

Review on Effect of Edible Coatings on Quality and Shelf Life of Fruits and Vegetables

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Abstract
The consumption of fruits and vegetables has increased in because of their attractive sensorial properties, nutritional and health benefits. However, they are susceptible to deterioration because of postharvest physiology and metabolic activities during processing, packaging and storage. Thus, postharvest treatments are crucially important in order to preserve the quality and extend the shelf life of fresh produce. Postharvest technology strategies like application of edible coatings (alginate, chitosan, cellulose derivate, beeswax, and protein-based coating) and active packaging are required to maintain quality and shelf life of fruit and vegetable. Edible coatings affect physicochemical characteristics and deterioration of bioactive compounds of fruits and vegetables during ripening and storage. Furthermore, application of various postharvest coatings to perishable fruit is used to increase shelf life, delay ripening, reduce weight loss, slows rate of deterioration, improving postharvest quality and reduce losses in firmness and appearance, and prevent microbial growth specifically in fresh fruits and vegetables.
Keywords: fruit and vegetable, edible coating, shelf life, postharvest handling, physicochemical property
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1. INTRODUCTION

Post-harvest loss of fruits and vegetables are high due to its perishable nature. The most important techniques used to minimize the post-harvest losses are delay in biochemical changes such as ethylene formation, softening, degradation of pigment, respiration rate, acidity and decrease in weight. Physical changes during storage can be reduced by using edible coating of lipids, polysaccharides and proteins. Edible coatings are natural compounds that are biodegradable and edible so that they can address both environmental concerns and consumer safety concern (Karunanayake et al; 2020). Depending on the nature of the components, edible coatings can be classified into the following groups (Villa-Rodriguez et al; 2015): (i) polysaccharides (such as alginate, chitosan, carrageenan, malto dextrin, methylcellulose, carboxy methylcellulose (CMC), pectin, starch); (ii) proteins (collagen, gelatine, whey proteins); and (iii) lipids (beeswax, glycerol esters). Edible coating is used to extend the postharvest life of fresh fruits and vegetables. It also used to improve food appearance, provide safety to the food, preservation of volatile flavours and act as a barrier to water loss and oxygen access (Mladenoska, I., 2012).

Minimal processing technique used for preservation of nutritional, biological values and sensory characteristics include modified atmosphere, antimicrobial packaging and the application of edible films and coatings (Pavlath et al; 2009).)The basic composition of edible coatings for fresh-cut fruits may include hydrocolloids and lipids. The main function of edible coating is to provide barrier between respiration and transpiration. The hydrocolloids (proteins and carbohydrates) tend to form hydrophilic networks, usually being a good barrier to oxygen and carbon dioxide, but a poor barrier to water. The characteristics required from an edible coating depend on the specific requirements of the product to be coated, including the primary degradation modes to which it is most susceptible. Fresh and minimally processed fruits have complex requirements concerning packaging systems, since such products are still metabolically active.

The main requirements for a fruit coating are moderately low permeability to oxygen and carbon dioxide in order to slow down respiration and overall metabolic activity, retarding ripening and its related changes (Adetunji et al., 2014). Edible coatings have been used to decrease metabolic activity, retard-softening changes which result from the loss of turgor pressure and degradation of cell walls, contributing to a decrease in fruit brittleness and firmness (Zhou et al., 2011). The degradation of cell wall structure has been attributed to activity of enzymes such as pectin methylesterase, cellulase, and polygalacturonase on polysaccharides present in the cell wall (Goulao and Oliveira, 2008). Low water vapor permeability in order to retard desiccation (de Azeredo, H.M.C., 2012). In the processed fruits, the product surface contains a very high water activity, which tends to decrease the performance of hydrophilic coatings (de Azeredo, H.M.C., 2012). Edible coatings were traditionally supposed to be tasteless so would not interfere with the flavor of the product and they may have sensory properties compatible with those of the food. For instance, fruit purees have been studied as film forming edible materials, which can be used as edible coatings for fruits due to the presence of film forming polysaccharides in their compositions.

