

Chapter: 19

ADVANCEMENTS IN FOOD PACKAGING: FOCUS ON POLYSACCHARIDE-BASED MATERIALS

MOHD YUSUF*

*Correspondence- Glocal School of Science and Technology,
Glocal University, Saharanpur, U.P. – 247121, India

SUKHVINDER PAL

Scholar, Glocal University, Saharanpur, U.P. – 247121, India

UMARFAROOQ A. HALYAL

Scholar, Glocal University, Saharanpur, U.P. – 247121, India

KM KAJAL PARVEEN, SHALU

Scholar, Glocal University, Saharanpur, U.P. – 247121, India

SANDEEP CHAURASIA

Scholar, Glocal University, Saharanpur, U.P. – 247121, India

ANURADHA

Student, Glocal University, Saharanpur, U.P. – 247121, India

SHIVANI

Student, Glocal University, Saharanpur, U.P. – 247121, India

SHUBHAM

Student, Glocal University, Saharanpur, U.P. – 247121, India

Email: yusuf1020@gmail.com; mohd.yusuf@theglobaluniversity.in

Orcid Id: <https://orcid.org/0000-0003-0927-8490>

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ABSTRACT

In recent years, the field of food packaging has witnessed a paradigm shift towards the integration of innovative materials to address the growing concerns associated with traditional packaging solutions. This comprehensive review deals with the recent advancements in food packaging, with a specific focus on the utilization of polysaccharide-based materials. Polysaccharides, derived from a variety of natural sources such as alginate, starch, cellulose, pectin, and carboxymethyl cellulose, have emerged as promising alternatives for sustainable and functional food packaging. The review discusses the inherent properties of these polysaccharides, including biocompatibility, biodegradability, and versatile functionality, which make them well-suited for addressing the evolving needs of the food packaging industry. The exploration covers the applications of polysaccharide-based materials, and their contributions to enhancing barrier properties, antimicrobial features, and overall sustainability. As the food industry grapples with the demand for eco-friendly and effective packaging solutions, this review provides insights into the potential of polysaccharide-based materials to revolutionize food packaging practices.

Keywords: *Natural products, biodegradable films, Safety, Food packaging.*

1. INTRODUCTION

The demand for sustainable and environmentally friendly packaging solutions has spurred research into alternative materials that can mitigate the ecological impact of traditional packaging. Polysaccharides, abundant in nature, have gained significant attention for their intrinsic properties, such as biocompatibility, biodegradability, and low toxicity. These attributes make polysaccharides an attractive choice for developing nanomaterials, particularly nanoparticles, that can be employed in food packaging to address both environmental concerns and the need for improved packaging performance [1-3]. Polysaccharides, derived from various natural sources such as starch, cellulose, chitosan, and alginate, are inherently biocompatible and pose minimal health risks. When formulated into nanoparticles, these polysaccharides offer a safe and non-toxic alternative to conventional packaging materials [4]. This aspect is of paramount importance, especially when considering the direct contact of packaging materials with food products. The ability of polysaccharide-based nanoparticles to form a protective barrier without introducing harmful substances into the food matrix makes them an ideal choice for ensuring food safety.

The nanoscale structure of these particles allows for a more effective hindrance of gas and moisture permeation, thereby extending the shelf life of food products. This improvement in barrier properties is attributed to the unique structural characteristics of polysaccharides and their ability to form dense networks within the packaging matrix. Microbial contamination is a significant concern in the food industry, leading to spoilage

and potential health risks. Polysaccharide-based nanoparticles, particularly those incorporating antimicrobial agents, exhibit remarkable antimicrobial properties [5-8]. Chitosan nanoparticles, for instance, have been widely studied for their ability to inhibit the growth of bacteria and fungi. The controlled release of antimicrobial agents from polysaccharide-based nanoparticles provides an added layer of protection against microbial contamination, further enhancing the preservation of packaged food products. Polysaccharide-based nanoparticles offer a versatile platform for tailoring the physical and chemical properties of food packaging materials. Through modifications in size, shape, and surface chemistry, these nanoparticles can be designed to meet specific requirements, such as controlled release of active compounds, improved mechanical strength, or responsiveness to environmental stimuli. This versatility enables the development of customized packaging solutions for different types of food products, ranging from perishable goods to dry commodities.

