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Review Article

Edible Coating of Fruits and Vegetables

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Abstract

Approximately 30% of fruits and vegetables are harmed or altered by insects, microorganisms and post-harvesting conditions, during transport and preservation. Green technology-based post-harvest methods for fruits and vegetables demonstrate notable health advantages. The widely used post-harvest technique of edible coating extends the shelf life of perishable fruits and vegetables. Due to their film-forming features, antibacterial properties, biodegradability and biochemical properties, edible coatings have been recognized as one of the most reliable and secure strategies for preserving fruits and vegetables. These effectively block O2, CO2, moisture and water vapour. It responds favourably to the physiological (respiration rate, ethylene evolution rate), biochemical (cell wall degrading enzymes), and physical (moisture retention, glossiness, appearance, firmness) characteristics. As a result, this post-harvest method is the safest, non-toxic, and most environmentally friendly method for extending the shelf life of fruit and vegetable harvests.

Keywords: Edible coatings, fruits and vegetables, post-harvest technique, shelf life, antibacterial

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Introduction

Fruits and vegetables experience the most post-harvest loss because of their perishable nature. Chopped fruits and vegetables are getting more and more popular as people choose fresh and organic items, and as lifestyle changes are proven to work. Maintaining the manufacture of cutting-edge food items for an extended period of time is still a challenge for the food business. A healthy diet should include fruits and vegetables as staples [1].

Delaying biochemical changes such as ethylene production, softening, pigmentation change, respiration rate, acidity, and weight loss is a crucial step in minimizing post-harvest losses [2]. Consumer preferences have changed, however, as more people are becoming aware of the issues related to plastics, such as the usage of non-renewable resources, safety concerns, and significant accumulation and contamination in the environment. The adoption of edible films and coatings is one strategy that might be used to meet the current demand [3].

The quality of fruits and vegetables is maintained by edible coatings, making them useful in postharvest management techniques. Using an edible coating of lipids, polysaccharides and proteins can stop physical changes during preservation. A barrier between respiration and transpiration is what an edible coating's principal purpose is to provide. It serves as a variety of functional compounds, such as antioxidant and antibacterial agents, boosting the quality and shelf life of fresh and minimally processed fruits and vegetables. Edible coatings provide a layer to the outside of fruits and vegetables, covering the stomata in the process. This lowers the rate of transpiration, which in turn slows down weight loss [4]. It has been demonstrated in a variety of fruits and vegetables, including radish, potato, tomato, turnip, guava, plum, mango, apricot, banana, orange, and others.

Natural biomolecules called edible coatings are employed to improve the beauty and preservation of fruits and vegetables. The safety and nutritional value of the fruits and vegetables are improved by adding additional active substances to edible films and coatings. To modify the structure and advance the characteristics of coatings, food-grade extracts such as flavouring agents, pigments, antioxidants, and antimicrobials can be added. This improves the quality of produce when applied to it [5].

Due to their edibility, non-toxic makeup and cost-effectiveness in comparison to alternative synthetic coatings, edible coatings are in great demand from consumers today. The creation of edible biodegradable coatings and films as alternatives to synthetic polymers, which cause less environmental harm than plastic waste, has increased. A lot of research is currently being done on edible coating and the materials used in the edible coating in food processing technology to decrease waste and limit loss and is healthy, functional for storage and market distribution and ecologically friendly [2].

Edible Coating

This is not a novel preservation technique; edible coatings and edible films have been utilised for millennia in the food industry. An illustration would be the waxing on fruits and vegetables and the cellulose coating on meat casings. Since the 12th century, Chinese cuisine has included edible coverings. The waxing of fruits was created and used for the first time on fruits and vegetables in a commercial setting in 1922 [6].

The term "edible coating" refers to a thin covering of material that can be digested and protects food from oxygen, external microorganisms, moisture, and solute movement [7]. A semi-permeable barrier is supplied in edible coatings with the goal of extending shelf life by lowering gas exchange, respiration, oxidative reaction rates, moisture and solute migration [8] and other physiological diseases [9].

Properties of Edible Coating

The molecular makeup, molecular size and chemical composition of edible coatings all influence their properties. These characteristics are as follows:

- Edible coatings offer good water, moisture, O_2, CO_2 and ethylene barrier qualities.
- It enhances the appearance and mechanical handling to preserve the shape and colour of fruits and vegetables.
- Edible coating contains active ingredients including antioxidants, vitamins and others; they improve the nutritional composition of fruits and vegetables without degrading their quality.
- These coatings extend the shelf life of fruits and vegetables by giving them a protective layer [10].

