



Edible Coatings for Postharvest Loss Reduction in Vegetables: Nature's Shield for Freshness

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Postharvest losses of vegetables are a significant challenge globally, particularly in developing countries. Due to their high moisture content, soft texture, and biological activity, vegetables are highly perishable. According to the Food and Agriculture Organization (FAO), approximately 30–40% of fruits and vegetables are lost before reaching consumers. This not only affects food security but also economic returns to farmers and retailers. In recent years, the demand for eco-friendly and chemical-free preservation methods has grown among consumers. One promising innovation addressing this concern is the use of edible coatings. These coatings are designed to protect vegetables from spoilage while maintaining freshness, appearance, and nutritional quality.

What Are Edible Coatings?

Edible coatings are thin, edible films applied directly to the surface of vegetables to act as a barrier against moisture, oxygen, and microbial invasion. They are made from natural substances such as polysaccharides (e.g., starch, cellulose), proteins (e.g., whey, soy), and lipids (e.g., waxes, fatty acids). These coatings help in maintaining the structural and nutritional integrity of vegetables by slowing down physiological processes like respiration and moisture loss (Falguera *et al.*, 2011).

Mechanism of Action

Edible coatings work by forming a semi-permeable layer over the vegetable surface. This layer modifies the internal atmosphere by:

- Reducing respiration rate
- Slowing moisture evaporation
- Limiting microbial access
- Maintaining firmness and color

Moreover, bioactive compounds like essential oils and plant extracts can be incorporated to add antimicrobial and antioxidant properties, making them multifunctional (Espitia *et al.*, 2014).

Types of Edible Coating Materials

1. Polysaccharide-Based Coatings

Materials: Starch, cellulose, chitosan, alginate

Properties: Good gas barrier, biodegradable, but poor water vapor resistance

Chitosan is widely used due to its excellent antimicrobial properties and compatibility with other natural substances (Ali *et al.*, 2010).

2. Protein-Based Coatings

Materials: Zein, soy protein, casein, whey protein

Properties: Good film-forming ability, mechanical strength, and gas barriers; susceptible to moisture

3. Lipid-Based Coatings

Materials: Waxes, fatty acids, oils

Properties: Excellent moisture barriers; used for high-water content vegetables like cucumbers and peppers (Ramos *et al.*, 2016).

Functional Additives in Coatings

To enhance functionality, bioactive compounds such as:

- Essential oils (e.g., oregano, clove, thyme)
- Plant extracts (e.g., neem, turmeric)
- Natural antioxidants (e.g., ascorbic acid, tocopherols)

These additives contribute antimicrobial, antifungal, and antioxidative effects, extending the shelf life significantly (Thakur *et al.*, 2019).

Application Techniques

Common application methods include:

- Dipping: Submerging vegetables in coating solution
- Spraying: Uniform film application through mist or jet sprays
- Brushing: Manual application for delicate vegetables

These methods are simple, cost-effective, and scalable for industrial use.

