Edible Packaging for Fruits and Vegetables

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Fresh fruits and vegetables are vital components of a nutritious diet, valued for their exceptional nutritional content. In India, approximately 25-30% of the total fruit and vegetable production is lost during postharvest stages, which include storage, handling, and transportation. This poses a significant challenge, affecting the income of growers and incurring a substantial economic cost for the nation. Hence, prolonging the postharvest shelf-life of fresh fruits and vegetables is crucial for the well-being of growers, processors, handlers, and for promoting nutritious dietary practices between consumers. Employing edible packaging as films and coatings for fruits and vegetables has proven to be an effective method for preserving their quality and prolonging their postharvest shelf-life. Although synthetic-wax coatings and synthetic plastic polymer-based packaging have been widely employed for preservation, it's crucial to emphasize that these synthetic materials are non-biodegradable and can pose risks to both consumers and the environment.

So, an eco-friendly approach to product development involves the use of bio-based materials. These materials are composed of elements derived from renewable sources like plants, animals, and microorganisms. When natural fibers are reinforced with biopolymers, they form what's identified as "green composites." These biodegradable biopolymer composites can be broken down by natural environmental elements such as microorganisms, heat, light, or air. Serving as sustainable alternatives, these biopolymers, whether used independently or in combination with nanomaterials and/or natural active agents, can be employed to develop edible films and coatings. Essential oils derived from plants, in addition to other natural compounds and nanomaterials, react as potent antioxidant and antimicrobial agents. These elements can be incorporated to augment the capabilities of these active films and coatings.

What is edible packaging

Edible packaging comprises a thin layer of food-grade material which restricts the transfer of lipids, gases, and water vapor between the food and its environment. It is rapidly evolving, incorporating edible compounds sourced from various renewable origins. These materials are designed to be integrated into food products and consumed along with them, making them naturally biodegradable and environment friendly. Tablet coatings, Hard-gel capsules, soft-gel capsules, or microcapsules create from edible materials can be classified as edible packaging. Their primary aim is to prolong the product shelf life. Developing and utilizing such packaging for fruits and vegetables holds immense promise. This is because of their versatility, allowing them to be created from a variety of materials, as well as their ability to carry active substances like antimicrobials and antioxidants. Additionally, they can include food additives like vitamins, natural extracts, fungicides, bacteriocins, enzymes, organic acids, etc. These additives work to minimize the growth of pathogenic microbe on the surface of the food while enhancing the sensory properties of the treated products. Edible packaging serves as a sustainable substitute to synthetic packaging and aids in maintaining the fresh produce quality by preserving their nutritional, biological, and sensory attributes. It effectively addresses issues like weight loss, lipid oxidation, enzymatic browning, and delayed respiration of fruits and vegetables

Type of edible packaging

Within the realm of active food packaging, edible packaging is considered sustainable and biodegradable. It stands out for its ability to enhance food quality, offering an advantage over synthetic packaging methods. The importance of edible packaging is found in how well it increases shelf life, preserves food quality, decreases waste, and increases the economic effectiveness of packaging materials.

