



IMPACTO DE LOS RECUBRIMIENTOS COMESTIBLES EN LA CALIDAD Y VIDA DE ÚTIL DE FRUTAS Y VERDURAS FRESCAS

IMPACT OF EDIBLE COATINGS ON THE QUALITY AND SHELF LIFE OF FRESH FRUITS AND VEGETABLES

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RESUMEN

Los recubrimientos comestibles han surgido como una solución innovadora y sostenible para abordar el reto de preservar la calidad y extender la vida útil de frutas y verduras frescas. Estos recubrimientos, elaborados a partir de materiales naturales y biodegradables, operan como barreras físicas que minimizan la pérdida de agua y el intercambio gaseoso, contribuyendo a desacelerar los procesos de maduración y senescencia. El objetivo de esta investigación es examinar y sintetizar la evidencia existente sobre el impacto de los recubrimientos comestibles en la calidad y vida útil de frutas y verduras frescas. La metodología utiliza métodos tanto cualitativos como cuantitativos para ayudarlo a obtener una comprensión integral, esto incluyó una revisión sistemática de la literatura publicada entre 2020 y 2024, utilizando categorías clave específicas para establecer criterios estrictos de inclusión y exclusión se presenta un análisis completo de sus trabajos de investigación, artículos informativos y análisis relacionados cuidadosamente seleccionados en plataformas confiables. El resultado mostró que los recubrimientos eran capaces de retener células, reducir la pérdida de humedad y retardar el envejecimiento, lo que significa que su vida útil aumentó significativamente. En conclusión, los recubrimientos comestibles han demostrado ser una alternativa prometedora y prometedora para mejorar la calidad y extender la temporada de frutas y verduras.

Palabras clave

Recubrimientos, vida útil, conservación, calidad nutricional, patógenos, estandarización

ABSTRACT

Edible coatings have emerged as an innovative and sustainable solution to address the challenge of preserving the quality and extending the shelf life of fresh fruits and vegetables. These coatings, made from natural and biodegradable materials, operate as

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physical barriers that minimise water loss and gas exchange, helping to slow down the maturation and senescence processes. The aim of this research is to examine and synthesize existing evidence on the impact of edible coatings on the quality and shelf life of fresh fruits and vegetables. The methodology uses both qualitative and quantitative methods to help you gain a comprehensive understanding, this included a systematic review of literature published between 2020 and 2024, using specific key categories to establish strict inclusion and exclusion criteria. A comprehensive analysis of your carefully selected research papers, informative articles, and related analyses is presented on trusted platforms. The result showed that the coatings were able to retain cells, reduce moisture loss and slow aging, meaning their lifespan was significantly increased. In conclusion, edible coatings have proven to be a promising and promising alternative for improving quality and extending the fruit and vegetable season.

Keywords

Coatings, shelf life, preservation, nutritional quality, pathogens, standardization.

INTRODUCTION

Edible coatings have emerged as an innovative and sustainable way to address quality control problems and extend the shelf life of fresh fruits and vegetables. These barriers are composed of organic compounds and biodegradable substances such as polysaccharides, proteins, and lipids that act as physical barriers reducing water loss and gas exchange. This helps to reduce growth delay and senescence, which are the main causes of deterioration of fruits and vegetables. In addition, the incorporation of preservatives and antimicrobials in the formulation provides additional protection against pathogenic microorganisms and the deterioration of sensory and nutritional quality.

The preservation of fresh fruits and vegetables stands as a significant challenge at the global level, impacting both producers and consumers. This problem is manifested in the alarming postharvest losses, which represent a critical aspect within the food supply chain. It is estimated that between 30% and 50% of fresh horticultural products are lost from the moment of harvest until their consumption, with the processes of decomposition and deterioration being the main ones responsible for this situation. This reality not only adversely affects the agricultural economy, but also intensifies food insecurity and the waste of valuable natural resources (1).

