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Pectin-Based Biopolymer Films: From Structural Properties to Smart Food Packaging

Preetham Sai K[1], M. Bavanilatha[1], V. Ganesh Kumar[2]

[1]Department of Biotechnology, Sathyabama Institute of Science and Technology, Chennai, India.
[2]Centre for Ocean Research, Sathyabama Institute of Science and Technology, Chennai, India.

Pectin is a naturally occurring polysaccharide widely extracted from plant cell walls and identified as a promising biopolymer for food packaging. Due to its extensive film- forming capacity, intrinsic gelling properties and its biodegradable properties makes it a perfect replacement for the petroleum-based plastics, especially in the food packaging sector. Bioplastics are preferred rather than petroleum-based plastics in food packaging since these petroleum-based plastics tend to degrade into microplastics and enter our bodies during the intake of plastic-covered food. This review critically examines the structural and physicochemical properties of pectin that influence the film formation, including the degree of esterification, molecular weight, and interactions with other biopolymers and nanoparticles. This review mainly focuses on adapting strategies to enhance the mechanical strength, barrier performances, and thermal stability through chemical modifications, cross-linking of polymers and incorporation of various bioactive agents. This review further explores advances in smart pectin-based films, i.e. films with anti-microbial, anti-oxidant, and pH-responsive functionalities, enabling real-time monitoring of food quality and shelf-life extension. Currently, there are various challenges such as scalability, cost-effectiveness and regulatory considerations which are also discussed in this paper. Overall, this review highlights the potential of pectin-based biopolymer films as a next-generation solution for sustainable and intelligent food packaging.

Keywords: Biodegradable, Bioplastics, Intelligent Food Packaging, Pectin