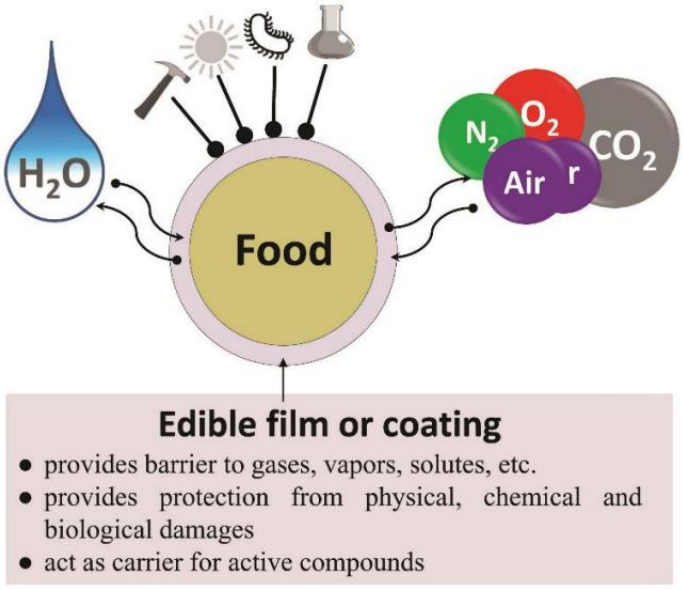

Fig 1. Important of edible packaging

There are two categories of edible packaging

1. **Edible film:** An edible film is a preformed, thin layer used as a wrapping for food products.
2. **Edible coating:** An edible coating is a fine layer of consumable substance, typically applied in liquid form onto the surface of food, often through methods like spraying or immersion or spreading in a solution of the edible material.

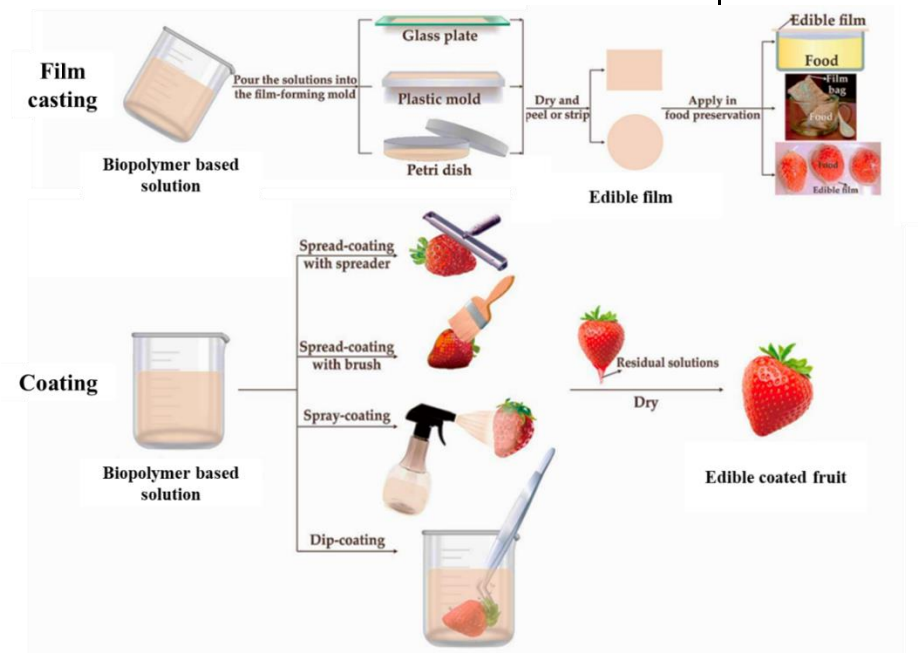

Fig 2. Manufacturing techniques for developing edible packaging. (Adapted from Zhao et al., 2021).

Edible films, typically around 254 µm thick, are independent structures frequently used in producing casings, capsules, bags, pouches, and wraps. In contrast, coatings are directly administered to the surface of the food. Unlike films, coatings are regarded as a crucial component of the food product, naturally meant to stay with the food item rather than being removed.

The selection of components for edible packaging largely depends on the particular food product being packaged. It's also crucial to consider the material composition from which the edible packaging is derived, as well as the processing method. Additionally, the packaging should be sensorily compatible with the food it contains. This ensures that it not only provides effective protection but also maintains the superiority and sensory attributes of the packed food.

Edible packaging materials

The materials used in edible packaging are sourced from consumable ingredients, specifically natural polymers that are safe for human consumption with no associated health risks. These ingredients can be changed into numerous forms of films and coatings, with variations primarily attributed to changes in their thickness. Edible packaging materials, designed for efficient biodegradability, predominantly consist of biopolymers. Ongoing efforts are directed towards enhancing and innovating their composition for improved performance and sustainability.

Biopolymers employed in edible materials can be categorized as follows:

Polysaccharide

The polysaccharides are a long-chain biopolymer constructed from recurring units of carbohydrates (monosaccharaides), linked together by glycosidic bonds.

