EC NUTRITION
Editorial

New Packaging Strategies to Guarantee the Quality of Minimally Processed Fruits: The Application of Edible Coatings

Monica Rosa Loizzo*

Department of Pharmacy, Health and Nutritional Sciences, University of Calabria, Rende, Italy

***Corresponding Author:** Monica Rosa Loizzo, Professor in Food Science Technology, Department of Pharmacy, Health and Nutritional Sciences, University of Calabria, Rende, Italy.

Received: December 18, 2018; **Published:** December 28, 2018

It is estimated that postharvest losses of minimally processed fruits depend on a series of factors including species, harvesting, transport, and storage and may represent about 20 - 25% of total production in industrialized countries and more than 50% in developing countries, where postharvest operation techniques are not optimal.

Following the change of lifestyle, consumers are interest to buy healthy foods with particular reference to fruit minimally processed. However, technological operations of washing, sorting, peeling, and cutting cause several damage of fruit soft tissue and consequently limited the shelf life of these products [1,2]. Moreover, the quality of food matrix depends not only by its nutritional and organoleptic characteristics but also by the hygienic condition of the products during the shelf-life period. Several of these characteristics change due to the interactions between food and the surrounding environment [3]. Among technological operation, cutting represents one of the most critical since it causes releasing of enzymes such as pectin methylesterase and polygalacturonase that cause the enzymatic degradation of the cell wall, mainly composed of cellulose, hemicellulose and pectins [4]. Fruit tissue softening is frequently associated to the browning of fruit surface [5]. The flesh browning process involves two oxidoreductases: polyphenol oxidase (PPO) and peroxidase (POD) [6]. PPO acts in two steps. In the first step, the enzyme catalyses the hydroxylation of monophenols to diphenols, successively it causes the oxidation of diphenols to quinines. This second reaction is rapid and produces coloured compounds [7]. Normally the substrates involved in these reactions are confined in the vacuoles while enzymes in the cytoplasm. Cutting process determines a loss of compartmentalization, which in the presence of oxygen causes the browning of fruits [8].

During fruits postharvest storage the tissue softening is accompanied by an increase in sugar level, and decrease in organic acid levels, degradation of chlorophyll accompanied by the synthesis of carotenoids or anthocyanins, production and losses of volatile compounds decrease in phenolic and amino acid contents, and breakdown of cell materials due to respiration [9]. Other important parameters are humidity and temperature that can directly affect postharvest respiration and transpiration of fruits. In particular, high temperature speeding up respiration, leading to increased ethylene production and high CO_2 level [10]. All these modifications determined changes in taste, flavour, colour, texture and nutrient content [9]. For these reasons, fruit processing industries needs to find proper postharvest operations able to maintain the safety of products, minimize organoleptic and visual modifications during shelf life [11-13].

To prolong the shelf life of minimally processed fruits different technologies based on physical and chemical preservation strategies have been developed [14]. Citric acid, ascorbic acid and its derivatives, cinnamate, benzoate, and cyclodextrins are used as chemical food additives to retard both flesh browning and tissue softening however they confer off-flavours and recently some of these compounds are recognised non-generally recognized as safe (GRAS) [15]. Therefore, manipulation of headspace atmosphere with Modified Atmosphere Packaging (MAP) represent a more safe strategy to prolong the shelf life of minimally processed fruit. MAP is a dynamic system in which two gas fluxes, allows the respiration of the fresh fruit and the gas exchange through a packaging film [16]. The composition of MAP is generally characterized by a high percentage of CO_2 with low in O_2. Moreover, important parameters are package total surface area, product weight and respiration rate, film gas transmission capacity and storage temperature. Despite the recent innovations in the MAP sector, this technology is not sufficient to significantly extend the shelf life of the majority of the minimally processed fruits even if it is applied at low temperature [15]. Recently edible coating option growing in popularity for its natural character and for the promising results obtained by the application of this type of packaging to different fruit matrix [17,18]. Edible coatings did not replace traditional packaging system but they can additionally control moisture and gases and be supporters of additives [19]. The application of edible coatings on fruits and minimally processed fruits consists on the application of a layer of edible material on the surface of a cut-fruit in order to providing it with a modified atmosphere, retarding gas transfer, reducing moisture, delaying color changes and aroma loss, and improving the general appearance of the product during the shelf life period carry active ingredients [18]. Edible coating use on minimally processed fruits determined:

