Edible Coatings for Improving Quality and Shelf Life of Fresh Vegetables

Swagat Ranjan Behera*[1] and Riya Pandey[2]
[1]M. Sc. Scholar, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, India
[2]Ph. D. Scholar, Department of Vegetable Science, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India
*Corresponding Author: swgtbehera@gmail.com

Vegetables, by virtue of their high (80-90%) water content, are highly perishable in nature and, therefore, post-harvest losses in vegetable crops are estimated to be around 20%. Majority of the losses in quality and quantity of fresh vegetables occurs between harvest and consumption. Most of the vegetables are botanically fruits, *e.g.*, tomato, eggplant, hot and bell pepper, okra, cucurbits, peas and beans etc., which continue some physiological processes like respiration and ethylene production even after harvest. These lead to gradual maturation and eventual senescence of the produce, and render them susceptible to contamination by enzymatic reactions such as browning, off-flavour development and texture breakdown and/or microbial attack. To alleviate the wastage of vegetables and extend their shelf life, it is essential to explore new methods of preservation. Several techniques like controlled atmospheric (CA) storage and modified atmosphere packaging (MAP) are already in use, however, edible coatings can provide an alternative to these methods. In fact, during the past two decades, there has been an increase in interest in the development and use of edible coatings to improve the shelf life and enhance the quality of fresh vegetables.

What are edible coatings?

Edible coatings are the thin layers (thickness <10 µm) of edible polymer materials that are directly applied over the fresh produce so as to prolong their shelf-life. They are generally prepared from biodegradable polymers as an alternative to the non-degradable packaging materials which generate large amounts of waste and cause environmental pollution. Edible coatings are affordable; non-polluting; possess good organoleptic properties, mechanical strength, biochemical and microbial stability; serve as moisture and gas barrier; and are safe for human consumption, *i.e.*, non-toxic.

How do edible coatings work?

Vegetables continue to respire even after harvest and use up all the oxygen within the produce, which is not replaced as quickly as by edible coating. The resultant carbon dioxide builds up inside the produce since it cannot escape as readily through the coating. Vegetables eventually transition to partial anaerobic respiration, which uses 1-3% less oxygen. Low oxygen concentration disrupts ethylene production (which accelerates ripening process) is disrupted and physiological loss of water is minimized. Thus, the vegetables remain firm, fresh and nutritious for longer period and their shelf life almost doubles. The natural barrier on fruit and vegetable, and the type and amount of coating influences the extent to which the internal atmosphere (oxygen and carbon dioxide) is modified.

Furthermore, studies have demonstrated that edible coatings containing antimicrobial agents, such as organic acids, essential oils from plants and polypeptides, prevent microbial growth on the produce (Nandane *et al.*, 2017). Edible coatings can reduce enzymatic activity, minimize browning reaction and softening of the texture. In addition, they have the potential to maintain the natural volatile flavour compounds and colour components (Sapper and Chiralt, 2018).

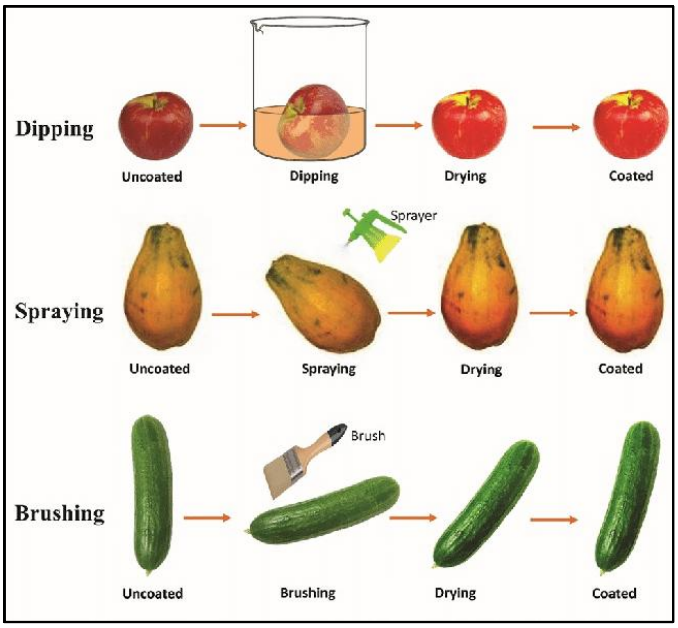

Fig 1: Methods of application of edible coatings on fresh produce

Salient features of edible coatings

Some of the specific requirements for edible coatings are as follows:

i. The coating should be water-resistant and cover the produce appropriately.
ii. It should reduce transpiration.
iii. It should neither deplete oxygen nor build up excess carbon dioxide.
iv. It should improve appearance of the produce.
v. It should be translucent to opaque and possess mechanical strength.
vi. It should be easily emulsifiable and non-sticky, and have good drying performance.
vii. It should not interfere with the quality of the fresh produce.
viii. It should melt above 40˚C without decomposition.

Vegetables that can be coated

Edible coatings can be applied on whole as well as fresh-cut vegetables. Vegetables that are coated as whole include tomato, bell pepper (capsicum), cucumber and melons.

Fresh-cut vegetables undergo physical stress while peeling, cutting, slicing, shredding etc. and the removal of their skin makes them highly perishable. Edible coatings are commercially applied on minimally processed carrot and onion; and fresh-cut lettuce, cabbage, tomato and muskmelon.

Method of application of edible coatings

The surface of fresh vegetables are coated with edible coatings by dipping, brushing, spraying or layer-by-layer (LBL) deposition technique followed by drying.

Composition of edible coatings

Edible coatings can be produced from materials which have the ability to form film. Film components must be disseminated and dissolved in a solvent during production, such as water, alcohol, a blend of the two, or a combination of various solvents. Antimicrobials, plasticizers, vitamins, minerals, colours or flavours may be added. The pH of the solution can be changed or the solution can be subjected to heat for effective dispersion depending on the polymer. To create free-standing films, the solution is then cast and dried at the correct temperature and relative humidity.

Polysaccharides, proteins, lipids and other substances may be found in edible coatings, none of which can provide the required protection by themselves. Therefore, they are used in combinations to get the best results.

Polysaccharides

These polymers are derived from marine and agricultural plants and animals. These coatings have been used to prevent moisture loss from produce

Table 1: Specific edible coating applications to different vegetables

Coating material	Composition	Vegetable	Effect of coating	References
Semperfresh™	Sucrose esters with high proportion of short-chain unsaturated fatty acid esters, sodium salts of CMC and mixed mono and di-glycerides	Zucchini	Reduced moisture loss and internal CO_2 of fruit	Avena-Bustillos *et al.*, 1994
		Tomato	Reduced colour changes, retained acid, increased shelf life and mainatained quality	Tasdelen and Bayindirli, 1998
Nature-seal™	Cellulose-based edible coating	Carrot	Retarded discoloration and carotene loss, and is a barrier for O_2 diffusion	Chen *et al.*, 1996
Chitosan	Chitosan and Tween 80	Cucumber and bell pepper	Antimicrobial coatings	El-Ghaouth *et al.*, 1991
		Carrot	Reduced decay and improved appearance	Cheah *et al.*, 1997; Li and Barth, 1998
Zein	Corn zein protein	Tomato	Delayed colour change, loss of firmness and weight, and extended shelf life	Park *et al.*, 1994
Brilloshine	Sucrose esters and wax (shine)	Melons	Increased shine and extended shelf life	Baldwin, 1994
Cellulose	MC and glycerol	Carrot	Extended storage life, resulting in more carotene than control	Li and Barth, 1998

during short-term storage. However, due to their hydrophilic nature, polysaccharides are not effective as physical moisture barriers. They serve as a sacrificial moisture barrier to the environment, so that the moisture content of the coated produce can be preserved. Various polysaccharide coatings not only reduce moisture loss but also decrease oxygen permeability. The commonly used polysaccharides included in edible coating formulations are cellulose and its derivatives; starch and its derivatives; chitin and chitosan; alginates and carrageenans; and pectin.