Faced with these challenges, edible coatings have emerged as an innovative and sustainable solution that promises to transform the way fresh products are handled. These thin layers applied to the surface of fruits and vegetables are specifically designed to offer effective protection against environmental factors that contribute to their deterioration, thus prolonging their shelf life. They are elaborated from natural and biodegradable materials, which include polysaccharides (such as starch, cellulose, and chitin), proteins (such as casein, soy, and gelatin), and lipids (such as wax and fatty acids) (2).

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Edible coatings not only operate as physical barriers that minimize water loss and gas exchange, but also facilitate the incorporation of antimicrobial agents, antioxidants, and other beneficial additives. Their mechanism of action is complex and multifaceted; by reducing the transpiration and respiration of fresh products, these coatings contribute to slowing down the processes of ripening and senescence (3).

Furthermore, the inclusion of bioactive substances in these coatings provides additional defense against pathogenic microorganisms, which is crucial for reducing postharvest diseases. This approach has proven to be especially effective in improving the nutritional and sensory quality of fruits and vegetables, ensuring the preservation of their freshness, texture, and flavor over prolonged periods (4).

The practical applications of edible coatings are broad and diverse; therefore, recent research has documented their efficacy across a variety of products, including apples, bananas, strawberries, citrus fruits, cucumbers, peppers, and carrots (5). Each type of coating can be adapted to the specific needs and characteristics of different fruits and vegetables, offering personalized solutions that adjust to diverse agricultural and commercial contexts, which have been facilitated by progress in formulation and application techniques, as well as by the integration of technological innovations, such as nanotechnology and controlled-release systems (6).

Nevertheless, the implementation of edible coatings faces significant challenges that cannot be ignored, such as production costs, current regulations, consumer acceptability, and variability in efficacy according to product type; therefore, storage conditions are factors that require continuous and rigorous attention, highlighting that research in this field is in constant evolution, with an increasingly greater focus on the optimization of formulations and the evaluation of their environmental and economic impact (7).

The purpose of this review article is to examine and synthesize existing research on the impact of edible coatings on the quality and shelf life of fresh fruits and vegetables in order to identify both the benefits and the challenges and future perspectives of this emerging technology in postharvest management.

MATERIALS AND METHODS

Research method:

The present study is based on a mixed research approach, which combines both qualitative and quantitative methods. This methodological design is chosen to provide a more complete and in-depth understanding of the phenomenon in question, integrating diverse perspectives and types of data. The combination of quantitative and qualitative methods in this research allows for data triangulation, which strengthens the validity and reliability of the findings.

Population or sample:

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An exhaustive analysis was carried out of a broad spectrum of information sources that include scientific articles, outreach documents, academic journals, and relevant books in the field of fruit and vegetable preservation, which allowed the identification of pertinent studies published between the years 2020 and 2024, using reliable and prestigious access platforms, such as SciELO, Redalyc, and specialized search engines such as Google Scholar, employing specific keywords that facilitated the search and filtering of relevant information. The keywords used included terms such as “edible coatings,” “fruit and vegetable preservation,” “postharvest shelf life,” and “fruit and vegetable quality.” These keywords were strategically selected to adequately frame the essential aspects of the research. In addition, rigorous inclusion and exclusion criteria were established that served to identify the most pertinent and significant studies.

The inclusion criteria focused on the consideration of articles published in English and Spanish that explicitly evaluated the use of edible coatings on fresh fruits and vegetables, in addition to those that reported experimental data on the effects of such coatings on the quality and shelf life of the products. Conversely, articles that did not provide concrete experimental data, previous review studies that did not offer new approaches, as well as works that focused on non-edible coatings or on the application of these to products other than fresh fruits and vegetables were excluded.

Measurements:

Once the pertinent studies were collected, an initial review of the titles and abstracts was carried out to evaluate their relevance in relation to the objectives established for the research; those meeting the inclusion criteria were selected and downloaded to carry out a detailed review of the full text. This thorough review allowed deepening into the findings and data presented in each study, ensuring that the information used was relevant and of high quality.

