5.4	1.2	0.	-	4.40	51.10	-	Neuroprotective activity	[216]
209	<i>Polygala tenuifolia</i>	Pectins	-	19.8	63.5	-	8.3	-	-	-	8.40	-	Neuroprotective activity	[217]
210	<i>Eucommia ulmoides</i>	Pectins	1.5	9.43	34.2	0.9	18.	-	0.	1.27	34.11	-	Anti-osteoporosis activity	[218]

4. The Correlation Between Activities and Monosaccharide Composition of Medicinal Plant Polysaccharides

Based on the analysis of collected literature in Table 1, it appears that there may be some relationship between monosaccharide composition and the biological activity of medicinal plant polysaccharides (Figure 4).

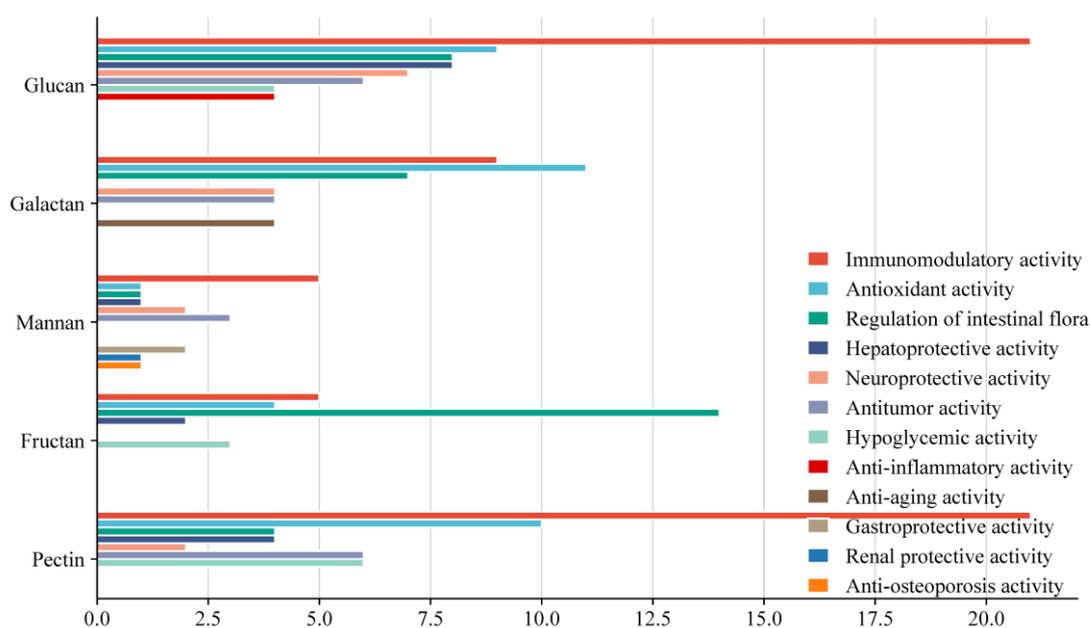


Figure 4. The Correlation Between Activities and Monosaccharide Composition of Medicinal Plant Polysaccharides.

Glucans play a critical role in immune regulation, antioxidant effects, and the regulation of gut microbiota. Galactans play a critical role in antioxidant effects, immune regulation, and the regulation of gut microbiota. Mannans play a critical role in immune regulation, antitumor effects, and neuroprotection. Fructans play a critical role in the regulation of gut microbiota, immune regulation, and antioxidant effects. Pectin plays a critical role in immune regulation, antioxidant effects, and lowering blood sugar. Furthermore, due to the limited variety of Arabinan and arabinoxylan found in medicinal plants, they are not discussed in this article.

5. Effects of the Monosaccharide Composition on the Bioactivity of Medicinal Plant Polysaccharides

5.1. Immunomodulatory Activity

Medicinal plant polysaccharides are important macromolecules that can strongly affect the immune system and have the potential to be used as immunomodulators with broad clinical applications [219]. A substantial body of research has demonstrated that the immunomodulatory effects of polysaccharides are positively correlated to the content of glucose.