a) A reduction of moisture loss as consequence of moisture barrier on the surface of the product;
b) Controlling gas exchange between the fresh product and its surrounding atmosphere, slowing down respiration and delaying deterioration of aspect and aroma;
c) Retarding enzymatic oxidation responsible of the flesh browning of the fruits or texture softening during the shelf-life period;
d) Protecting product from physical damage caused by mechanical factors;
e) Carry functional ingredients, such as antioxidants, antimicrobials anti-browning and healthy compounds [21].

Different materials such as polysaccharides, proteins and lipids are used as edible coating [9,20]. Among polysaccharides, alginates, cellulose derivatives, carrageenan, chitosan, gums, and pectinates are used. These materials are characterized by a hydrophilic nature and its use guarantee a gas barrier rather than retarding water loss. Carboxymethyl cellulose (CMC) alone or in combination with chitosan was successfully applied to extend the shelf life of *Nephelium lappaceum* fruit especially on terms of vitamin C content and eating quality at room temperature for 3 days of storage [22]. A gelatin-based edible coating containing cellulose nanocrystals (GEL/CNC) is used to maintain the quality in terms of visual aspect, aroma and nutrient content of fresh strawberries during storage. Results evidenced that fruits coated with GEL/CNC had a significant improvement in its shelf life in fact the weight loss after 8 days of storage was 31 - 36 vs 65% of untreated fruits. Moreover, a promising retention of ascorbic acid was observed [23]. Low methoxyl edible pectins (2%) formulated with glycerol, sunflower oil and $CaCl_2$ were used as coating on fresh-cut melon. This operation improved water vapour resistance, preventing dehydration and maintaining the initial firmness and quality attributes during 15 days of storage at 4°C [24]. The same formulation with the addition of N-acetylcysteine Glutathione on pears exerted antimicrobial, anti-browning and antioxidant activity during 14 days of storage at 4°C. The sensory attributes of the fruits were also maintained [25].

More recently, Lin., *et al.* [26] reported the effect carrageenan-based and chitosan edible coatings on *Dimocarpus longan* fruits. The best combinations to preserve longan by minimal quality changes and quantity losses resulted 1.49% (w/v) carrageenan with 0.03% glycerol and 1.29% (w/v) chitosan with 0.42% glycerol. Pectin and sodium alginate coatings formulated with essential oils rich in citral and eugenol (PE 1% + Cit 0.15% + Eug 0.1%.) applied to raspberries determined a reduced loss of the colour, soluble solids content, and weight loss together with a maintain of good antioxidant capacity and taste up to 14 days, while control fruit were acceptable only till 7 days [27]. Pullulan coating was characterized by colorless, tasteless, and odorless at the same time it has good adhesive properties and high mechanical strength. Several works describes the use of this polysaccharide to extending the shelf life of whole and cutted apples, kiwifruit and strawberries [28,29]. A great protection on L-ascorbic acid, phenolic compounds (total phenolics, phenolics acids and anthocyanins) loss was observed in pullulan coated blueberries fruits monitored at 4 and 16°C by 28 and 14 days, respectively [1]. Moreover, pullulan minimizes respiration rate, controlling microbial growth and delaying overall deterioration of the fruits.

An edible coating of *Aloe vera* gel recently addressed research attention. This coating guarantee a highly effective as a moisture barrier without the incorporation of lipids [30]. The *A. vera* mucilaginous gel is odourless and colourless, and consisting of approximately 99.0 - 99.5% of water and 0.5 - 1% of polysaccharides, minerals, vitamins, phenolic compounds, organic acids and enzymes [31]. Serrano., *et al.* [32] reported that this gel forming a protective layer on the surface of fruit matrix able to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in fruits.

