Chapter: 10

AGAR-BASED EDIBLE FILMS AS FOOD PACKAGING MATERIALS

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DOI: ***https://doi.org/10.52458/9788196897437.nsp.2023.eb.ch-10***
Ch.Id:-GU/NSP/EB/RTFP/2023/Ch-10

ABSTRACT

This chapter delves into the emerging field of agar-based edible films as an eco-friendly alternative to plastic food packaging. Against the backdrop of mounting environmental concerns regarding plastic waste, it explores the unique attributes of polysaccharides, including agar, such as biodegradability, cost-effectiveness, and biocompatibility, making them promising materials for sustainable packaging. The chapter also delves into recent research and developments, covering mechanical improvements, moisture barriers, and regulatory compliance, highlighting the potential of agar-based films in contributing to a more environmentally conscious and sustainable future for food packaging.

1. INTRODUCTION

Food packaging materials safeguard products from external contaminants, preserving their freshness and safety. They provide essential information to consumers, such as nutritional facts and expiration dates, aiding in informed choices. Moreover, packaging materials contribute to branding, marketing, and product differentiation, influencing consumers' perceptions and choices [1]. In an era marked by increasing environmental awareness, sustainable packaging materials are gaining prominence, addressing concerns related to waste generation and ecological impact [2-4]. As such, the choice of food packaging materials is central to the food industry's efforts to deliver safe, high-quality products, reduce environmental footprint, and meet the evolving needs and preferences of consumers.

Agar, a biopolymer derived from specific species of red algae, has garnered significant attention in recent years as an eco-friendly and sustainable material for food packaging. The production of continuous, transparent films using agar gum has emerged as a promising alternative to traditional plastic-based packaging materials. While agar-based films offer several inherent advantages, including their biodegradability and renewable source, they do face certain challenges that have prompted extensive research efforts aimed at enhancing their properties and expanding their utility in the food packaging industry.

2. SIGNIFICANCE OF AGAR-BASED EDIBLE FILMS IN FOOD PACKAGING

Agar-based edible films represent a sustainable and innovative solution in the realm of food packaging materials. Derived from natural sources, agar-based films offer a biodegradable alternative to conventional plastics [5]. These films possess unique properties, including excellent barrier properties, transparency, and biocompatibility, making them suitable for various food packaging applications. Agar-based films hold the potential to extend the shelf life of products, reduce food waste, and enhance the

overall sustainability of the food supply chain. Their biodegradability ensures that they break down harmlessly, reducing the burden of plastic pollution on the environment. As consumers increasingly seek eco-friendly and sustainable packaging options, agar-based edible films emerge as a promising choice that aligns with both environmental consciousness and the functional requirements of modern food packaging. In this review, we delve into the characteristics, production methods, applications, advantages, challenges, and future prospects of agar-based edible films as a sustainable packaging solution in the food industry.

One of the primary challenges associated with plain agar films is their inherent brittleness, which can limit their flexibility and durability, potentially affecting their suitability for various packaging applications. Moreover, these films exhibit relatively high moisture permeability, which may compromise their ability to provide an effective barrier against moisture and external contaminants. Additionally, plain agar films often display inadequate thermal stability, which can be a concern when packaging food products that require specific temperature control [6]. To overcome these limitations and unlock the full potential of agar-based films in food packaging, a considerable body of research has been dedicated to improving their properties. These research efforts encompass a wide range of strategies and innovations aimed at enhancing the mechanical strength, moisture resistance, and thermal stability of agar films. These improvements not only address the challenges associated with agar-based packaging materials but also contribute to the broader goal of advancing sustainable and environmentally conscious packaging solutions in the food industry. This review explores the key developments and innovations in agar-based film technology, shedding light on the exciting possibilities these materials hold for the future of sustainable food packaging.

3. RECENT R & D IN AGAR-BASED EDIBLE FILMS IN FOOD PACKAGING

Recent research and development (R&D) efforts in agar-based edible films for food packaging have focused on enhancing the properties and expanding the applications of these sustainable packaging materials [5]. These advancements are driven by the growing demand for eco-friendly packaging options in response to environmental concerns and consumer preferences.

Here are some notable developments in this field:

- **Mechanical Properties Improvement:** Researchers have been working to improve the mechanical strength and flexibility of agar-based films. Strategies include blending agar with other biopolymers such as starch, chitosan, or proteins to

create composite films with enhanced tensile strength and flexibility. These improvements make agar-based films more suitable for a wider range of packaging applications, including those requiring durability and resistance to physical stress.