Edible coatings are used to inhibit loss of firmness, reduce moisture loss, delay oxidative browning, reduce microorganism proliferation and control respiratory rate (Tiwari et al., 2022). Edible coatings have also a potential to carry active ingredients such as anti-browning agents, colorants, flavours, nutrients, spices and antimicrobial compounds that increase the shelf life and reduce the risk of pathogen growth on food surfaces (Kore et al., 2017). The relative humidity and temperature of storage area has bee controlled during storage since respiration increase with temperature. Edible coatings have long been used to retain quality and extend shelf life of some fresh fruits and vegetables, such as citric fruits, apples and cucumbers (Lin and Zhao, 2007). Fruits or vegetables are usually coated by dipping in or spraying with a range of edible materials, so that a semipermeable membrane is formed on the surface which suppressing respiration, controlling moisture loss and providing other functions. Edible coatings can be utilized for most foods to meet challenges associated with stable quality, market safety, nutritional value and economic production cost. It limits the exchange of volatile compounds into its surrounding environment through providing gas barriers, which prevents the loss of natural volatile flavour compounds and colour components from fresh commodities. Edible coating act as carriers of other functional ingredients, such as nutraceuticals, flavour, antimicrobial and antioxidant agents' ingredients for reducing microbial loads, delaying oxidation, discoloration and improving quality (Tiwari et al., 2022). Therefore, the purpose of this review is to summarize different types of edible coatings and discuss about their effect on quality and shelf of fresh fruits and vegetables.

2. EDIBLE COATING FOR FRUITS AND VEGETABLES

2.1. Lipid based coatings

Lipid compounds include neutral lipids of glyceride which are esters of glycerol and fatty acid and waxes which are esters of long chain monohydric alcohols and fatty acids. Resins are a group of acidic substances that are secreted by special plant cell into long resin duets or canals in response to injury or infection in many trees and shrubs (Salgado et al., 2015). Edible lipids are neutral lipids, waxes and resin used as coating material for fresh produce, provide effective moisture barrier property and improve surface appearance (Morillon et al., 2002).Waxes (carnauba wax, beeswax, paraffin wax and other) are commercially used as protective coating for fresh fruits and vegetables. It reduces moisture loss and surface abrasion during fruit handling (Ritter et al., 2001). Generally wax coatings are resistant to moisture loss as compared to lipid and non -lipid coating and it is an effective on citrus, apple, mature green tomato, cucumber and other vegetables such as asparagus, beans, carrots, eggplant, okra, sweet potatoes and turnip where shiny surface is desired (Bai and Plotto, 2012). Shellac and other resin based coatings have lower permeability to oxygen, carbon dioxide and ethylene gas. Shellac coating dries fast and provides shiny surface on the coated produce (Baldwin et al., 2011).

The beneficial properties of lipid based coatings include good compatibility with other coating agents and have high water vapour and gas barrier properties as compared to polysaccharide and protein based coating (Talens and Krochta, 2005). Lipid based coating gives greasy surface and undesirable organoleptic properties such as waxy taste and lipid rancidity (Robertson, 2009). Wax coatings are naturally found on fruit and vegetable surfaces, where they help prevent moisture loss, especially in the dry humid season (Abdul Khalil et al., 2018). The bio-wax (bemul-wax), developed from liquefied cassava starch and bees wax was reported to be comparable to the Indian's commercial wax "waxol" for shelf-life extension of mandarin oranges (Kore et al., 2017). It has ability to preserve both the nutritional and sensory qualities of four months at low temperature stored sweet oranges.

