Introduction

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Abstract

Microbial polysaccharides are a renewable resource that has gained increasing interest for biomedical applications due to their outstanding properties. The abundance of these polysaccharides allows their sustainability and provides monetary value for new functional biomaterials. Furthermore, the increasing worldwide demand for active substances offering several health benefits could be the future source of innovation for microbial polysaccharides. The latest developments involving polysaccharides of microbial origin and their biomedical applications are overviewed herein.

Keywords

Microbial · Polysaccharides · Biomedical applications

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1 Context

Nature comprises a wide diversity of microorganisms, and in consequence it is predictable that microorganisms produce new materials with different structures and properties. This unlimited structural diversity results in an extensive range of applications for microbial polysaccharides that can be obtained from microorganisms such as bacteria, yeast, fungi, and microalgae (Smelcerovic et al. 2008). Polysaccharides, in many forms, play an essential function in all living organisms for storage and supply of energy and/or protection and structural integrity of cells (Shanmugam and Abirami 2019). Microbial polysaccharides, one of the most diverse families of biopolymers, are high molecular weight polymers being able to reach until several millions of Dalton, sharing a substantial component of the cellular carbohydrates found in and surrounding microbial cells (Delattre et al. 2007). Thus, microbial polysaccharides can serve as renewable resources and are now widely used in different industry sectors, principally due to their amazing rheological properties, where they are used as coagulants, binders, gelling agents, lubricants, film formers, emulsifiers, thickeners, and stabilizers, among others (Jindal and Singh Khattar 2018).

In the last few years, polysaccharide-based materials have been receiving an increasing interest in the pharmaceutical and materials engineering fields because of their biocompatibility, bio-absorbability, versatility, and nontoxic nature, among others (Dave 2016). In fact, xanthan, xylinan, gellan, curdlan, dextran, pullulan, scleroglucan, schizophyllan, and alginate are, among others, common microbial polysaccharides in current use (Ahmad et al. 2015; Lei and Edmund 2019). These polysaccharides can also offer not only the advantages of a well-controlled production process with consistent and reproducible yield that can be continued throughout the year but also constant structural, chemical, and physical characteristics (Giavasis 2013). Commonly, microbial polysaccharides are being used in food industries (Giavasis 2013; Ramalingam et al. 2014; Jindal and Singh Khattar 2018; Nešić et al. 2020) but recently other successfully developed microbial polysaccharides have found their applications in cosmetic, pharmaceutical, and medical fields (Morris and Harding 2009; Ahmad et al. 2015). In fact, there are significant advances focused on the use of polysaccharides of microbial origin for biomedical applications including but not limited to drug delivery (Miao et al. 2018), imaging (Moscovici 2015), wound healing and dressing (Azuma et al. 2015; Zhu et al. 2019), surgery (Gupta et al. 2019), and tissue engineering (Delattre et al. 2007; Silva et al. 2017). Developments in the applications of polysaccharides from microorganisms are thoroughly related to the capability of the scientific community to entirely understand the complexity of these biopolymers. Hence, translating this knowledge to practical applications is necessary to fully characterize their structural, biological, and physicochemical properties.

Herein, the "Polysaccharides of Microbial Origin: Biomedical Applications" book presents the microbial polysaccharides status, from their classifications to their wide range of biomedical applications. The book is presented in six major sections, conceptualized in Fig. 1.