In addition, a secondary review of the references cited in the selected articles was carried out, which allowed identifying additional studies that were not captured in the initial search. This exhaustive approach ensures a complete collection of relevant and updated literature in the field of edible coatings, contributing significantly to the solidity of the analysis performed.

Data analysis:

It was carried out in a systematic and rigorous manner, seeking patterns and trends in the effects of edible coatings on the quality and shelf life of fruits and vegetables. This approach not only allowed obtaining a clear and structured view of the benefits and limitations of the different coating formulations, but also helped to identify critical areas for future research.

RESULTS

The reviewed studies demonstrate that the application of edible coatings on fresh fruits and vegetables has a positive impact on the preservation of their quality and the

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increase of their shelf life. Regarding quality, edible coatings have shown to be effective in maintaining the organoleptic properties of the products, such as color, aroma, flavor, and texture. For example, (8) found that the use of a formulation based on coffee mucilage and gelatin on apples allowed controlling the increase in °Brix, pH, and maturity index, as well as the decrease in acidity, thereby preserving the commercial and nutritional attributes of the fruit.

Likewise, edible coatings have proven to be an effective barrier against moisture loss and gas exchange, which translates into a lower respiration rate and delay in the ripening process. (9) reports that coatings based on chitosan and fish gelatin managed to preserve the quality characteristics of guavas for twice as long compared to uncoated fruits, reducing weight loss.

Regarding shelf life, various studies have evidenced that the application of this type of coatings allows significantly extending the conservation period of fresh fruits and vegetables. Therefore, (10) observed that a coating composed of nopal mucilage, gelatin, and beeswax applied to plums stored under refrigeration importantly reduced the loss of firmness, discoloration, and the incidence of chilling injury, managing to increase their shelf life. Similarly, (11) mentions that a coating based on oil, beeswax, and gelatin applied to blackberries decreased the rate of deterioration and maintained the quality of the fruit for 8 additional days compared to uncoated blackberries.

On the other hand, in Table 1, a compilation of data is presented, which evidences that edible coatings, independently of the nature of the fruits, have proven to be a viable and effective alternative to prolong the shelf life and maintain the quality of fresh fruits and vegetables. This is due to the barrier properties offered by these coatings, which allow controlling the respiration rate, moisture loss, and microbial growth. In addition, these coatings, composed of natural or synthetic substances, act as a protective barrier on the fruit, improving its quality (12), (13), (14), (15).

Additionally, the incorporation of additives such as antioxidants and antimicrobials in the formulations of edible coatings has demonstrated contributing even more to improving the effectiveness of these coatings in the conservation of horticultural products. These additives help control microbial growth and preserve the bioactive compounds and sensory properties of fresh fruits and vegetables.

Table 1. Effect of edible coatings on the conservation of fruits

Fruit	Coating	Effect
Plum	Mucilage, Gelatin and beeswax	Preserves postharvest quality, reduces weight loss, firmness loss and respiration rate
Avocado	Ethanollic propolis extract (EEP)	Slows respiratory activity, prevents weight loss and maintains hydrogen potential
Pitahaya	Chitosan and glacial acetic acid	Preserves color, weight and firmness of the fruit
Strawberry	Gellan gum	Decreases weight loss, microbial growth and improves firmness