Zhang et al. isolated a glucan from *Astragalus mongholicus* using a Sephadex G200 column chromatography and named it APS-II [9]. Its monosaccharide composition is 89.0% glucose. Subsequently, the immunomodulatory capacity of APS-II was investigated. The results indicate that APS-II exerts its effects through the TLR4-MyD88-NF- κ B signaling pathway. It promotes polarization of M0-type macrophages to the M1-type and repolarized M2-type to M1-type. Additionally, APS-II preferentially accumulates at tumor sites, thereby enhancing the innate immune system's antitumor capabilities. Zhang et al. isolated a glucan from *Sagittaria sagittifolia* using the DEAE-52 cellulose column and Sephadex G-100 column and named it SSP-S1 [14]. Its monosaccharide composition is 91.0% glucose. Subsequently, the immunomodulatory capacity of SSP-S1 was investigated. The results indicate that SSP-S1 could promote the proliferation, production of NO, and secretion of TNF- α and IL-10 of macrophages RAW 264.7. Wang et al. isolated a glucan from *Angelicae dahuricae* using the DEAE-52 cellulose column and Sephadex G-100 column and named it ADPs [18]. Its monosaccharide composition is 97.0% glucose. Subsequently, the immunomodulatory capacity of ADPs was investigated. The results indicate that ADPs could significantly enhance the phagocytic activity of RAW264.7 cells and activate the NF- κ B/MAPK signaling pathway and promote the expression of cytokines NO, TNF- α , and IL-6. Yang et al. isolated a glucan from *Aconitum carmichaeli* using the DEAE-52 cellulose column and Sephadex G-50 column and named it FZPS-1 [21]. Its monosaccharide composition is 92.0% glucose. Subsequently, the immunomodulatory capacity of FZPS-1 was investigated. The results indicate that FZPS-1 promotes macrophage phagocytosis, increases the secretion of macrophage-derived biological factors (NO, IL-6, IL-1, TNF- α) in RAW 264.7 cells, and significantly enhances the index of the spleen and thymus.

In summary, glucan exerts broad immunomodulatory activity by regulating immune organs, immune cells, and immune factors. It holds potential for further development as an immunomodulator.

5.2. Antioxidant Activity

Oxidative stress is caused by a variety of oxygen-derived free radicals (ROS), such as superoxide anion, hydrogen peroxide, and hydroxyl radical. High ROS levels cause damage to proteins, lipids, and DNA, leading to cell demise [220]. Due to their remarkable antioxidant activity, polysaccharides have garnered increasing research attention in recent years. A substantial body of research has demonstrated that the antioxidant activity of polysaccharides is positively correlated to the content of galactose and arabinose.

Cao et al. isolated an arabinogalactan from *Angelica sinensis* using a Sephadex G-50 column and named it ASP [91]. Its monosaccharide composition is 52.40% galactose and 19.31% arabinose. Subsequently, the antioxidant activity of ASP was investigated. The results indicate that ASP could protect against acetaminophen-induced acute liver injury and cell death by suppressing oxidative stress and hepatic apoptosis in vivo and in vitro. Specific mechanism of action: ASP increases GSH levels, decreases MDA levels, and enhances SOD activity. Li et al. isolated an arabinogalactan from *Pueraria mirifica* using a DEAE liquid chromatography column and named it PMP-2 [94]. Its monosaccharide composition is 58.5% galactose and 27.8% arabinose. Subsequently, the antioxidant activity of PMP-2 was investigated. The results indicate that PMP-2 exhibits concentration-dependent antioxidant activities. These are against DPPH, ABTS and hydroxyl radicals. Chen et al. isolated an arabinogalactan from *Taraxacum mongolicum* by cold water extraction and named it DLP4 [96]. Its monosaccharide composition is 52.94% galactose and 25.95% arabinose. Subsequently, the antioxidant activity of DLP4 was investigated. The results indicate that DLP4 enables the clearance of free radicals, including DPPH, ABTS, as well as hydroxyl radical scavenging and the polysaccharides' reducing power. Further, DLP4 provides better protection against H₂O₂-induced oxidative damage in HepG2 cells by enhancing cell viability, scavenging ROS, boosting the activity of the antioxidant enzyme SOD, and reducing the levels of MDA.