2.2. Polysaccharide based coating

2.2.1. Starch and its derivative

Starch is a natural polysaccharide used for food hydrocolloid because of its high functionality and relatively low cost. It composed of amylose and amylopectin, is primarily derived from cereal grains like corn (maize), with the largest source of starch (Dhanapal et al., 2012). Different sources of starch like corn, potato, cassava and cereals can be used (Dhanapal et al., 2012). Generally, the varieties contain high amylase starches can be utilized for edible film formation. Starch film is generally transparent, odourless, tasteless and colorless and has low permeability to oxygen (Whistler et al., 2012). Dextrin is derived from starch and has smaller molecular size and used in coating formation, better resistance to water vapour as compared to starch coating (Stone et al., 2003). Pullulan is an edible biodegradable extracellular polysaccharide and it is colourless, odourless, and tasteless and show high oxygen barrier properties. Pullulan coating can be applied for preserving strawberries and kiwi fruits (Zhu et al., 2014). Starch coating is effective for fruits and vegetables because they have high respiration rate.

2.2.2. Cellulose and its derivative

Cellulose is a structural building of plant cell walls which shows an excellent film forming property but they are too expensive for large scale application (Dhall, R.K., 2013). Cellulose derivatives are polysaccharides composed of linear chains of β (1-4) glucosidic units with methyl, hydroxyl propyl or carboxyl substituents (Dhanapal et al., 2012). Only four cellulose derivative forms are used for edible coatings or films include Hydroxy propyl cellulose (E463; HPC), hydroxyl propyl methyl cellulose (E464; HPMC), Carboxy methyl cellulose (E466; CMC) or Methyl cellulose (E461; MC). However, cellulose derivative films are poor water vapour barriers because of the inherent hydrophilic nature of polysaccharides and they possess poor mechanical properties. These are water soluble, nonionic and compatible with surfactants. Edible coatings produced from CMC, MC, HPC and HPMC are applied on some fruit and vegetables for providing barrier to oxygen, oil or moisture transfer and providing better adhesion (Sharma et al., 2019). CMC is the most important cellulose derivative for food application. When used in dry coating process it improves the firmness and crispness of apple, peaches and carrots. It also, prevents the flavour loss of some fruit and vegetable and reduce oxygen uptake without any increase in carbon dioxide level in internal environment of coated apples.

2.2.3. Seaweed extracts

2.2.3.1. Alginate

Alginate is a major structure of polysaccharide isolated from marine brown seaweed (Phaeophyceae) is finding increasing use in the food industry as texturizing and gelling agents (Lee and Rogers, 2012). Alginate has unique colloidal properties and can form strong gels or insoluble polymers through crossed linking with Ca^{2+} by post-treatment of $CaCl_2$ solution. Such biopolymer-based films can keep good quality and prolong shelf life of foods by increasing water barrier, preventing microbe contamination, maintaining the flavour and texture of the fresh-cut fruits. Alginate consists of good film forming property, transparent and soluble in water. Alginates have low permeability to oil and fats but have high permeability to water vapour (Valero et al., 2013). It also act as a sacrificing agent and good adhesion property. Calcium alginate coatings enhance the quality of fruits and vegetables by retarding shrinkage, oxidative rancidity, moisture migration and oil absorption. It reduces weight loss and improves appearance and colour.

2.2.3.2. Carrageenan

Carrageenan is extracted from several red seaweeds mainly Chrondrus crispus and complex mixture of polysaccharide. It is water- soluble polymers with a linear chain of partially sulphated galactans, which present high potentiality as film-forming material extracted from the red-sea weed (Dhanapal et al., 2012). It protects against moisture loss by acting as a sacrificial moisture layer. It consist of a family of sulfonated polysaccharides of D-glucose and 3, 6-anhydro-D-galactose. Recently, carrageenan films were also found to be less opaque than those made of starch. Carrageenan based coating reduces moisture loss and oxidation of apple slices (Lee et al., 2003). It also inhibits microbial growth.

2.2.4. Chitosan

The application of edible coatings based on chitosan or caseinates is interesting because of its high nutritional quality, excellent sensory properties, and adequate protection of food products from their environment (Pereda et al., 2011). Chitosan is a modified, natural nontoxic biopolymer derived by deacetylation of chitin (poly- β-(1→4)-N-acetyl-D-glucose-amine). It is a shell component of crab and shrimp, skeletal substances of invertebrates and cell wall constituent of fungi and insects (Raghav et al., 2016). Chitosan is one of the best coating material for fresh produce because of its excellent film forming properties, antimicrobial activity and its compatibility with other substances such as minerals, vitamins and antimicrobial agents (Gutiérrez, 2017). Chitosan coating is used to delay ripening and decrease respiration rate of fruits and vegetables. It retards weight loss, colour wilting and fungal infection in cucumber and tomatoes (Thumula, 2006).