Polysaccharides such as starches, chitosan, and gums are suitable for developing edible packaging because of their hydrocolloid properties and their capacity to gelatinize. Polysaccharide films exhibit

outstanding oxygen barrier properties, but a significant drawback is their limited resistance to moisture.

Protein

- Proteins based edible packaging can be sourced either from plant-based protein like zein, wheat gluten, soybean, and pea or animal-based proteins including whey protein, casein, collagen, and egg white.
- Protein-based edible films typically offer strong resistance to gases and possess favorable mechanical properties.
- In comparison to polysaccharide-based coatings, these films are more flexible. Still, owing to their hydrophilic properties, they tend to exhibit lower resistance to moisture.

Lipids

- Lipid-based components encompass materials like beeswax, carnauba wax, and various fatty acids.
- Lipid-based films are inherently extremely hydrophobic, which grants them exceptional resistance to moisture compared to films based on polysaccharides or proteins.
- Edible films and coatings derived from lipids typically do not contain a polymeric matrix.

Such edible materials are applied in a range of food applications, either independently or in combination with other components. They form a subset of biodegradable and bio-based materials, and have undergone extensive research as a substitute to conventional food packaging, particularly with regard to their film-forming characteristics.

Edible packaging for shelf-life extension

Edible films and coatings are pivotal in elevating the quality of fruits and vegetables. They function as a semipermeable protective barrier, safeguarding the produce from physical, chemical, and biological degradation. This includes reducing phenol oxidation, respiration, and transpiration rates, as well as modifying the gaseous environment, particularly levels of oxygen and carbon dioxide. Additionally, they contribute to retarding the ripening process of fruits and vegetables. The use of edible films and coatings can significantly enhance the visual and tactile aspects of product surfaces as well. They serve as a barrier, shielding fruits and vegetables from nutrient oxidation and light-induced chemical alterations, surface microbial growth, moisture migration. Furthermore, these films and coatings are capable of containing antioxidants, antimicrobials, coloring agents, and flavors. With this capability, the shelf life of the produce can be extended and safety measures can be enhanced.

Advantages of edible packaging

Edibility and biodegradability: Edible film and coating can be consumed directly with the fruits and vegetables, leaving no waste for decomposition, even if discarded, they have no adverse effects on the environment due to their natural ability to biodegrade. This makes them an environmentally sustainable and eco-friendly substitute for conventional packaging materials.

Organoleptic properties: Edible films and coatings improve the sensory properties of the fruits and vegetables, offering a range of flavors and colors while also adjusting surface attributes like water-repellency and water-absorption.

Improved quality: Edible films and coatings have the capacity to serve as a substitute for and potential reinforcement of the outer layers in treated products. They prevent the loss of ingredients, aromas, and moisture within the foods. Simultaneously, they enable controlled exchange of crucial gases such as ethylene, carbon dioxide, and oxygen which play a role in the respiration process and contributes to the enhancement of the fruits and vegetables quality.

Individual packaging: Edible films and coatings offer a practical solution for individually packaging small-sized foods like peas, beans, and similar items, a task that synthetic packaging may not be well-suited for.

Shelf-life: Edible films and coatings possess many functional properties, including antimicrobial, antioxidant, barrier, and mechanical attributes. These properties enable them to effectively delay the ripening process and increase the postharvest shelf life of the fruits and vegetables.

Conclusion

The global production of fruits and vegetables, coupled with the postharvest waste and plastic waste, poses a significant environmental challenge. With the rising demand for fresh and minimally processed fruits, edible packaging emerges as a promising resolution. It offers a multitude of benefits in maintaining fruit quality and extending shelf life, ultimately reducing food waste. The growing consumer preference for healthier and fresher food choices has propelled the usage of edible materials sourced from natural origins, including initiatives for valorizing waste, thereby representing a potential for a circular economy. Moreover, the adoption of edible packaging contributes toward the advancement of a circular bioeconomy, fostering sustainability within the food sector. This holistic approach holds promise in addressing both environmental and consumer demands.

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