Radi., *et al.* [33] reported the effect of *A. vera* gel and green and black tea extracts on physicochemical, microbial, and sensorial properties of fresh-cut oranges storage for 17 days at 4°C. Significant differences in terms of quality parameters were observed between the control and coated fresh-cut oranges treated with 100% *A. vera* gel and 10% of green tea extract. Moreover, this sample received, also, the highest score in sensory evaluation. A similar formulation was used by the same research team onto fresh-cut apples storage at 4°C for 16 days. In this case, the highest variation in quality parameters including softening was observed in coated slices with 150% of *A. vera* gel [34]. *A. vera* gel was successfully applied to *Ziziphus mauritiana* (ber) fruit. This fruits are highly perishable and has a limited shelf life at room temperature. *A. vera* gel coated ber fruits presented a lower weight loss, shrinkage percentage, loss in acid content and a maximum colour retention as compared to uncoated ones [35]. Atlaw [36] proposed the use of *A. vera* gel (T1) and formulation with citric acid (T2) to control mango fruit deterioration. A shelf life of 17 days was found for uncoated fruits whereas both treatment can extend the shelf life of mango fruit to 29 days. These treated fruits presented a lower loss in weight (8.6 and 7.6% for T1, and T2, respectively vs 22.04%) and titratable acidity and a significantly increase of both pH and TSS content. The successfully application of *A. vera* gel on pomegranate arils cv. Bhagwa was described by Sridevi., *et al* [37].

Arils treated with gel (30%) showed a significantly lowest total sugars and titrable acidity content during the early phase of storage. Moreover, treated arils presented a higher content of ascorbic acid, total anthocyanins and antioxidant activity throughout the shelf-life period in comparison to the untreated sample.

Soy protein, whey protein, wheat gluten, and corn zein have been extensively studied as films/coatings for their mechanical properties. Protein based films/coatings acts as oxygen blockers even at low relative humidity Hassan., *et al* [38]. A soybean protein isolate (SPI) formulated with chitosan was used to prolong the shelf life of apricots stored at 2°C in fact, it significantly decreased the weight loss and firmness of the treated apricots respect untreated fruits. Moreover, SPI-chitosan coating inhibited the degradation of pectin molecules. Meanwhile, this treatment prevented the decrease in firmness and benefited the textural properties of the apricots tissue due inhibition of pectin degradation [39].

A combination of whey protein/pectin film prepared in the presence of transglutaminase was used onto fresh cut apples. Coating determined a significantly reduction of apple weight loss after 10 days storage [40]. Whereas dipping sun dried *Prunus armeniaca* fruits with zein film after pre-treatment with 2.5% citric acid solution maintain the quality of intermediate moisture apricots for 10 months storage at both 5 and 20°C with particular reference to colour modifications, microbial [41].

Respect polysaccharides, lipids especially mixed with proteins are able to produce coatings with higher mechanical and barrier properties [42]. Lipid coating is considered highly effective to block the delivery of moisture due to their low polarity. Coating formulated with lipids are thicker and extra brittle due to their hydrophobic character however they negative affect the appearance and gloss of the coated fruits [43]. Ochoia-Reyes., *et al.* [44] reported the effect of natural wax extracted from *Euphorbia antisyphilitica* + ellagic acid 0.01% on the shelf life quality and safety of "Golden Delicious" apples. Results evidenced that edible coating prevents apparent damages to the fruits in terms of weight loss, colour, total solids content. Moreover, it is approved by the sensorial panel. Candelilla was formulated with biocontrol bacteria was used to efficiently prolong the strawberry shelf-life and their quality. In particular, the treatment significantly reduce damage caused by *Rhizopus stolonifera* [45]. A formulation of Candelilla wax blended with white mineral oil as the lipid phase and mesquite gum as the structural material was used onto *Psidium guajava* fruits to retarding loss of weight and ethylene emission and enhancing texture as compared to untreated fruits [46].

Herein we reported only few studies of the multiple published both in foods and materials sector journals. This proves the interest in this research topic by not only professionals but also consumers who have changed their lifestyle without renounce to consume fresh fruit with high nutritional quality, especially if already partially processed. In the future new edible coating formulated with nano-emulsions and nanoparticles can extend the shelf life of fruits due additional protection of those systems or by carrying active phytochemicals that can released during the shelf-life period.

Further studies are necessary in order to identify the best coating solution for each processed fruit characterized by high sensory performance and technological functionality.