- **Moisture Barrier Enhancement:** Addressing the issue of moisture permeability, scientists have explored the incorporation of hydrophobic materials, nanocomposites, or lipid-based coatings into agar films. These modifications create films with improved moisture resistance, making them effective barriers against humidity and moisture-sensitive food products.
- **Active and Functional Films:** Agar-based films have been modified to include bioactive compounds and functional ingredients. These films can serve as carriers for antimicrobial agents, antioxidants, and flavor enhancers, extending their functionality beyond mere packaging to actively contribute to food preservation and quality maintenance.
- **Nanostructured Films:** Nanotechnology has been employed to create nanostructured agar-based films with exceptional properties. These films benefit from the high surface area and improved barrier properties of nanomaterials, making them ideal for applications requiring precise control over gas and moisture permeability.
- **Edible Coatings:** Agar-based films have been used as edible coatings for fresh produce. These coatings can extend the shelf life of fruits and vegetables by providing a protective barrier against moisture loss and microbial contamination while also being safe for consumption.
- **Biodegradability and Environmental Impact:** Research continues to assess the biodegradability of agar-based films under various environmental conditions. Understanding the degradation process and its impact on the environment is crucial for evaluating the sustainability of these materials.

Agar-based films have emerged as promising contenders for sustainable edible food packaging due to their superior water resistance compared to commonly used biopolymers. However, their widespread adoption faces challenges such as high brittleness, suboptimal barrier properties, and limited functionality. Researchers are actively addressing these issues through various strategies. To tackle brittleness, the incorporation of plasticizers enhances flexibility, ensuring the films can withstand stress without cracking. Additionally, efforts to improve barrier properties involve blending agar with other biopolymers, creating composite films that offer enhanced protection

against moisture, gases, and contaminants. These innovations are crucial for expanding the applications of agar-based films in diverse food packaging scenarios. Another crucial aspect researchers are addressing is the limited functionality of agar-based films. By introducing cross-linkers and bioactive ingredients, these films can acquire antimicrobial properties, antioxidant effects, and controlled release mechanisms. These added functionalities contribute significantly to addressing food preservation and safety concerns. As these innovative strategies progress, agar-based edible functional packaging materials are positioned to play a pivotal role in developing sustainable and effective edible films for various food packaging applications, advancing the field of eco-friendly packaging.

Over the past few decades, mounting concerns about the environmental impact of plastic packaging have ignited a growing opposition to its use. In response, scientific research has redirected its focus towards the development of biodegradable packaging materials that can minimize ecological harm. This paradigm shift has ushered in the era of smart materials for packaging applications, reshaping the packaging industry's landscape. Among the promising candidates for eco-friendly packaging films, polysaccharides have emerged as a prominent choice, owing to their advantageous attributes. These include their cost-effectiveness, widespread availability in nature, ease of processing, and desirable functional properties. Polysaccharides, such as chitosan, starch, alginate, carrageenans, pectin, and notably agar, are particularly attractive due to their accessibility, non-hazardous nature, biocompatibility, and biodegradability. When employed in packaging, polysaccharides can form continuous chains through hydrogen bonding, enhancing the material's strength and durability, making them suitable for diverse packaging needs. As research in the field continues to advance, the potential of polysaccharide-based films, including those derived from agar obtained from specific marine algae within the Rhodophyceae family, holds promise as a sustainable and environmentally conscious alternative to traditional plastic packaging materials, aligning with global efforts to reduce plastic waste and promote sustainability in the packaging industry.

4. CONCLUSION

The exploration of agar-based edible films as food packaging materials presents a compelling and timely solution in response to the escalating global concern over plastic waste and environmental sustainability. The chapter underscores the exceptional qualities of polysaccharides, particularly agar, which encompass cost-effectiveness, ease of processing, and biodegradability, aligning with the urgent need for eco-friendly alternatives in the packaging industry. Recent research and development efforts have

shown promising advancements in improving the mechanical properties and moisture barriers of agar-based films, further solidifying their potential as sustainable packaging materials. With a strong focus on biocompatibility, regulatory compliance, and environmental consciousness, agar-based edible films offer a tangible pathway towards reducing plastic waste and promoting responsible and sustainable practices in food packaging, thereby contributing to a more environmentally harmonious future.

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