2.2.5. Aloe vera

Aloe vera is a tropical and subtropical plant that has been used for centuries for its medicinal and therapeutic properties (Eshun and He, 2004). Aloe vera contains malic acid-acetylated carbohydrates (including β-1, 4 glucomannans) that demonstrated anti- inflammatory activity (Esua and Rauwald, 2006).It used as edible coating for fruit and vegetables. It prevents moisture loss and retains firmness, decreases respiration rate, delays oxidative browning and reduces the growth of microorganisms in table grapes (Valverde et al., 2005). Recently, there has been increasing interest for the use of Aloe Vera gel as an edible coating material for fruits and vegetables driven by its antifungal activity (Arunkumar and Muthuselvam, 2009). Valverde et al., (2005) reported that this edible coating was able to reduce the initial microbial counts for both mesophillic aerobic and yeast and molds in cv. Crimson Seedless table grapes.

2.3. Protein based edible coating

Sources of proteins used in edible coatings of plant derived include corn zein, wheat gluten, soy protein, milk proteins and animal derived proteins like collagen, keratin and gelatin (Lacroix and Vu, 2014).They show excellent oxygen, carbon dioxide and lipid barrier properties particularly at low relative humidity. Protein-based films have impressive gas barrier and mechanical properties compared with those from lipids and polysaccharides (Bourtoom, 2009.). However, most protein films are hydrophobic and, therefore, do not present good barriers to moisture and these coatings are brittle and susceptible to cracking and poor water barrier properties (Kokoszka et al., 210).

2.3.1. Plant origin

Zein and soy protein are the two main plant origin proteins used as edible coating for fruits and vegetables. Zein is the storage protein of corn and comprises of 45 to 50% of the protein in corn. Corn-zein and sucrose fatty acid ester coatings have been applied successfully on fresh fruits and vegetables, such as apples, bananas and tomatoes, as oxygen and water vapor barriers for extending their shelf lives (Ryu et al., 2002). Zein based coating has lower permeability to water vapour as compared to other protein based coatings (Lawton, 2004; Ghanbarzadeh et al., 2006). It also has lower permeability to oxygen and carbon dioxide as compared to polysaccharide and lipid composite coatings. Soy protein concentrate (SPC) or Soy protein Isolate (SPI) is produced from defatted protein contain 65 to 72% and 90% protein respectively (Cho et al., 2007). Soy protein based edible coating shows low resistance to moisture because of its hydrophilic characteristics. However, it exhibits good barrier properties to oxygen at low relative humidity.

2.3.2. Animal origin

Whey protein and Casein are the main milk proteins used as edible coating for fruit and vegetables. Casein comprises 80% of the total milk protein (Shendurse et al., 2018). Casein films are transparent, flavourless, and flexible and are attractive for food applications. Whey proteins comprise 20% of the total milk protein and purified to produce whey protein concentrate. It can has 25 to 80% protein content or whey protein isolate has 90% protein content. Whey protein films show good oxygen barrier properties in low and intermediate relative humidity. Milk proteins especially sodium caseinate (NaCas) are effective as edible coatings since they provide a high nutritional added value, good taste, show excellent functional properties (Fuchs et al., 2008). Whey protein coating helped to improve the shelf life of, for example, peanuts, by retarding the lipid oxidation causing rancidity (Khwaldia et al., 2004). In addition, those edible films were reported not to modify the sensory attributes of the coated good or its aspect, while providing some health benefits for the consumer.