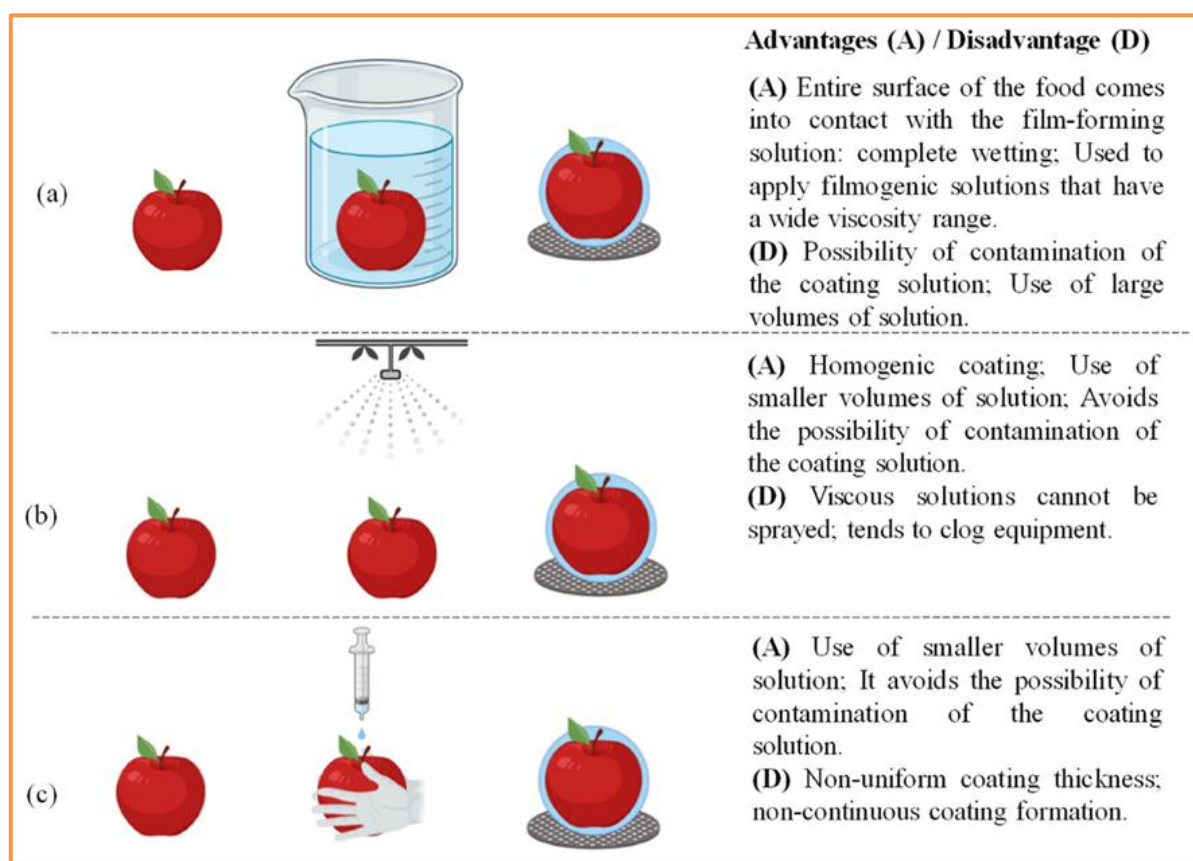


Fig 1: Dipping (a), spraying (b), and (c) hand coating techniques to apply edible coatings, (Josemar *et al.*, 2021)

Table 1: Vegetable Crops and Suitable Edible Coatings

Vegetable Crop	Coating Material	Function/Benefit	Shelf-Life Extension
Tomato	Chitosan + Aloe vera	Reduces microbial spoilage, delays ripening	5–10 days
Cucumber	Carnauba wax / Beeswax	Prevents water loss, maintains firmness	10–15 days
Brinjal (Eggplant)	Chitosan + Neem extract	Inhibits fungal growth, retains antioxidants	7–10 days

Carrot	Guar gum + Cinnamon oil	Reduces fungal decay, preserves crunch	15–20 days
Leafy Greens	Soy protein + Alginate	Reduces wilting, retains chlorophyll	5–7 days
Chili/Bell Pepper	Lipid-based + Zein	Preserves vitamin C, reduces water loss	10–14 days
Mushroom	Chitosan + Ascorbic acid	Prevents browning and bacterial contamination	7–10 days

Table 2: Benefits of Edible Coatings

Feature	Advantage
Moisture control	Prevents wilting and weight loss
Microbial barrier	Reduces spoilage and decay
Gas exchange regulation	Slows respiration, extends shelf life
Nutrient preservation	Maintains vitamins and antioxidants
Biodegradability	Environmentally friendly and safe for consumption
Consumer preference	Aligns with clean-label, chemical-free demand

Real-World Applications and Innovations

Companies like Apeel Sciences have commercialized edible coatings derived from plant-based lipids to extend the shelf life of vegetables and fruits (Apeel Sciences, 2023). In India, ICAR institutes are experimenting with chitosan and herbal extract coatings for regional vegetables under low-cost storage conditions (ICAR-CIPHET, 2023).

Future trends include:

- Smart coatings that indicate spoilage
- QR-coded edible films for traceability
- Nanotechnology-infused coatings for enhanced protection

Limitations and Challenges

While edible coatings are promising, they come with limitations:

- Higher cost of some natural polymers and essential oils
- Need for regulatory clearance and consumer awareness
- Limited scalability in rural or small-scale settings

Nonetheless, ongoing research and industry interest are addressing these barriers.

Conclusion

Edible coatings represent a sustainable, natural, and consumer-friendly approach to reducing postharvest losses in vegetables. They offer a multifaceted solution by protecting produce, reducing dependency on plastic packaging, and aligning with global sustainability goals. As research advances and technologies scale up, edible coatings are set to play a crucial role in the future of food preservation.

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