Classification of Edible Coatings

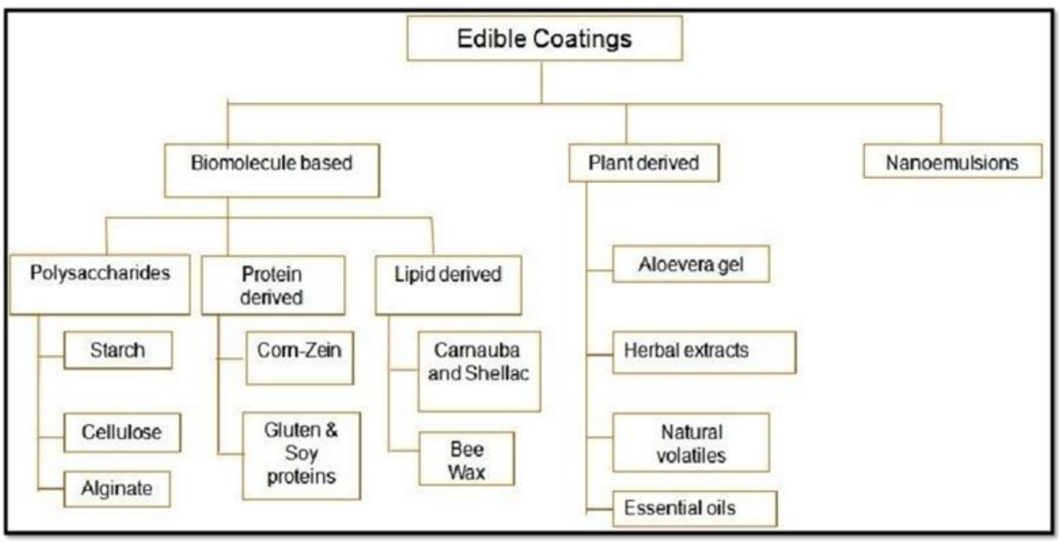

Figure 1 Different sources of edible coatings [11]

Polysaccharide-based edible coatings

The most popular polysaccharide-based edible coatings for fruits and vegetables include starch, cellulose, gums and alginate, which are produced from plant species [12]. These coatings limit water loss, inhibit ripening and senescence and function as a partial barrier for gas exchange.

Starch-based edible coating

Starch is a readily available and reasonably priced complex polysaccharide i.e., present in a variety of foods, including grains, legumes, tubers, fruits and vegetables. The semi-permeable, biodegradable coverings made of starch function as a barrier for the exchange of carbon dioxide and oxygen [13].

Cellulose-based edible coating

These are the polysaccharides that are most readily available as natural polymers and are often hydrophilic, however, they have very poor mechanical characteristics as edible coatings. The commercially available cellulose-based edible coatings are carboxymethylcellulose (CMC), hydroxypropyl methylcellulose (HPMC), methylcellulose and hydroxypropyl cellulose (HPC) [14, 15].

Alginate

Brown seaweed, which belongs to the *Phaeophyceae* family, is used to make alginate. Alginic acid salts are found in alginate. It is available as a white, yellow and fibrous powder. The most popular type of alginate is sodium alginate. Alginate is an excellent barrier to moisture and water vapour [10].

Protein-based edible coatings

Edible coverings made of protein can be obtained from both plants and animals. Animal-based proteins include egg albumen, collagen and others. Whey protein, milk protein casein, gluten (from wheat), zein (from maize), soy protein and other plant-based proteins are used as edible coating materials [16].

Corn-Zein-based edible coating

Maize, which is comprised of corn gluten flour, is the source of zein proteins. Corn-Zein protein has high O_2 barrier properties and is useful for extending the shelf life of fruits and vegetables by preventing colour change, hardness and weight loss [10].

Soy protein-based edible coating

These products contain isolated chitosan, which contributes to the preservation of the products' firmness and minimises weight loss. Ionic strength and pH play a role in the stability of soy protein. Due to its low permeability to CO_2 and O_2, soy protein is appropriate for edible coating [17, 18].

