Chapter 16

Thermophilic Bacterial Exopolysaccharides:

From Bio-Physicochemical Characterization to Biotechnological Applications

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ABSTRACT

Bacterial exopolysaccharides have enormous diversity with valuable characteristics, synthesized by various pathways in extreme conditions like salinity, geothermal springs, or hydrothermal vents. Due to extreme environments, these microorganisms have various adaption principles (e.g., low pH, high temperature, high saltation, and high radiation). Exopolysaccharide is an organic compound produced by most bacteria during fermentation using various carbon sources, resulting in a jelly-like or mass network structure outside the cell wall. This biopolymer has an adherent cohesive layer throughout the cell layer. Hot spring bacterial polysaccharides contain diverse extracellular polymeric substances. With a gain in popularity in applications of thermophilic microbial polysaccharides and its demand in diverse value-added industrial products, this chapter aims to provide valuable information on the physicochemical function and biotechnological applications in the field of food, medical imaging, nano-drugs, bioremediation, cancer, anti-bacterial, tissue engineering, etc.

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1. INTRODUCTION

Over the last few decades, vast numbers of extracellular polysaccharides or exopolysaccharides from extremophiles have been extensively studied all over the world. In the year 1972 Sutherland, proposed the word 'exopolysaccharide' (EPS) which stands for a variety of bacterial and microalgal heterogeneous long-chain polysaccharides that are synthesized and released outside the cell wall into their ambience during growth. Hot spring microorganisms produce a large number of structurally diverse extracellular polymeric substances i.e. EPSs. Diverse macromolecules e.g. peptidoglycan, lipopolysaccharide, and exopolysaccharide are the most important component of bacterial polysaccharides and these polysaccharides make the structure of their cell wall (e.g. Peptidoglycan) and Poly N-acetyl glucosamine plays a major role in bacteria to survive in the unfavourable environments (Kazak et al., 2010; Nichols et al., 2005; Ruffing & Chen, 2006). The thermophilic bacterium *Geobacillus* sp. (WSUCF1) has a great production rate in the production of two exopolysaccharides with prominent quantities. Following purification of these two exopolysaccharides, it was discovered that EPS-1 is composed of glucomannan with a 1:0.21 molar ratio of mannose and glucose, whereas EPS-2 was made up entirely of mannan. Both EPSs have molecular weights of around 1000 kDa, and their FTIR and NMR spectra revealed the existence of α-type glycosidic linkages in a linear structure. XRD examination revealed a low degree of crystallinity i.e. for EPS-1 and EPS-2 is 0.11 and 0.27 respectively (Wang et al., 2021). Most of the exopolysaccharides have their applications in food, pharmaceutical, and other industries. Exopolysaccharides produced by thermophiles have been used for various biotechnological processes like fermentation and food emulsification (Ruffing & Chen, 2006). A novel exopolysaccharide (EPS-B3-15) isolated from marine thermo-tolerant *Bacillus licheniformis* strain B3-15 showed high-temperature stability up to 80ºC. Depending on this property of thermal stability it can be used for nano-medicine development (Caccamo et al., 2020). High-temperature-loving (thermophilic) bacteria from different classes of Archaea and Bacteria have been discovered from a variety of thermal habitats, including both deep and shallow marine hot springs, as well as terrestrial hot springs, which have provided the genesis for the separation of microbial EPS producers. Some thermophilic bacteria e.g. *Archaeoglobus fulgidus*, *Thermococcus litoralis*, *Pseudomonas aeruginosa* are good EPSs producers (Lapaglia & Hartzell, 1997; Nicolaus et al., 1993).

Presently, bioremediation technology is a new and challenging field of research on environmental issues. EPSs are ubiquitous and low-cost chemicals that have been utilised to adsorb oil and those are biodegradable. EPSs possess a high number of negatively charged functional groups, therefore they can remove a variety of heavy metals and organic pollutants successfully (Lakzian et al., 2008). EPSs of *Ensifer meliloti* have potent adsorption potential for Lead, Nickel and Zinc from industrial waste (Lakzian et al., 2008). EPS acts as an excellent biosorbent material for arsenic bioremediation. Recently, novel strains of *Exiguobacterium profundum* PT2 and *Ochrobactrum ciceri* SW1 have been isolated which can produce biopolymers and possess a large number of polyanionic functional groups on their surface and can sequester arsenic (a potent carcinogen), through electrostatic or covalent interactions (Saba et al., 2019). Researches on bioremediation reveal that the dead biomass of bacteria with exopolysaccharides is an important substrate for heavy metal sequestration. Dead biomass of *Ochrobactrum anthropi* removes cadmium ions along with other toxic metals under specific pH and initial metal ion concentration. The dead biomass has high heavy metal tolerance activity (up to 30 mg/L of cadmium ion concentration) (Ozdemir et al., 2003). Numerous studies have established that EPSs from *Lactobacillus* sp. can be utilized in diverse health benefits like anticancer, antiulcer, anti-viral properties and also act as immune-

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