In summary, arabinogalactan exerts broad antioxidant activity by directly scavenging free radicals, reducing oxidative stress, and enhancing intracellular antioxidant defense system. It holds potential for further development as antioxidants.

5.3. Antitumor Activity

Cancer is the leading cause of death worldwide. The development and progression of cancer can be attributed to genetic, environmental, and current lifestyle factors [221]. Current anticancer drugs carry significant toxic side effects and induce drug resistance in cancer cells, creating new challenges for cancer patients. Therefore, the search for new anticancer drugs is urgently needed. Due to their remarkable antitumor activity, polysaccharides have garnered increasing research attention in recent years. A substantial body of research has demonstrated that the antitumor activity of polysaccharides is positively correlated to the content of mannose.

Ye et al. isolated a mannan from *Dendrobium wardianum* using the DEAE-cellulose column and Sephadex-G100 chromatography column and named it DWPP-Is [125]. Its monosaccharide composition is 76.66% mannose. Subsequently, the antitumor activity of DWPP-Is was investigated. The results indicate that DWPP-Is exhibits good inhibition on SPC-A-1 cells in vitro and A549 cells in vivo. Zhang et al. isolated a mannan from *Dendrobium officinale* and named it DOP [126]. Its monosaccharide composition is 87.34% mannose. Subsequently, the antitumor activity of DOP was investigated. The results indicate that DOP significantly inhibits the proliferation of CT26 cells and enhances autophagy level. Furthermore, DOP disrupts mitochondrial function by increasing reactive oxygen species (ROS) and reducing mitochondrial membrane potential (MMP), thereby impairing ATP biosynthesis, which activates AMPK/mTOR autophagy signaling pathway. Zhang et al. isolated a mannan from *Platycodon grandiflorum* using the DEAE-Sepharose Fast Flow column and Sephadex-G75 chromatography column and named it PGP40-1 [127]. Its monosaccharide composition is 57.96% mannose. Subsequently, the antitumor activity of PGP40-1 was investigated. The results indicate that PGP40-1 could inhibit tumor proliferation and migration by inducing cell apoptosis and blocking angiogenesis.

In summary, mannan exerts broad antitumor activity by inhibiting tumor cell proliferation, inducing tumor cell apoptosis, and suppressing tumor cell invasion and metastasis. It holds potential for further development as antitumor drugs.

5.4. Regulation of Intestinal Flora

The gut is the largest organ in the human body, performing digestive and immune functions while having a diverse microbial community. The gut microbiota is involved in various physiological activities of the body, including nutrient absorption, metabolism, and immune regulation [222]. Due to their remarkable function of regulating gut microbiota, polysaccharides have garnered increasing research attention in recent years. A substantial body of research has demonstrated that the function of regulating gut microbiota of polysaccharides is positively correlated to the content of fructose.

Fan et al. isolated a fructan from *Polygonati kingianum* and named it PKP [145]. Its monosaccharide composition is 91.3% fructose. Subsequently, the function of regulating gut microbiota of PKP was investigated. The results indicate that PKP enhances tight junction protein expression of zonula occludens-1 (ZO-1) and occludin. Furthermore, PKP restores intestinal microbiota diversity by increasing the abundance of Firmicutes and reducing the abundance of Verrucomicrobiota. Yuan et al. isolated a fructan from *Polygonatum cyrtonema* and named it PCP [148]. Its monosaccharide composition is 77.4% fructose. Subsequently, the function of regulating gut microbiota of PCP was investigated. The results indicate that PCP could protect the intestinal barrier and regulate short-chain fatty acid levels. Furthermore, PCP could modulate the composition of the gut microbiota, promote the proliferation of beneficial bacteria, and inhibit the growth of pathogenic bacteria. Cheng et al. isolated a fructan from *Polygonatum cyrtonema* and named it PCP-80% [150]. Its monosaccharide composition is 89.48% fructose. Subsequently, the function of regulating gut microbiota of PCP-80% was investigated. The results indicate that PCP-80% promotes the production