2.4. Effect of edible coating on quality and shelf life of fruits and vegetables

2.4.1. Effect of edible coating on weight loss

Edible coatings add layer on outer surface of fruits and vegetables that coats the stomata resulting in reduced transpiration rate hence leading to the reduction in weight loss. It has been proved in a wide range of fruits such as apple, papaya, carrot, guava, plum, mango, apricot, banana, orange, mushroom, tomato and vegetables like radish, potato, tomato etc. (Prasad et al., 2022). It also protects a layer from deterioration by inhibiting dehydration, preventing respiration, improving texture quality, helping to retain volatile flavour compounds and decreasing microbial contamination. The weight of horticultural commodity determines the returns of farmers. This loss in weight of particular commodity is due to the transpiration process which is determined by the gradient of water vapour pressure between the fruit and the atmosphere. Edible coatings act as an extra barrier between the fruit surface and atmosphere, the process transpiration which occurs across it (Momin et al., 2021). As indicated in **Table 1**, the percentage of weight loss is increased with days of storage. The percentage of weight loss and fruit decay were maximum in control whereas minimum in wax-coated fruits.

Table 1. Effect of edible coatings on percent of weight loss, decay and shelf life of mango fruits.

Treatment	Weight loss (%)			Fruit decay (%)	Shelf life (days)
	4 day	8 day	12 day	12 day	
T1: olive oil coated	9.38	14.67	17.95	22.73	16.35
T2: wax coated	0.00	0.56	1.18	10.05	19.65
T3:chitosan 1%	2.86	5.25	7.53	11.25	18.25
T4: chitosan 2%	1.98	2.26	4.09	10.55	19.12
T5: CMC 1%	8.70	13.04	26.41	28.27	15.75
T6: CMC 2%	7.33	11.39	20.41	24.56	16.12
T7: Aloe gel coated	7.23	9.64	10.8	18.25	17.35
T8: control	12.22	23.61	26.41	30.79	15.50
S. Em±	0.5649	0.5790	1.4740	1.1673	0.6760
C.D. (*P=.05)*	0.9863	1.0110	2.5735	2.0382	1.1804

Source: Mandal et al., 2018

Fruits coated with arabic gum had less weight loss during storage than the control, and weight loss increased gradually during the storage period. Al-Juhaimi et al., (2012) reported that gum significantly ($p \leq 0.05$) reduced weight loss and acts as barrier against water loss. The basic mechanism of weight loss from fresh fruit and vegetables is by vapor pressure at different locations (Yaman and Bayoindirli, 2002). **Figure 1** shows the effect of gum Arabic coating on weight loss of cucumber fruits stored at 10 and 25 °C for different period of time (0-16 days). Weight loss of the control fruits significantly increased with storage time and reached 8 and 11% at day 16 at 10 °C (**Figure 1a**) and 25°C (**Figure 1b**), respectively.

