

Biopolymers in Modern Food Packaging Solutions

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Food packaging plays a crucial role in maintaining the quality and safety of food products. Traditional packaging materials, such as plastics derived from petrochemicals, pose significant environmental concerns due to their non-biodegradable nature. In response, the development and use of biopolymers in food packaging have emerged as sustainable alternatives. This article explores the various types of biopolymers, their applications, benefits, and challenges in the food packaging industry.

Biopolymers are natural polymers produced by the cells of living organisms. They can be categorized into three main types based on their origin and production processes:

- 1. Polysaccharides:** These include starch, cellulose, and chitosan. Starch-based biopolymers are widely used due to their abundance and biodegradability. Cellulose, derived from plant cell walls, is a commonly used biopolymer with excellent mechanical properties. Chitosan, obtained from chitin in shellfish exoskeletons, is known for its antimicrobial properties.
- 2. Proteins:** These include gelatin, casein, and soy protein. These biopolymers offer good film-forming properties and are often used in edible coatings and films to enhance food preservation.
- 3. Polyesters:** Polylactic acid (PLA) and polyhydroxyalkanoates (PHA) are notable examples of Polyester. PLA, derived from fermented plant starch, is compostable and widely used in packaging applications. PHAs, produced by microbial fermentation, are fully biodegradable and can be tailored for specific properties.

Fabrication process of biopolymer includes the following steps (Fig.1).

- Sourcing the raw material from plants and micro-organisms e.g. cellulose from sugarcane, starch from cassava, PHA by bacterial fermentation etc.
- Extraction and purification through milling, solvent extraction and chemical treatment to remove lignin and hemicellulose.
- Polymerization through condensation or ring opening polymerization.

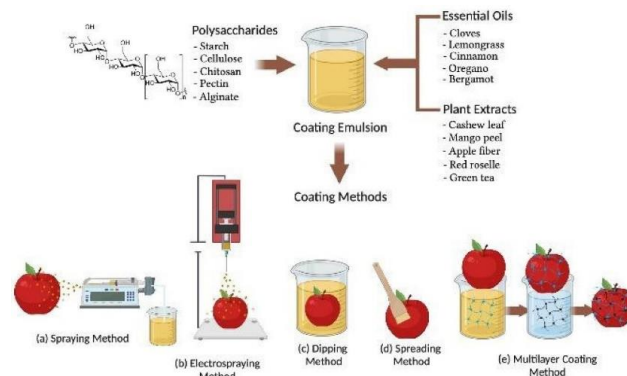


Fig. 1 Process of Biopolymer preparation

Source: www.meyers.com

- Computing and blending by the usage of plasticizer and filler to enhance flexibility and mechanical strength.
- Processing techniques such as the compounded polymers then processed to packaging material by various techniques such as extrusion, thermoforming, coating, injection moulding and blow moulding etc.
- Post-processing including annealing (heating the biopolymer products to improve their crystallinity and mechanical properties), surface treatment, laminating etc.
- Then the polymers undergo various testing such as mechanical strength, barrier properties, biodegradability testing, food safety testing etc.

Applications in Food Packaging

Biopolymers are increasingly being used in various food packaging applications (Abdulla et al., 2022) such as:

Edible Films and Coatings: These are applied directly to food products to extend shelf life by reducing moisture loss and microbial growth. For example, chitosan and gelatin coatings are used on fruits and vegetables.

Biodegradable Films: PLA and starch-based films are used to package a variety of food products, offering an eco-friendly alternative to conventional plastics.

Composite Materials: Combining biopolymers with other biodegradable materials can enhance their mechanical and barrier properties and these are called composite materials (Porta et al., 2020). For instance, adding cellulose nanocrystals to starch films improves their strength and moisture resistance.

Benefits of Biopolymers in Food Packaging

Biopolymers offer numerous benefits in food packaging, from reducing environmental impact and supporting renewable resource-use to provide effective barrier properties and mechanical strength. As technology advances and consumer demand for sustainable products grows, biopolymers are poised to play a crucial role in the future of food packaging.

Sustainability

- Biopolymers are derived from renewable resources. Materials like corn, sugarcane, and potato are cultivated annually, providing a constant supply of raw materials.
- Growing plants for biopolymers captures carbon dioxide from the atmosphere, potentially lowering the overall carbon footprint compared to petroleum-based plastics.
- Utilizing agricultural products reduces dependency on oil and enhances the resilience of the material supply chain.

Biodegradability

- Biopolymers decompose naturally through microbial activity, leading to significant environmental benefits. Biodegradable packaging reduces the accumulation of plastic waste in landfills and oceans.
- As biopolymers break down into natural substances like water, carbon dioxide, and biomass, they do not leave harmful residues.
- Many biopolymers can be composted in industrial or home composting systems, turning packaging waste into valuable compost.

Circular Economy Support

- Biopolymers contribute to a circular economy model, promoting sustainability through the entire lifecycle. By using renewable resources and reducing waste, biopolymers align with principles of resource efficiency and sustainable development.
- Comprehensive lifecycle assessments (LCA) often show that biopolymers have a lower environmental impact over their lifecycle compared to conventional plastics.
- Beyond biodegradability, some biopolymers can be recycled or repurposed, further reducing their environmental footprint.

Consumer Preference and Market Differentiation

- Growing environmental awareness is driving consumer demand for sustainable packaging solutions. Biopolymer packaging appeals to

consumers who prioritize environmental sustainability, enhancing brand reputation and loyalty.

- Brands that adopt biopolymer packaging can leverage it as a unique selling point, differentiating them in a competitive market.
- With increasing regulatory pressure to reduce plastic waste, biopolymers offer a proactive approach to compliance with environmental laws and standards.

The future of biopolymers in food packaging looks promising, with ongoing research and development aimed at overcoming current challenges. By improving performance, reducing costs, and enhancing consumer awareness, biopolymers can play a significant role in creating sustainable packaging solutions that reduce environmental impact. Collaboration between industry, academia, and government will be crucial in driving these advancements and achieving widespread adoption. Biopolymer-based packaging materials should also be ensured to meet regulatory standards and gain consumer acceptance which is essential for its widespread adoption in the society. Future research and development efforts are focused on improving the performance and cost-effectiveness of biopolymers. Innovations in biotechnology and materials science are expected to lead to new biopolymers with enhanced properties and broader application potential.

Conclusion

Biopolymers offer a promising solution to the environmental challenges posed by traditional food packaging materials. Their biodegradability, sustainability, and functional benefits make them an attractive option for the food packaging industry. However, overcoming current challenges related to cost, performance, and processing will be crucial for achieving their full potential. Continued research and innovation in this field hold the key to a more sustainable future in biopolymer-based food packaging materials.

References

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