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Editorial

Edible Films and Coatings with Tailored Features for Improvement of Food Quality

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The interest in edible films and coatings has rapidly increased in recent years, driven by the need for fresher and safer foods and the growing attention toward sustainable solutions capable of reducing the use of chemical postharvest treatments. Scientific advances clearly show that the incorporation of bioactive compounds, essential oils, and nanomaterials into biodegradable matrices represents one of the most effective strategies for extending food's shelf life and enhancing food safety. Coatings based on chitosan, alginate, and other polysaccharides are widely applied as barriers to moisture and gas exchange, delaying ripening and deterioration processes [1]. Their effectiveness increases considerably when enriched with phenolic compounds, essential oils, or nanoparticles, which provide antimicrobial and antioxidant activity without altering the nutritional properties of the food [2–4]. Plant extracts rich in polyphenols and essential oils, such as neem and thyme, have shown notable effectiveness in suppressing microbial growth and maintaining the quality of fruits [5–10].

In parallel, developments in nanotechnology have introduced new possibilities for controlled-release systems. Coatings enriched with nanoparticles can allow the gradual diffusion of bioactive compounds, ensuring prolonged and more uniform antimicrobial action, and improving barrier properties [11]. This strategy reduces moisture loss, limits oxidation, and inhibits microbial proliferation, generating an overall positive effect on the shelf life of fresh products [8,11,12]. Major innovations in the sector include the combined use of biopolymers, such as chitosan and alginate, with essential oils to obtain active coatings that extend the shelf life of fruits [2,5,7]. Nanoemulsions and nanostructured systems, which have been successfully applied to papaya, offer further advantages in terms of controlled release and achieving an improvement in mechanical and barrier properties [13]. The use of polymeric blends and composites also improves the mechanical, thermal, and flexibility properties of coatings, as observed in applications on grapes, pomegranate, and banana [14–16].

Recently published scientific results support these trends and further highlight the potential of combining biopolymers, natural antimicrobials, and advanced technologies. The incorporation of antagonistic microorganisms into alginate-based coatings, as demonstrated by Du et al. [17], extended the shelf life of peaches by 6–7 days through the combined contribution of the polymeric matrix and the antifungal activity of the yeasts *Candida oleophila* and *Cryptococcus laurentii*. Other studies have evidenced the central role of essential oils: nanoemulsions of carnauba wax with *Cymbopogon martinii* reduced weight loss and delayed the ripening of papaya [17], while the incorporation of neem oil into coatings based on hydroxypropyl methylcellulose and $CaCl_2$ preserved the quality of fresh-cut mango and significantly reduced microbial load [18]. Kumar et al. [19] showed that a composite of chitosan and pullulan enriched with pomegranate peel extract maintained mango quality for a longer period, also preserving phenolic content. Advanced

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approaches in the field also include the use of optimization techniques. Kawhena et al. [15] applied Response Surface Methodology to identify an optimal formulation of gum arabic, starch, and lemongrass essential oil capable of improving the preservation of *Wonderful* pomegranate. Significant improvements in mechanical and antimicrobial properties were also obtained in carboxymethyl cellulose films enriched with Chinese fir essential oil, which was successfully used to maintain the quality of *Shine Muscat* grapes [16]. The combination of chitosan and vanillin also proved effective in maintaining the postharvest quality of tomato, reducing disease incidence and preserving the antioxidant activity of the fruit [20]. The recent literature further emphasizes the potential of active coatings enriched with natural antimicrobials and nano-encapsulated agents as sustainable alternatives to traditional disinfectants, contributing to greater food safety in fresh horticultural production [21]. Plant-protein-based gels have also emerged as promising materials for functional coatings because their gelling properties can be modulated in response to environmental and technological factors [22]. These developments illustrate how research is converging toward sustainable, multifunctional solutions integrating biomaterials, natural compounds, and advanced formulation technologies. Despite the significant progress made, several challenges remain. Among the most critical issues are the stability of bioactive compounds during storage, the potential sensory impact of coatings, the variability in formulations, and the lack of standardized protocols for application and evaluation. Future research must focus on improving controlled-release systems, harmonizing experimental methodologies, conducting thorough sensory assessments, and validating formulations at the industrial scale [4,12,23]. It is also essential to develop multiscale predictive models capable of correlating material properties with real performance under operational conditions. Overall, edible films and coatings represent an innovative, sustainable, and effective solution for the preservation of fresh food and provide a valid alternative to chemical preservatives. Scientific evidence clearly demonstrates their potential to improve postharvest quality, reduce food losses, and address increasing demands for safety and sustainability. The evolution of formulation technologies, the integration of bioactive compounds, and the introduction of nanotechnology and antagonistic microorganisms open new perspectives for increasingly advanced, reliable, and versatile applications in the sector. Their ability to act simultaneously as physical barriers, carriers of functional agents, and modulators of biochemical processes makes edible coatings a key technology in the ongoing transition toward greener postharvest management strategies. As research continues to deepen the understanding of the interactions between coating materials, bioactive compounds, food physiology, and environmental conditions, it has become possible to design more efficient and tailored solutions for different commodities. These advancements position edible films and coatings as one of the most promising tools for meeting the dual challenge of ensuring food quality and reducing environmental impact in modern supply chains.

Contributions of the Special Issue

The articles in this Special Issue directly illustrate the advances described above. Firstly, Du et al. [17] demonstrated the ability of alginate-based coatings enriched with antagonistic yeasts to extend peach shelf life. In their study, Oliveira Filho et al. [13] applied carnauba wax nanoemulsions with *Cymbopogon martinii* essential oil to papaya, delaying ripening and reducing weight loss, while Passafiume et al. [18] used neem-oil-enriched coatings on fresh-cut mango to improve microbial stability and quality. Kumar et al. [19] showed that chitosan–pullulan coatings with pomegranate peel extract preserved mango quality and phenolic content, and Kawhena et al. [15] optimized gum arabic–starch coatings with lemongrass essential oil for pomegranate preservation. Mei et al. [16] enhanced the mechanical and antimicrobial properties of carboxymethyl cellulose films with Chinese fir essential oil for grapes, while Safari et al. [20] demonstrated that chitosan–vanillin coatings

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maintained tomato quality and reduced disease incidence. Finally, Bautista-Baños et al. [21] and Ma & Chen [22] explored sustainable disinfectant alternatives and plant-protein-based gels for functional coatings. Together, these studies emphasize the effectiveness, versatility, and sustainability of edible films and coatings in postharvest management.

Conflicts of Interest: The author declare no conflict of interest.

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