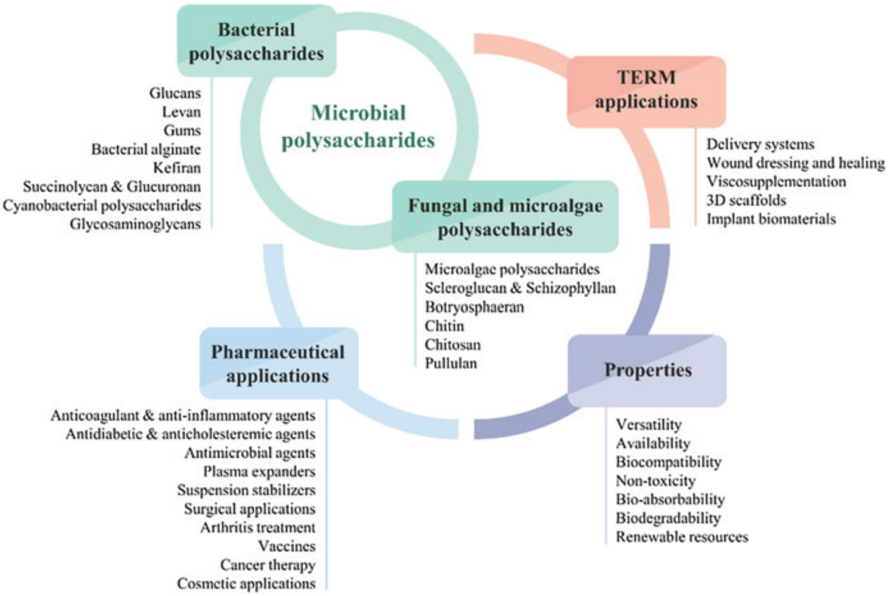

Fig. 1 Polysaccharides of microbial origin in biomedical applications

Section 1 provides an overview of some of the major bacterial polysaccharides such as cellulose, dextran, levan, gums, curdlan, bacterial alginate, bacterial hyaluronic acid, kefiran, and cyanobacterial polysaccharides, among others. Essentially, they have been identified both in Gram-positive and Gram-negative bacteria, having in general an exocellular location (Delattre et al. 2007).

Section 2 comprises the main fungal and microalgal polysaccharides which include chitin, chitosan, pullulan, scleroglucan, and schizophyllan, among others, with successful examples of their biomedical exploitation. Moreover, new bioactive polysaccharides from marine bacteria are highlighted in this section as a valid alternative to traditional polysaccharides.

Section 3 describes the most recent isolation, extraction, purification, and production processes used to obtain microbial polysaccharides of high purity and yields, together with an economic efficiency. These production processes are currently a matter of intense research, and appropriate techniques need to be implemented to enhance process optimization. There are several methods, described in this book, that are used to isolate and purify microbial polysaccharides; the main criterion to select a certain method is to maintain the intrinsic properties of these polymers unchanged during the whole process.

Section 4 presents a comprehensive understanding on the structural, physicochemical, and biological properties of microbial polysaccharides that could guide researchers in the development of target therapeutic products meeting desired characteristics and profiles. Furthermore, this section provides a number of approaches that can be followed to modify these polymers in order to enhance their functional and technological properties through either physical or chemical cross-linking reactions. One of the greatest biotechnological approaches is the transfer of specific gene constructs by several methods (Ahmed 2003). In this section, genetic engineering technologies are described to increase the production yield of biopolymers in a short span of time. Genetically modified organisms are continually being explored, and these techniques certainly offer promising results as well as pose both technical and scientific challenges.

Sections 5 and 6 provide a review on the pharmaceutical and tissue engineering applications of microbial polysaccharides according to current and outstanding research works in biomedical science. The probable future trends for the utilization of these bioactive compounds in biomedical fields are also discussed. It has been previously shown that these polysaccharides have huge potential owing to their unique rheological properties, and great antitumor, antioxidant, anti-inflammatory, anticoagulant, antiallergic, and antidiabetic properties, among others (Ahmad et al. 2015; Jenab et al. 2020). Promising applications of these polysaccharides have been reported in different therapeutic fields such as cancer, diabetes, vaccines, wound healing, and surgery, among many others (Hasnain and Nayak 2019). During the last decades, the use of microbial polysaccharides, in tissue engineering and regenerative medicine, has noticeably changed from a simple three-dimensional scaffold for cell and drug incorporation, to be used as new functional biomaterials with excellent physicochemical and biological properties. Due to their unique properties, microbial polysaccharides are considered potential candidates for natural product drug discovery and for the delivery of new derived products such as genes, drugs, vaccines, peptides, and proteins, particularly in form of matrix tablets, microspheres, nanoparticles, hydrogels, and capsules (Tiwari et al. 2012), resulting in a powerful synergism of treatment options for biomedical applications. The development of controlled drug delivery systems opens a new opportunity in the biomedical use of these biopolymers being their vast area of application supported by the multifarious series of derivatives available whose valuable properties can be controlled. The potential of these bioactive polysaccharides is being constantly studied, and a new generation of therapeutics will be accomplished by combining their biological activity with natural biodiversity. Nonetheless, the growing worldwide demand for active ingredients providing health benefits will expectedly act as a springboard for future innovation regarding microbial polysaccharides.

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