# Chapter: 17

# NEED FOR SUSTAINABLE PACKAGING SUBSTITUTES

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## ABSTRACT

*Sustainable packaging is gaining paramount importance in the contemporary global scenario, driven by a growing awareness of environmental issues and a collective commitment towards eco-friendly practices. This extensive review explores into the critical need for sustainable packaging, emphasizing the utilization of biopolymers derived from various sources, including biomass, microorganisms, and chemical processes. In particular, the review focuses on the extraction of biopolymers from biomass sources, such as cellulose, starch, and galactomannans, the production of polyhydroxyalkanoates (PHA) and polysaccharides from microorganisms, and the chemical synthesis of bio-based monomers like polylactic acid (PLA).*

**Keywords:** *Packaging materials, Sustainability,*

## 1. INTRODUCTION

Sustainability, a complex and multifaceted concept, is commonly categorized into three pivotal dimensions: human well-being, economic viability, and environmental integrity. These dimensions serve as the foundation for advancing human prosperity, ensuring equitable burden-sharing, and preserving the resilience of the ecosystem [1-2]. Within the framework of sustainability, ecological considerations emphasize the imperative of contributing to the perpetual maintenance of a healthy environment. This ecological perspective becomes particularly pertinent when examining the sustainability of packaging materials. Sustainable packaging materials are characterized by a concerted effort to diminish reliance on virgin resources while prioritizing the recyclability or reusability of post-consumed materials. The essence of material sustainability encapsulates a multitude of factors, spanning economic and environmental realms. This includes assessing the costs and impacts associated with the production, functionality, and aesthetic properties of materials, extending to considerations of end-of-life processing [3-5]. Material sustainability operates within a spectrum, encompassing local to global-scale effects and intricately weaving together diverse aspects of the economic and environmental fabric.

In scrutinizing the ecological component of sustainability, it becomes evident that maintaining a harmonious balance between human activities and the environment is imperative. The application of sustainability principles to packaging materials demands a strategic approach that goes beyond the reduction of virgin resource usage. The emphasis extends to ensuring that post-consumed materials are not only recyclable but also capable of being seamlessly reintegrated into the production cycle. This circularity in material use aligns with the broader sustainability goals, fostering responsible resource management and minimizing environmental impact [6-8]. Material

sustainability in packaging involves navigating a nuanced landscape, considering the entire life cycle of materials, from their initial production through consumption to their eventual end-of-life processing. Evaluating the sustainability of packaging materials necessitates a holistic perspective that weighs economic considerations against environmental impacts. Striking a balance between functionality, aesthetics, and environmental responsibility becomes paramount in the pursuit of sustainable packaging solutions [9]. This comprehensive approach, spanning local to global scales, ensures that sustainability in packaging aligns with broader ecological imperatives and contributes to the overarching goal of fostering a resilient and harmonious coexistence between human activities and the environment.

The escalating environmental concerns associated with traditional packaging materials, primarily derived from non-renewable resources, underscore the urgency for sustainable packaging alternatives. As the global population continues to grow, the packaging industry faces the challenge of meeting rising demand while minimizing its ecological footprint. This review aims to shed light on the pivotal role of sustainable packaging, with a focus on biopolymers sourced from biomass, microorganisms, and chemical processes [10-12].