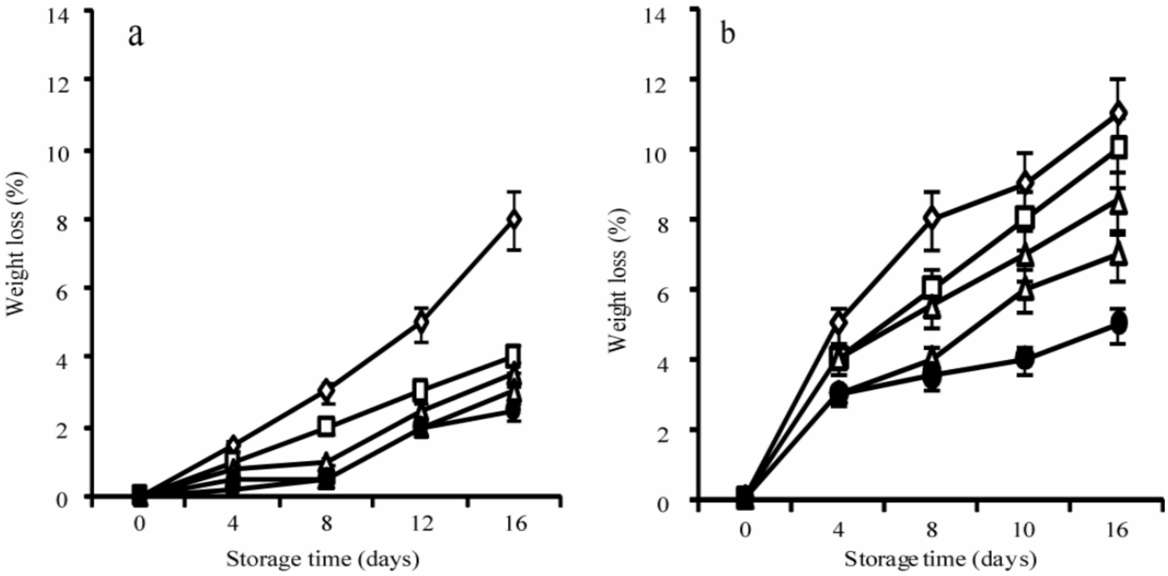

Figure 1. Effect of coating of cucumber with different concentrations of gum Arabic on weight loss during storage at 10 ºC (a) and 25 ºC (b). Control (◇), 5% (□), 10% (△), 15% (▲), 20% (●).

Source: Yaman and Bayoindirli, 2002

2.4.3. Effect of edible coating on firmness (hardness)

The maturity level of fruit can be determined by reducing the level of fruit hardness because its flesh will be more tender and juicy during the fruit ripening process. Modified atmosphere ormed by the edible coatings around the surface of the fruit, thus affected the delay in changing the texture of the fruit (Khaliq G et al., 2016). Moreover, the edible coating was able to prevent water loss and maintain fruit hardness, as the fruit softening influenced by the loss of water content in the fruit and associated with enzymatic hydrolysis reactions of cell wall components and pectin degradation. Moreover, the use of edible coatings inhibited the respiration process as the breakdown of carbohydrates into water-soluble compounds was reduced. Edible coating maintains the firmness by avoiding excessive respiration and transpiration those involved directly in depleting storage reserves. Edible coating directly affects fruit firmness by delaying ripening process and decreasing the activity of cell wall degrading enzymes (Maftoonazad et al., 2019). It is well known that calcium directly affects fruit firmness, the incorporation of calcium in the edible coatng was also proved effective (Dhall Rk, 2013).

2.4.4. Effect of edible coating on total soluble solids (TSS)

The TSS was increased after storage in all the treatments that might be due to the conversion of starch and other insoluble carbohydrates into soluble solids (Barsha et al., 2021). In terms of TSS, 50% paraffin wax was best because it recorded the lowest TSS (10.00°Brix) which indicates the lowest increment in TSS value during storage(Shahid et al., 2011). The highest TSS was recorded in control which indicates the rapid increment in TSS during storage. Other edible coating materials also showed a low increment in TSS value than control. The low value of TSS in 50% paraffin wax and other edible coating materials as compared to control during storage might be due to the creation of a physical barrier for transpiration losses and a modified atmosphere by coating materials (Jholgiker & Reddy, 2007). The highest value of TSS in control might be due to the faster metabolic activities through respiration and transpiration in control as compared to treated with different coating materials (Rokaya et al., 2016).

Table 2. Effects of edible coatings on physicochemical characteristics of banana, papaya and melon.

Fruit	Edible coating (%)	Weight loss (%)	Acidity ((%)	Soluble solids (%)	Firmness (N)	References
Banana	Chitosan:0 Chitosan:0.5 Chitosan:0.75 Chitosan: 1.0 Chitosan:1.5	30.41 25.20 23.12 2.34 19.01	0.17 0.23 0.22 0.21 0.21	9.7 8.7 8.5 8.1 8.0	39.21 42.12 46.26 46.78 47.11	Maqbool et al., (2010)
Papaya	Arabic: 0 Arabic gum:10	38.12 22.15	0.15 0.18	11.23 8.73	32.18 54.90	Maqbool et al., (2011)
Melon	Xanthan gum	3.16	0.12	7.34	-	Zambrano Zaragoza et al. (2017)

Table 3. Effect of different edible coatings on total soluble solids (TSS) content, titrable acidity and TSS: acid ratio of mango fruits .