Conflicts of Interest

The author have no conflict of interest.

Bibliography

1. Kraśniewska K., *et al*. "Effect of Pullulan Coating on Postharvest Quality and Shelf-Life of Highbush Blueberry (Vaccinium corymbosum L.)". *Materials (Basel)* 10.8 (2017): 965-972.
2. Saltveit ME. "Fresh-cut vegetables". In: Post harvest Physiology and Pathology of Vegetables, Bartz JA, Brecht JK, Marcel Dekker Inc, USA (2003).
3. Beaulieu JC and Baldwin EA. "Flavor and aroma of fresh cut fruits and vegetables". In: O Lamikanra (Ed.), Fresh-cut Fruits and Vegetables, CRC Press, Florida (2002): 391-425.
4. Oms-Oliu G., *et al*. "Recent approaches using chemical treatments to preserve quality of fresh-cut fruit: a review". *Postharvest Biology and Technology* 57.3 (2010): 139-148.
5. Soliva-Fortuny RC and Martin-Belloso O. "New advances in extending the shelf-life of fresh-cut fruits: a review". *Trends Food Science Technology* 14.9 (2003): 341-353.
6. Ioannou I and Ghoul M. "Prevention of enzymatic browning in fruit and vegetables". *European Scientific Journal* 9 (2013): 310-341.
7. Queiroz C., *et al*. "Polyphenol Oxidase: Characteristics and Mechanisms of Browning Control". *Food Reviews International* 24.4 (2008): 361-375.
8. Loizzo M., *et al*. "Natural and Synthetic Tyrosinase Inhibitors as Antibrowning Agents: An Update". *Comprehensive Reviews in Food Science and Food Safety* 11 (2012): 378-398.
9. Lin D and Zhao Y. "Innovations in the Development and Application of Edible Coatings for Fresh and Minimally Processed Fruits and Vegetables". *Comprehensive Reviews in Food Science and Food Safety* 6.3 (2007): 60-75.
10. Castellanos DA., *et al*. "Respiration and ethylene generation modeling of "Hass" avocado and feijoa fruits and application in modified atmosphere packaging". *International Journal of Food Properties* 20.2 (2017): 333-349.
11. Kader A. "Quality Parameters of Fresh-Cut Fruit and Vegetable Products". In Fresh-cut fruits and vegetables Lamikanra O, Eds. CRC Press LLC: Boca Raton, Fla (2002): 11-20.
12. Kader AA. "Perspective flavor quality of fruits and vegetables". *Journal of the Science of Food and Agriculture* 88 (2008): 1863-1868.

13. Sharma R and Singh R. "Harvesting, Postharvest Handling and Physiology of Fruits and Vegetables". In Postharvest technology of fruits and vegetables Volume 1. Handling, processing, fermentation and waste management. Verma LR, Joshi VK, E., Ed. Indus Publishing Co.: Tagore Garden, New Delhi (2000): 94-147.

14. Rojas-Graü MA., *et al*. "The use of packaging techniques to maintain freshness in fresh-cut fruits and vegetables: a review". *International Journal of Food Science and Technology* 44.5 (2009): 875-889.

15. Porta R., *et al*. "Edible Coating as Packaging Strategy to Extend the Shelf-life of Fresh-Cut Fruits and Vegetables". *Journal of Biotechnology and Biomaterials* 3 (2013): e124-e134.

16. Wilson MD., *et al*. "Innovative processes and technologies for modified atmosphere packaging of fresh and fresh-cut fruits and vegetables". *Critical Reviews in Food Science and Nutrition* 11 (2017): 1-12.

17. Dhall RK. "Advances in edible coatings for fresh fruits and vegetables: a review". *Critical Reviews in Food Science and Nutrition* 53.5 (2013): 435-450.

18. Kumar P and Sethi S. "Edible Coating for Fresh Fruit: A Review". *International Journal of Current Microbiology and Applied Sciences* 7.5 (2018): 2619-2626.

19. Campos C., *et al*. "Development of edible films and coatings with antimicrobial activity". *Food and Bioprocess Technology* 4.6 (2010): 849-875.