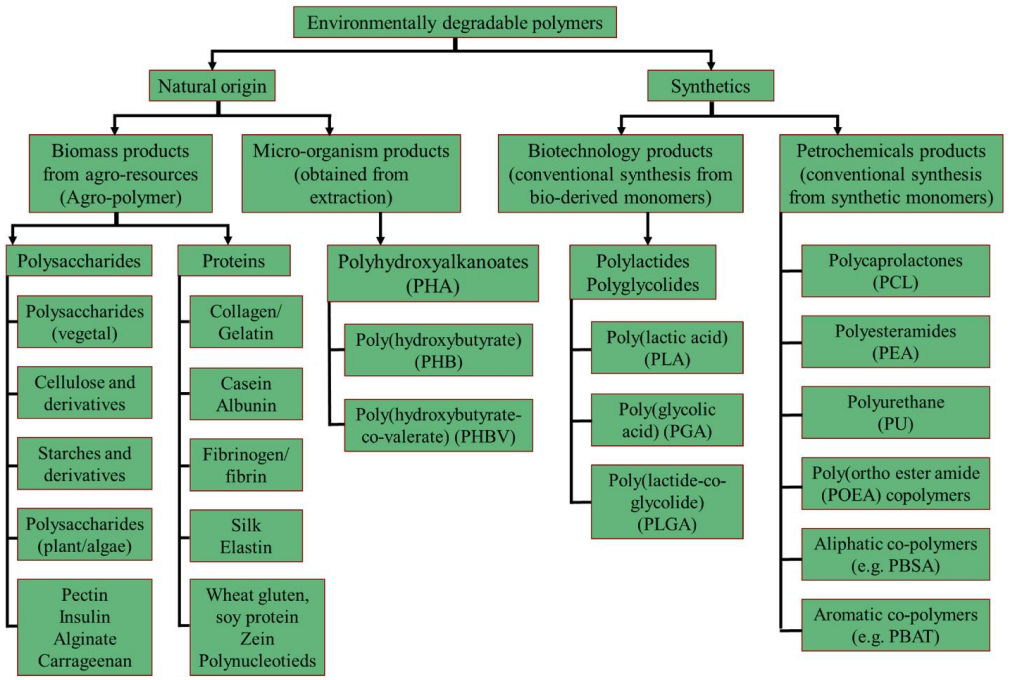


**Figure 1: Classifications of biopolymer and biodegradable materials (Adapted from Ref. [5] under CCBY Attribution, MDPI 2022).**

## 2. BIOMASS SOURCES

One of the key avenues for sustainable packaging lies in the extraction of biopolymers directly from biomass sources. This includes the utilization of polysaccharides like cellulose, starch, and galactomannans. These renewable resources offer a promising solution as they are abundantly available and can be harnessed without depleting natural ecosystems. The exploration of these biomass-derived biopolymers for packaging applications forms a crucial component of the sustainable packaging paradigm. The visual representation in Figure 1 provides a comprehensive overview of the diverse classifications of biopolymers and biodegradable materials [5]. Within this graphical depiction, we gain insights into the extensive categorization of these materials, offering a structured and insightful framework. Biopolymers and biodegradable materials are systematically organized which showcasing the intricate web of classifications that contribute to our understanding of their diverse nature [13]. This figure serves as a valuable reference point, illustrating the nuanced relationships and distinctions among different types of biopolymers and biodegradable materials. By providing a visual map of the intricate classifications, the figure facilitates a deeper comprehension of the complexity and interconnectivity within the realm of biopolymers and biodegradable materials.

## 3. MICROORGANISM SOURCES

Microorganisms present another sustainable avenue for biopolymer production, with a focus on polyhydroxyalkanoates (PHA) and polysaccharides. The ability of microorganisms to synthesize biopolymers under controlled conditions provides a scalable and environmentally friendly approach. This section explores the methods and potential applications of biopolymers derived from microorganisms, shedding light on their versatility and sustainability.

## 4. CHEMICAL SOURCES

The chemical synthesis of bio-based monomers, exemplified by polylactic acid (PLA) and lactic acid-based thermoplastic aliphatic polyesters, represents an innovative approach to sustainable packaging. Chemical processes enable the creation of biopolymers with tailored properties, enhancing their suitability for various packaging applications. This section delves into the methods and advancements in the chemical synthesis of bio-based monomers, providing insights into their feasibility and impact [14]. Packaging materials, an integral facet of the industry, exhibit a wide-ranging diversity that spans from traditional options like paper and glass to contemporary materials such as plastics and metals.

The sustainability of the packaging sector hinges on a multifaceted evaluation of various factors. Assessing the availability of raw materials, implementing effective recycling practices, utilizing renewable resources, and enacting sound policies for product packaging materials are key determinants in charting a sustainable course for the industry. Each material type carries unique environmental implications, underscoring the need for a holistic approach to sustainability that considers the entire life cycle of these materials. Plastics have been a cornerstone in the packaging industry for decades. However, they pose a distinctive challenge due to their environmental impact [15]. Plastics are primarily produced from petroleum-based polymers such as polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyester (PET). To address this issue, innovative alternatives, including bio-based or biodegradable plastics are being explored. The industry needs to develop a comprehensive and nuanced strategy to align packaging practices with broader sustainability goals. This will ensure a harmonious balance between human convenience and environmental responsibility while grappling with the complexities of material choices.

## 5. CONCLUSION

In conclusion, the imperative for sustainable packaging is underscored by the urgent need to mitigate environmental challenges associated with traditional packaging materials. The exploration of biopolymers derived from biomass, microorganisms, and chemical processes offers a multifaceted and promising approach to address this need. As the world collectively strives towards a more sustainable future, the integration of these diverse sources of biopolymers in packaging materials holds the key to balancing human convenience with environmental responsibility. This review contributes to a deeper understanding of the current landscape and future potential of sustainable packaging solutions.

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