Proteins

Protein coatings are the least developed material for use as edible coating. Proteins are hydrophilic in nature and are susceptible to moisture absorption. Generally, proteins must be denatured by heat, acid, alkali or solvent to form extended structures that are required for film formation.

Protein films are expected to be good oxygen barriers at low relative humidity. The most commonly used protein-based edible coatings are gelatin, wheat gluten, corn zein, casein (milk protein), keratin, collagen and whey.

Lipids

Lipid coatings are mainly used for their hydrophobic properties, which makes them good moisture barriers. They can also reduce respiration and add shine on the vegetables, thereby extending shelf life and improving appearance. The most effective lipid substances used as edible coatings are beeswax and paraffin wax.

Advantages of edible coatings

i. Improve external appearance of vegetables by adding shine to their surface.
ii. Reduce physiological loss of weight (PLW) and maintain firmness of the produce.
iii. Delay senescence of vegetables by reducing rate of respiration and ethylene production.
iv. Prevent vegetables against chilling and freezing injuries, and storage disorders.
v. Coats the vegetables with antioxidants, vitamins and pigments that prevent enzymatic actions.
vi. Reduces the use of synthetic packaging materials.

Conclusion

At the moment, most of the studies related to application of edible coatings on vegetables have been conducted at a laboratory scale. However, future research focused on a commercial scale needs to be carried out. Lastly, more studies are necessary to understand the interactions among the components of edible coating materials. When active ingredients, such as antioxidants, antimicrobials and nutrients are added to edible coatings, they dramatically affect the mechanical, sensory and even functional properties of vegetables.

References

Avena-Bustillos, R. J., Cisneros-Zevallos, L. A., Krochta, J. M. and Saltveit Jr, M. E. (1994). Application of casein-lipid edible film emulsions to reduce white blush on minimally processed carrots. *Postharvest Biology and Technology*, **4**(4): 319-329.

Baldwin, E. A. (1994). Edible coatings for fresh fruits and vegetables: past, present, and future. *Edible coatings and films to improve food quality*, **1**: 25.

Cheah, L. H., Page, B. B. C. and Shepherd, R. (1997). Chitosan coating for inhibition of sclerotinia rot of carrots. *New Zealand Journal of Crop and Horticultural Science*, **25**: 89-92.

Chen, X. H., Campbell, C. A., Grant, L. A., Li, P., and Barth, M. (1996). Effect of nature seal® on

maintaining carotene in fresh-cut carrots. *Proceedings of the Florida State Horticultural Society*, **109**: 258-259.

El-Ghaouth, A., Arul, J., Ponnampalam, R. and Boulet, M. (1991b). Use of chitosan coating to reduce water loss and maintain quality of cucumber and bell pepper fruits. *Journal of Food Processing and Preservation*, **15**: 359-368.

Li, P. and Barth, M. M. (1998). Impact of edible coatings on nutritional and physiological changes in lightly processed carrots. *Postharvest Biology and Technology*, **14**: 51-60.

Nandane, A. S., Dave, R. K. and Rao, T. R. (2017). Optimization of edible coating formulations for improving postharvest quality and shelf life of pear fruit using response surface methodology. *Journal of Food Science and Technology*, **54**: 1-8.

Park, H. J., Chinnan, M. S. and Shewfelt, R. L. (1994). Edible corn-zein film coatings to extend storage life of tomatoes. *Journal of Food Processing and Preservation*, **18**: 317-331.

Sapper, M. and Chiralt, A. (2018). Starch-based coatings for preservation of fruits and vegetables. *Coatings*, **8**(5): 152.

Tasdelen, O. and Bayindirli, L. (1998). Controlled atmosphere storage and edible coating effects on storage life and quality of tomatoes. *Journal of Food Processing and* Preservation, **22**: 303-320.

* * * * * * * *