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Strawberry	Essential oils of <i>Cymbopogon citratus</i>	Maintains fruit quality after harvest
Strawberries	Chitosan	Greater firmness, bright red color, lower incidence of molds and yeasts
Strawberries	Alginate	Lower weight loss, greater retention of ascorbic acid compared to control
Blackberry	Oil, beeswax and gelatin formulation	Decreases the rate of deterioration and maintains fruit quality for 8 days
Pineapple	Aloe vera gel and canola vegetable oil	Extends and improves appearance, maintains pH, firmness and sensory attributes
Tomatoes	Beeswax	Lower weight loss, delay in ripening, better color and firmness
Tomatoes	Chitosan	Lower incidence of diseases, better retention of antioxidants
Apples	Starch	Lower water loss, greater firmness and sweetness for longer
Apples	Proteins	Lower oxidation, better color and texture during storage
Peppers	Whey protein	Lower transpiration rate, lower incidence of pathogens, maintaining quality for a longer period
Bananas	Chitosan	Longer shelf life, greater firmness, lower incidence of brown spots
Grapes	Alginate	Greater freshness and firmness, lower weight loss, lower appearance of mold
Cucumbers	Wax	Greater freshness, lower weight loss, lower appearance of wrinkles
Mango	Beeswax	Lower weight loss, better retention of firmness and color during storage

The effectiveness of edible coatings may vary depending on the type of fruit or vegetable and the material used for the coating. Each horticultural product has specific characteristics and needs; therefore, the selection of the appropriate coating is fundamental to achieve the best results in terms of quality conservation and shelf-life extension.

DISCUSSION

The results obtained clearly demonstrate that edible coatings can significantly improve the quality and shelf life of various fresh fruits and vegetables. Below, some key aspects based on the results are discussed:

Effectiveness of different materials

The effectiveness of edible coatings varies according to the type of material used and the characteristics of the horticultural product. Coatings based on chitosan and alginate have shown to be particularly effective in fruits with high water content, such as strawberries. This is due to the antimicrobial properties of these materials and their capacity to form films that reduce transpiration, which helps maintain quality and prolong the shelf life of this type of products (16).

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On the other hand, coatings based on wax and lipids have proven effective in reducing water loss, which is crucial for fruits and vegetables with a high transpiration rate, such as tomatoes and peppers (17). Likewise, coatings based on proteins and starch have demonstrated benefits for the conservation of antioxidant compounds and the retention of texture, especially in fruits such as apples (17). These results indicate that the selection of the appropriate material for the edible coating must consider the specific characteristics and needs of each type of fruit or vegetable, in order to maximize the effectiveness of the treatment and obtain the best results in terms of quality conservation and shelf-life extension.

Mechanisms of action

The capacity of coatings to modify gas permeability plays a crucial role in slowing down respiration and ripening, which extends the shelf life of fresh products (19).

The inclusion of antimicrobial agents in the coatings, as in the case of chitosan, provides additional defense against pathogens, which is essential to prevent postharvest diseases (20).

Impact on nutritional and sensory quality

Coatings help conserve essential nutrients and bioactive compounds, which not only prolongs shelf life but also maintains the nutritional value of the product (21).

The retention of sensory quality, such as color, firmness, and flavor, is crucial for consumer acceptance. Coatings have proven effective in this aspect, improving the appearance and texture of fresh products (22).

Challenges and opportunities

Although the results are promising, there are challenges in the standardization of formulations and application methods. The variability in the effectiveness of coatings according to the type of fruit or vegetable requires additional research (23).

Consumer acceptance is a critical factor. Coatings must be safe, not negatively affect flavor, and be perceived as natural and beneficial (24). Thus, future research should focus on the combination of different materials to optimize barrier and functional properties, as well as on the integration of efficient and scalable application technologies (25).

CONCLUSIONS

Edible coatings have proven to be an effective and promising solution to improve the quality and prolong the shelf life of fresh fruits and vegetables. These coatings act by creating a barrier that reduces water loss and slows down the respiration and ripening of the products, which contributes to greater durability during storage. Therefore, many

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coatings, such as those based on chitosan and alginate, have antimicrobial properties that help prevent the growth of pathogens and postharvest diseases, thereby improving food safety.

The capacity of these coatings to conserve the nutritional value and sensory quality of fruits and vegetables is another key aspect, since they retain antioxidant compounds and maintain the texture and flavor of the products. Despite these benefits, important challenges persist, such as the variability in the effectiveness of coatings depending on the type of product and the need to standardize formulations and application methods. In addition, consumer acceptance is crucial for the success of these coatings in the market.

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