Treatment	TSS (o Brix)			Titrable acidity (%)			TSS: Acid ratio		
	4 day	8 day	12 day	4 day	8day	12 day	4day	8day	12 day
T1:Oliveoilcoated	9.12	9.40	11.16	2.78	1.78	0.65	3.28	5.28	17.17
T2:Wax coated	8.00	8.80	9.60	3.16	2.26	1.00	2.53	3.89	9.60
T3:Chitosan 1%	8.47	9.08	10.00	3.04	2.03	0.90	2.79	4.47	11.11
T4:Chitosan 2%	8.30	8.85	9.66	3.12	2.18	1.00	2.66	4.06	9.66
T5:CMC 1%	9.47	9.67	12.50	2.16	1.27	0.40	4.38	7.61	31.25
T6:CMC 2%	9.20	9.58	11.90	2.45	1.67	0.42	3.76	5.74	28.33
T7:Aloe gel coated	8.67	8.94	10.57	2.98	1.96	0.95	2.91	4.56	11.13
T8:Control	9.87	10.00	13.20	1.92	0.95	0.45	5.14	10.53	29.33
S. Em±	0.2445	0.1538	0.3254	0.1281	0.1160	0.0785	0.1769	0.2146	1.5011
C. D. (P=0.05)	0.4268	0.2686	0.5682	0.2230	0.2025	0.1371	0.3089	0.3746	2.620

Source: Mandal et al., 2018

2.4.5. Effect of edible coating on bioactive components of fruits and vegetables

Edible coating acts as a variety of functional ingredients such as antimicrobial and antioxidant agents thus enhancing quality and improving shelf life of fresh and minimally processed fruits and vegetables. It reduced the rate of deterioration in ascorbic acid, total phenolics, and anthocyanins in fruit over time. Edible coatings can produce abiotic stress on produce, modifying its metabolism and affecting the production of such secondary metabolites as phenolic and flavonoid compounds (Dávila-Aviña et al. 2014). The application of edible coatings to fresh fruit has been associated with anaccumulation of phenolic compounds and ascorbic acid, causing an increase in the antioxidant capacity of the fruit (Razali et al., 2021). Edible coatings preserve fruit quality by surrounding the product with a modified atmosphere that serves as a partial barrier to gases (oxygen and carbon dioxide), water vapor and aroma compounds, decreasing the respiration and water loss rates of the fruit and preserving texture and flavor (Espino-Díaz et al. 2016). In grapes treated with edible chitosan coatings, an increase in the PAL enzyme responsible for synthesizing phenolic compounds was observed (Shiri et al., 2013). Phenolic and flavonoid compounds are secondary metabolites in plants with the ability to protect human body tissue against oxidative attacks (Dávila-Aviña et al., 2014). However, even when the use of mineral oil and carnauba edible coatings modifies the metabolism of tomato with positive effects on the organoleptic quality of the fruit (Dávila-Aviña et al., 2011).

Ascorbic acid content increases with ripening and storage time; however, once the fruit is fully ripe, the ascorbic acid content starts to decline (Tavarini et al., 2008). Ali et al., (2010) reported a similar slowing-down of ascorbic acid increase during ripening. They suggested that this slower increase in ascorbic acid in coated fruit suggests that the coating slowed down, but did not prevent the synthesis of ascorbic acid during ripening. Total phenolic and antioxidants have an influential role in the shelf life of horticultural commodity and their presence gives the resistance to various postharvest quality deterioration factors (Mohebbi et al., 2012). Antioxidants also extend the shelf life from the internal presence and external application.

