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Biopolymer Films with Antimicrobial Properties for Enhanced Food Preservation

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Abstract

Biopolymer flms with antimicrobial properties ofer a promising solution for enhancing food preservation by providing an efective barrier against microbial growth and extending shelf life. These flms, derived from natural sources such as starch, chitosan, alginate, and cellulose, can be functionalized with antimicrobial agents, such as essential oils, plant extracts, or nanoparticles, to inhibit the growth of bacteria, fungi, and molds on food surfaces. The integration of these biopolymer flms into food packaging systems helps reduce the need for chemical preservatives while promoting sustainability and environmental friendliness. This paper explores the development and application of antimicrobial biopolymer flms in food preservation, discussing their antimicrobial mechanisms, advantages, and challenges. The potential for these flms to be used in various food packaging applications, including fresh produce, dairy, meat, and bakery products, is also highlighted. By ofering an alternative to traditional food preservation methods, antimicrobial biopolymer flms contribute to the advancement of safer, more sustainable food packaging solutions.

Ke d : biopolymer lms; antimicrobial properties; food preservation; sustainable packaging; natural polymers; essential oils; chitosan; food safety; shelf life extension; biodegradable packaging; antimicrobial agents; eco-friendly packaging

I d c

Food preservation is a critical concern in the global food industry, aiming to maintain the freshness, safety, and nutritional value of food products while minimizing waste. Traditional food preservation methods, such as refrigeration, canning, and the use of chemical preservatives, have limitations, including the potential impact on food quality, safety, and the environment [1]. As consumer demand for more natural, sustainable, and safe food products increases, the food packaging industry has turned to biopolymers as an eco-friendly alternative. Among the most promising innovations are biopolymer lms with antimicrobial properties, which o er the dual bene t of protecting food from microbial contamination while enhancing shelf life. Biopolymer lms are derived from renewable sources such as starch, cellulose, chitosan, and alginates, making them biodegradable and less harmful to the environment than conventional petroleum-based plastics. e incorporation of antimicrobial agents into these lms, including essential oils, plant extracts, or nanoparticles, provides an additional layer of defense against spoilage-causing microorganisms such as bacteria, molds, and yeasts. ese biopolymer lms can serve as active food packaging, extending the shelf life of perishable products, reducing food waste, and promoting food safety. is paper delves into the development of antimicrobial biopolymer lms, exploring their mechanisms, applications, and the challenges associated with their use in food preservation [2].

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Mec a f A c b a B e F

Antimicrobial biopolymer lms work by releasing antimicrobial agents or by directly inhibiting microbial growth on the surface of the food. ese lms can be designed to either actively release antimicrobial agents or provide a physical barrier that disrupts microbial activity. e active release mechanism involves embedding natural antimicrobial substances like essential oils, plant extracts, or metal nanoparticles (e.g., silver or copper) within the biopolymer matrix. ese agents work by either disrupting the microbial cell membrane, inhibiting enzyme activity, or interfering with DNA replication. For example, essential oils such as thyme, oregano, or cinnamon oil, known for their antibacterial and antifungal properties, can be incorporated into the biopolymer matrix. ese compounds di use from the lm and act on the surface of the food, reducing microbial load and slowing down spoilage. Similarly, chitosan, a biopolymer derived from chitin, has inherent antimicrobial properties that make it an excellent choice for food packaging. It has been shown to inhibit the growth of a variety of foodborne pathogens, including Escherichia coli and Salmonella [3].

T e f B e U ed f A c b a F

Several types of biopolymers are utilized to create antimicrobial lms, each with distinct properties that can be tailored to speci c food preservation needs:

Chitosan: Chitosan is a widely used biopolymer derived from chitin, a natural polymer found in the exoskeleton of crustaceans. It has antimicrobial properties and is biocompatible and biodegradable. Chitosan-based lms can be functionalized with antimicrobial agents to improve food safety and extend shelf life, especially for fruits, vegetables, and meat products [4].

Starch: Starch-based lms are biodegradable and can be easily processed. ey are o en combined with antimicrobial agents such as essential oils or metal nanoparticles to enhance their e ectiveness

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