2. MAJOR POLYSACCHARIDE-BASED MATERIALS

In the realm of food packaging applications, researchers have delved into the exploration of diverse polysaccharide types, with a particular emphasis on materials like alginate. Alginate, among others, has been a subject of investigation for its potential contributions to advancing food packaging technologies. Beyond alginate, starch films have demonstrated significant promise as versatile materials in the food industry, finding applications in the creation of packaging solutions, compostable bags, carry bags, and various molded items. This versatility positions starch films as multifunctional components with the potential to address diverse packaging needs, ranging from the containment of food products to the development of environmentally friendly alternatives such as compostable bags [9-10]. Lignocellulosic fibers, composed of cellulose, pectin, hemicellulose, lignin, and waxy components, represent another class of naturally occurring materials that have garnered attention for their applicability in food packaging. The enzymatic activity inherent in lignocellulose facilitates its breakdown into constituent elements such as hemicellulose, lignin, and cellulose. This breakdown process holds significant promise for the development of sustainable and biodegradable packaging materials. The utilization of lignocellulosic fibers in food packaging aligns with the broader industry trends towards eco-friendly solutions that mitigate the environmental impact of traditional packaging materials. Figure 1 shows the key aspects of polysaccharide-based edible packaging. It illustrates the major sources, types, processing methods, and resulting product forms, emphasizing their diverse applications in food preservation. The figure provides a quick and comprehensive overview of the intricate landscape of polysaccharide-derived packaging within the food industry.

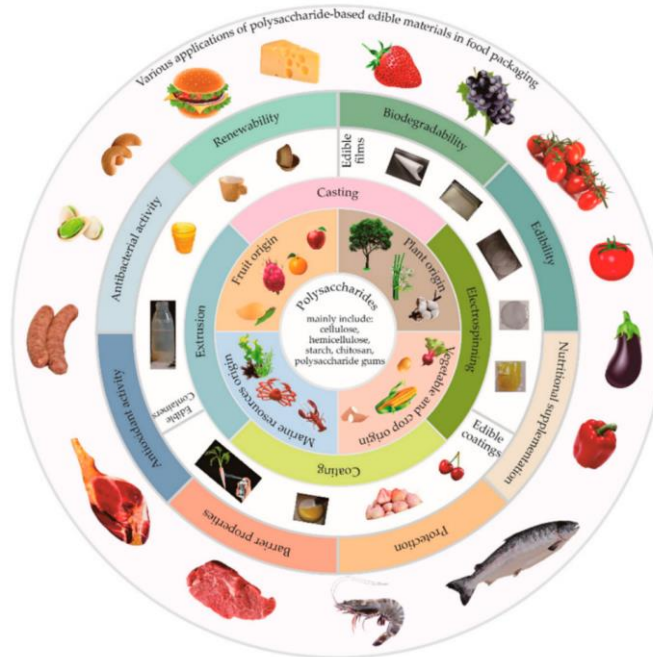


Figure 1: The principal origins, varieties, processing techniques, forms of products, and applications in food preservation of edible packaging based on polysaccharides. (Adapted from ref. [10] under CC BY MDPI 2021)