Table 4. Effect of application of different edible coatings in fruits

Fruit	Coating material	Effects	Reference
Mango	Emulsion of carnauba wax and acrylic resin	Reduced weight loss and retention of firmness	Mandal et al., 2018
Banana	Chitosan	Inhibited pathogenic growth of Colletotrichum musae Reduced weight loss	Malmiri et al., 2011; Hossain and Iqbal, 2016
Avocado	Carnauba	Reduced water loss, shrinkage, chlorophyll break- down and chilling injury	Feygenberg et al., 2004
Papaya	Aloe vera gel	Retained firmness. Delayed peel color development. Reduced weight loss	Marpudi et al., 2011
Grape	Aloe vera gel	Delayed softening process and color development. Lowered ethylene production and Reduced weight loss	Castillo et al., 2010
Strawberries	Aloe vera gel, chitosan coating, bees wax	Maintain firmness, reduce decay incidence and reduce respiration rate respectively,	Velickova et al., 2013
Apple	Aloe vera gel, Arabic gum	Maintain firmness and reduce weight loss, delay ripening and reduce decay respectively.	Ergun and Satici, 2012

Fruit	Coating material	Effects	Reference
Guava	Waxol	Maintain fruit quality, better the organoleptic properties, increased shelf life, highest acidity and total soluble solids under the treatment with 6 to 9 %	Kumar et al., 2017
	Carnauba wax	Delay ripening and reduce the water loss and decay incidence. Little effect on total soluble solid, total titratable acidity, and ascorbic acid.	Kore and Kabir, 2011

Table 5 .Effect of application of different edible coatings in vegetables

Fruit	Coating Material	Effects	Reference
Carrot	Aloe vera with Carboxymethyl cellulose	Reduced gaseous exchange, water vapor transit and microbial load. Mantained total soluble solids, sugar and carotenoids. Increased storage life.	Panwar et al., 2016
Cucumber	Carboxymethyl cellulose and corn starch	Reduce mechanical damage and decay incidence, reduce microbial load.	Bakliwal et al., 2019
	Pectin + sorbitol + bee wax	Reducing moisture loss, changes in firmness, color, chlorophyll, and other quality parameters. Prolong storage life	Moalemiyan and Ramaswamy, 2012
Tomato	Aloe juice + cinnamalde-hyde	Increased storage life, internal quality, skin colour and firmness. Decreased respiration rate and moisture loss	Athmaselvi et al., 2013
Potato	Calcium caseinate and whey protein	Delayed browning	Di Pierro et al., 2018
Sweet pepper	Chitosan + cinnamon oil	Improved texture, colour retention, cell membrane stability, storage life and ROS scavenge activity, low decay and electrolyte leakage	Xing et al; 2016
Egg plant	1% Cysteine + Soyprotein + MAP	Increased storage life and whiteness index. Reduced Polyphenol oxidase activity	Ghidelli et al., 2014

CONCLUSION

The postharvest practices used to minimize postharvest losses include maintenance of temperature, relative humidity and application of coating for enhancing shelf life of the products. Recent research focused on developing edible coatings and improving their properties like mechanical strength, softness, water resistance and transparency. The use of edible coating alone or as carriers of additives promoting novel technology and it is crucially important during transportation of horticultural crops in different sectors. Food safety regulatory bodies have recommended safe limits of edible coatings for horticultural crops and other food products. The development of biodegradable coatings and films from gums replace synthetic polymers and has been accepted because it reduces environmental harms due to plastic waste. They improve the external and internal quality characteristics of fruits and vegetables. Coatings can reduce dehydration and oxidation as well as the resulting undesirable changes in color, flavor, and texture.

Waxes and other coatings delay ripening and senescence of fresh produce and can increase the microbial stability of lightly processed fruits, vegetables, and some processed products. Most coating materials are produced from renewable edible resources and can even be manufactured from waste products that represent disposal problems for other industries. Furthermore, edible coatings are applied in order to extend shelf life, reduce moisture loss, delayed ripening process and prevent microbial growth specifically in fresh fruits and vegetables. The crucial study of edible coating application on horticultural commodities will help to develop novel coatings materials and explore new formulations, which will open surely the gate for future research.

Declaration of interest's statement
I declare no conflict of interest
Ethics approval- *not applicable*
Consent to participate- *not applicable*
Consent for publication-*not applicable*
Code availability –*not applicable*

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