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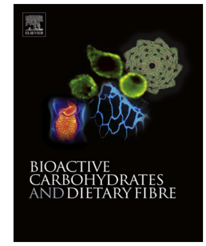


# A review of bioactive plant polysaccharides: Biological activities, functionalization, and biomedical applications

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ABSTRACT

Natural polysaccharides from different sources have long been studied and widely used in different areas, such as food and feed, medicine and pharmaceutics, and in papermaking. In recent decades, there has been an increased interest in the utilization of polysaccharides, particularly bioactive ones, for various novel applications owing to their biocompatibility, biodegradability, non-toxicity, and some specific therapeutic activities. The main goal of this paper was to review the sources, natively biological activities, isolation, characterization, and the structural features of natively bioactive polysaccharides. Moreover, the article has also been forcused on the chemical/chemo-enzymatic functionalizations that may create novel opportunities to maximally exploit the various valuable properties of polysaccharides, particularly from wood species, in previously unperceived applications especially for biomedical applications, such as tissue engineering, wound healing, and drug delivery. This article was to review novel strategies to tailor functional materials with above mentioned application potentials for the polysaccharides from wood species.



## Contents



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## 1. Introduction

Polysaccharides along with oligosaccharides, the most abundant group of biopolymers, have been found to participate in many biological processes, such as cell–cell communication, embryonic development, infection of bacteria and/or virus, and humoral and cellular immunity (Cooke, An, Kim, Solnick, & Lebrilla, 2007; Dube & Bertozzi, 2005; Varki, 1993). Therefore, polysaccharides together with polynucleotides, proteins, and lipids constitute the most important four biomacromolecules in life science. In this review, the bioactive polysaccharides refer to those polysaccharides that show biological effects on organisms and those polysaccharides that can be produced by living organisms or functionalized from sugar-based materials. Additionally, the biological effects that polysaccharides can exert are limited to therapeutic activities for diseases of humans and animals, and toxic activity responsible for causing human and animal disease (Colegate & Molyneux, 2008).

Although polysaccharides have been used for decades in various industrial applications, e.g. pharmaceuticals, biomaterials, food stuff and nutrition, and biofuels, growing understanding and deeper investigations of the importance of polysaccharides in life science are driving the development of polysaccharides for novel (biomolecular) applications (Alonso-Sande, Teijeiro-Osorio, Remunan-Lopez, & Alonso, 2009; Crini, 2005; García-González, Alnaief, & Smirnova, 2011; Kamerling & Boons, 2007; Pitarresi, Calabrese, Palumbo, Licciardi, & Giammona, 2009; Spizzirri et al. 2010; Suh & Matthew, 2000). The biological activities of polysaccharides are strongly affected by their chemical structure and chain conformations. However, the macromolecular structures of plant cell wall polysaccharides, especially hetero-polysaccharides or so-called hemicelluloses, are extremely complex due to the presence of different monosaccharides as building blocks, which usually are isobaric stereoisomers, variations in sequence, linkage, branching, and distribution of side chains (An & Lebrilla, 2011; Cancilla, Penn, & Lebrilla, 1998; Mäki-Arvela, Salmi, Holmbom, Willför, & Murzin, 2011). Besides, the polysaccharides in microorganisms (fungi, yeasts, and bacteria), algae, plants, and animals are always physically and/or chemically tangled together with other biomolecules, e.g. proteins, polynucleotides, lipids, lignin, and some inorganic mineral substances (Yang & Zhang, 2009). Therefore, comprehensive understanding the important roles of the bioactive polysaccharides in life science and exploring their application call for the multidisciplinary collaboration from experts on plant and microbial polysaccharides, glycochemistry, glycobiology, glycomedicine, phytology, and zoology (Colegate & Molyneux, 2008).

The aim of this article was to review the state-of-art in identification, isolation, functionalization, characterization, and application of bioactive polysaccharides derived from natural sources. Exploration of biomedical applications such as tissue engineering, wound healing, and drug delivery for polysaccharides were emphasized. The goal was to seek novel strategies to tailor functional materials with above mentioned application potentials for the polysaccharides from plants.

## 2. Sources and biological activities of bioactive polysaccharides

Polysaccharides can be classified in many possible ways, such as on the basis of structure, chemical composition, solubility, sources, and applications. With regard to the chemical composition, the polysaccharides are classified into two types, i.e. homo-polysaccharides or homoglycans, which are made up of a single type of monosaccharide, for example, cellulose and glycogen consist of glucose; hetero-polysaccharides or heteroglycans, which consist of more than one type of monosaccharide, such as heparin which consists of, α-L-idopyranosyluronic acid 2-sulfate and 2-deoxy-2-sulfoamino-α-D-glucopyranose 6-sulfate (Xiao et al., 2011). According to the glycosides linked onto the glycan, polysaccharides can also be classified as proteoglycans and glycoproteins, glycolipids, and glycoconjugates (Berg, Tymoczko, & Stryer, 2012; Gatti, Casu, Hamer, & Perlin, 1979). Based on the origins, bioactive polysaccharides from plant (dietary fibers, herbs and wood plants), algae and lichen, and other bioactive polysaccharides which are derived from animals (e.g. heparin, chondroitin sulfate, and hyaluronan)