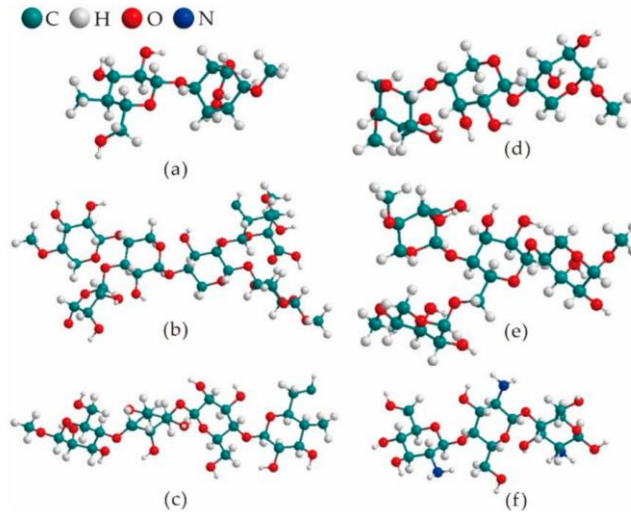


Figure 2: Three-dimensional models of the molecular structure of various polysaccharides. (a): Cellulose (b): Xylan (c): Glucomannan (d): Amylose (e): Amylopectin (f): Chitosan. (Adapted from ref. [10] under CC BY MDPI 2021)

Pectin, identified as a complex anionic polysaccharide, has found extensive use in the food industry, serving a myriad of functions such as gelling agents, thickeners, emulsifiers, and stabilizers. The versatility of pectin makes it a valuable component in the formulation of food packaging materials, contributing not only to structural integrity but also to the preservation and quality of packaged food items. The adoption of pectin in food packaging underscores its role in enhancing the overall performance and functionality of packaging solutions [7-9]. Figure 2 encompasses three-dimensional models illustrating the molecular structures of diverse polysaccharides, including Cellulose, Xylan, Glucomannan, Amylose, Amylopectin, and Chitosan [10]. Each model serves to visually articulate the intricate molecular arrangements and configurations inherent to these polysaccharides, providing a comprehensive understanding of their structural nuances. Carboxymethyl cellulose (CMC) emerges as a noteworthy polysaccharide with diverse applications within the food industry. Notably, CMC serves as a barrier against various pollutants, contributing to the preservation of food products by shielding them from external contaminants. This barrier function enhances the efficacy of food packaging, ensuring that the packaged items remain untainted and safe for consumption. The multifaceted utility of CMC in the food industry positions it as a valuable ingredient in the development of packaging materials that prioritize both functionality and food safety.

The integration of polysaccharide-based nanoparticles into food packaging represents a significant stride towards sustainable and advanced packaging solutions [11-13]. The biocompatibility, enhanced barrier properties, antimicrobial effects, and versatility of these nanoparticles make them promising candidates for addressing the multifaceted challenges associated with food packaging. As the food industry continues to evolve, the adoption of polysaccharide-based nanoparticles is poised to play a pivotal role in ensuring the safety, quality, and sustainability of packaged food products. Future research should focus on scaling up production methods, optimizing formulations, and conducting comprehensive safety assessments to accelerate the practical implementation of these innovative materials in the food packaging industry [14-15]. The ongoing exploration of polysaccharide-based nanoparticles opens exciting avenues for the development of next-generation packaging materials that align with the principles of environmental responsibility and consumer safety.

3. CONCLUSION

The review underscores the significant strides made in the realm of food packaging through the integration of polysaccharide-based materials. The versatility of polysaccharides, spanning diverse sources and functionalities, presents a compelling

case for their adoption as key components in the development of next-generation packaging materials. The unique properties of these materials, including biocompatibility and biodegradability, align with the global shift towards sustainable practices in packaging. The multifaceted applications of polysaccharide-based materials, ranging from barrier enhancement to antimicrobial effects, highlight their potential to address the complex challenges faced by the food packaging industry. As research in this field advances, the review anticipates continued innovation and the practical implementation of polysaccharide-based materials, heralding a new era of environmentally conscious and high-performance food packaging solutions. One of the key challenges in food packaging is creating barriers against oxygen, moisture, and other external factors that can compromise the quality and safety of packaged food. Polysaccharide-based nanoparticles have demonstrated the ability to enhance the barrier properties of packaging materials.

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