Lipid-based edible coatings

For fresh fruit, neutral lipids, waxes, and resin have traditionally been used as coatings because they are good moisture barriers and also enhance surface attractiveness. Beeswax, carnauba wax, paraffin wax, and mineral or vegetable oil are the most often utilised ingredients [5].

Carnauba wax

Natural waxes include carnauba wax. It originates from *Copernicia prunifera* palm leaves [19, 20]. Carnauba wax extends the shelf life of fruits and vegetables by reducing internal O_2 concentration, friction discolouration and oxidation [21].

Bee wax

After being purified, it is a natural wax made by honeybees of the species *Apis*. This coating is frequently used with coatings made of chitosan or cellulose [17].

Essential oil-based edible coatings

The shelf life of fruits can be extended by coating them with substances like ginger essential oil (EO), lemongrass, turmeric, neem extract, clove bud oil, mint oil, cinnamon oil and other EOs derived from spices and plants. EOs possess antimicrobial, antibacterial and antioxidant properties [17].

Applying Methods of Edible Coatings

The methods for applying edible coatings are as under:

Dipping Method

In order to completely coat their surfaces, fresh fruits are immersed in coating solutions. Any residual coating is scraped from the food surface once the coating solution has been drained from it. After the fruit is dried, a solid link develops between the exterior and the fruit.

Layer-by-Layer Method

By layering polyelectrolytes with opposing charges, layer-by-layer techniques regulate coating properties and functioning with greater precision. This procedure creates multilayer films that could improve the efficacy of edible coatings.

Vacuum Impregnation Method

Fresh items are dipped into an airtight vacuum chamber rather than a conventional dip tank. The foodstuff is returned to its normal atmospheric pressure after being submerged in an atmospheric pressure solution.

Spraying Method

Coating solutions with low viscosity and the ability to be sprayed under high pressure are advised to use the spraying method. Polymeric coatings applied manually are impacted by drying times and temperatures in the same way as spraying systems have an effect [22].

Foaming and Dripping Method

In the dripping method, brushes are used to apply the coating directly to the fruit surface. A foaming agent needs to be added before foamed coatings may be applied. The foam is dissolved using a variety of tumbling motions to ensure uniform dispersion [23, 24].

Herbal Coating: A Novel Idea

A recent coating technique in the food business uses herbs: herbal coatings. These are typically made with a mixture of food and herbs; the most popular herbal ingredients are Aloe vera gel, Neem, Lemon grass, Rosemary, Tulsi, and Turmeric. Herbs are antibacterial, vitamin-rich, and contain vital minerals and antioxidants [25]. Aloe vera gel is increasingly being used in fruit and vegetable supplements due to its antimicrobial qualities and ability to stop moisture loss. Herbal edible coverings for fruits and vegetables include essential oils and extracts in addition to ginger, clove buds, turmeric, neem, and mint [26, 27].

Advantages

The advantages of edible coatings are listed as under:

- Acids, colour, flavour and sugar are better retained due to edible coatings preserving the quality of fruits and vegetables as they are stored [28].
- Reduce the loss of firmness and weight [29].
- Reduce waste and packaging made of polymers.
- The healthy elements found in edible coatings can be taken with fruits and vegetables [30].

Disadvantages

The disadvantages of edible coatings are listed as under:

- Thick coating can prevent oxygen exchange and lead to the formation of bad flavours.
- Good gas barrier qualities in edible coatings lead to anaerobic respiration, which disturbs the natural ripening process in fruits and vegetables.
- Certain edible coatings have hygroscopic properties, which promote microbial growth [10, 31].

Conclusion

Edible coatings perform a variety of purposes for a wide range of fruits and vegetables. They enhance the outward and internal qualities of certain items. Coatings can help to prevent dryness and oxidation, as well as the resulting unattractive colour, flavour and texture changes. Waxes and other coatings can boost the microbiological stability of minimally processed fruits, vegetables and other processed items by delaying ripening and senescence. Coatings have shown potential as eco-friendly quarantine treatments. Most coating materials are made from renewable, edible resources and some are even made from waste products that pose disposal issues for other industries. Edible coatings increase shelf life, limit water and moisture loss, delay the ripening process and prevent microbiological growth, particularly in fruits and vegetables. As a result, it will be feasible to create less expensive and less dangerous edible films and coatings, allowing customers to access more high-quality, healthful meals with a longer shelf life. Thus, edible coatings have drawn the attention of experts and this will undoubtedly pave the way for further study.

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