of SCFAs. It also increases the relative abundance of beneficial bacteria. These include *Megamonas*, *Bifidobacterium* and *Phascolarctobacterium*. This changes the composition of the intestinal microbiota.

In summary, fructan exerts broad capabilities for gut microbiota modulation by promoting the production of short chain fatty acids (SCFAs), regulating the composition of the gut microbiota, maintaining intestinal barrier integrity, and restoring microbial metabolite levels.

5.5. Hypoglycemic Activity

Diabetes mellitus is a major health problem worldwide, characterised by metabolic disorders and several symptoms, including polyuria, polydipsia, polyphagia, selective loss of pancreatic β -cell mass and high blood glucose levels [223]. A substantial body of research has demonstrated that hypoglycemic activity of polysaccharides is positively correlated to the content of galacturonic acid.

Ko et al. isolated a pectin from *Ziziphus jujuba* and named it JP [205]. Its monosaccharide composition is 68.71% galacturonic acid. Subsequently, the hypoglycemic activity of JP was investigated. The results indicate that JP enhances glucose uptake by upregulating glucose transporter type 4 expression and restoring mitochondrial content. Guo et al. isolated a pectin from *Schisandra chinensis* and named it VSP [206]. Its monosaccharide composition is 90.06% galacturonic acid. Subsequently, the hypoglycemic activity of VSP was investigated. The results indicate that VSP treatment alleviates imbalances in glycolipid metabolism and inflammation in T2DM mice. Furthermore, VSP treatment significantly increases activation of the PI3K/AKT/GSK3 β and AMPK/SREBP-1c/FAS signalling pathways. Chen et al. isolated a pectin from *Pseudostellaria heterophylla* and named it 0.5MSC-F [207]. Its monosaccharide composition is 63.2% galacturonic acid. Subsequently, the hypoglycemic activity of 0.5MSC-F was investigated. The results indicate that 0.5MSC-F could stimulate the secretion of insulin by islet cells cultured in a high-glucose environment, which could have practical applications in the treatment of hypoglycaemia.

In summary, pectin exerts broad hypoglycemic activity by activating the insulin signaling pathway, promoting insulin β -cell function, and regulating liver glucose metabolism.

6. Conclusions and Prospects

Polysaccharides possess highly complex structural characteristics. These include molecular weight, monosaccharide composition, glycosidic bond configuration and functional groups [4]. It is these structural features that determine and influence the biological activity of polysaccharides. Monosaccharides are the most fundamental units of the primary structure of polysaccharides and form the basis for more complex structures [5]. This review systematically summarizes high-quality literature from recent years concerning the influence of monosaccharide composition on the biological activity of polysaccharides.

The results are as follows: Glucans are vital for immune regulation, antioxidant effects and the regulation of gut microbiota. Similarly, galactans are important for antioxidant effects, immune regulation and the regulation of gut microbiota. Mannans play a critical role in immune regulation, anti-tumour effects and neuroprotection. Fructans play a critical role in regulating gut microbiota, immune regulation, and antioxidant effects. Pectin plays a critical role in immune regulation, antioxidant effects, and lowering blood sugar.

Based on the fact that monosaccharide composition is a key factor affecting the activity of medicinal plant polysaccharides, subsequent researchers may consider isolating and purifying total polysaccharides to obtain target polysaccharides in order to improve their bioactivity. An in-depth and comprehensive understanding of the structure-activity relationship between the monosaccharide composition and biological activity of medicinal plant polysaccharides is expected to lead to the development and production of functional polysaccharides.

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