20. Robles-Sánchez RM., *et al*. "Influence of alginate-based edible coating as carrier of antibrowning agents on bioactive compounds and antioxidant activity in fresh-cut kent mangoes". *LWT - Food Science and Technology* 50.1 (2013): 240-246.

21. Montero Garcia MP., *et al*. "Edible films and coatings: fundamentals and applications". CRC Press (2016): 1-598.

22. Saowakon K., *et al*. "Effect of carboxymethyl cellulose as edible coating on postharvest quality of rambutan fruit under ambient temperature". *International Journal of Agricultural Technology* 13.7 (2017): 1449-1457.

23. Fakhouri FM., *et al*. "Effect of a gelatin-based edible coating containing cellulose nanocrystals (CNC) on the quality and nutrient retention of fresh strawberries during storage". IOP Conference Series: Materials Science and Engineering (2014).

24. Oms-Oliu G., *et al*. "Using polysaccharide-based edible coatings to enhance quality and antioxidant properties of fresh-cut melon". *LWT - Food Science and Technology* 41.10 (2008): 1862-1870.

25. Oms-Oliu G., *et al*. "Edible coatings with antibrowning agents to maintain sensory quality and antioxidant properties of fresh-cut pears". *Postharvest Biology and Technology* 50.1 (2008): 87-94.

26. Lin MG., *et al*. "Effect of chitosan and carrageenan-based edible coatings on post-harvested longan (Dimocarpus longan) fruits". *CyTA-Journal of Food* 16.1 (2018): 490-497.

27. Guerreiro AC., *et al*. "The influence of edible coatings enriched with citral and eugenol on the raspberry storage ability, nutritional and sensory quality". *Food Packaging and Shelf Life* 9 (2016): 20-28.

28. Wu S and Chen J. "Using pullulan-based edible coatings to extend shelf-life of fresh-cut "Fuji" apples". *International Journal of Biological Macromolecules* 55 (2013): 254-257.

29. Li L., *et al*. "Effects of polysaccharide-based edible coatings on quality and antioxidant enzyme system of strawberry during cold storage". *International Journal of Polymer Science* (2017): 9746174.

30. Ullah A., *et al*. "Bioplastics from feather quill". *Biomacromolecules* 12.10 (2011): 3826-3832.

31. Misir J., *et al*. "Aloe vera gel as a novel edible coating for fresh fruits: a review*". American Journal of Food Science and Technology* 2 (2014): 93-97.

32. Serrano M., *et al*. "Use of Aloe vera gel coating preserves the functional properties of table Grapes". *Journal of Agricultural and Food Chemistry* 54.11 (2006): 3882-3886.

33. Radi M., *et al*. "Effect of gelatin-based edible coatings incorporated with Aloe vera and black and green tea extracts on the shelf life of fresh-cut oranges". *Journal of Food Quality* (2017): 9764650.

34. Amiri S., *et al*. "Effect of gelatin-based edible coatings incorporated with Aloe vera and green tea extracts on the shelf-life of fresh-cut apple". *Italian Journal Food Science* 30.1 (2018): 61-74.

35. Mani A., *et al*. "Effects of Aloe vera edible coating on quality and postharvest physiology of ber (Zizyphus mauritiana Lamk.) under ambient storage conditions". *International Journal of Pure and Applied Bioscience* 5.6 (2017): 43-53.

36. Atlaw TK. "Preparation and utilization of natural Aloe vera to enhance quality of mango fruit". *Journal of Food and Nutrition Sciences* 6.3 (2018): 76-81.

37. Sridevi P., *et al*. "Effect of Aloe vera gel on the physiological, biochemical and quality parameters of pomegranate arils cv. 'Bhagwa'". *International Journal of Current Microbiology and Applied Sciences* 7.1 (2018): 1757-1766.

38. Hassan B., *et al*. "Recent advances on polysaccharides, lipids and protein based edible films and coatings: a review". *International Journal of Biological Macromolecules* 109 (2018): 1095-1107.

39. Zhang L., *et al*. "Impact of soybean protein isolate-chitosan edible coating on the softening of apricot fruit during storage". *LWT - Food Science and Technology* 96 (2018): 604-611.

40. Rossi Marquez G., *et al*. "Fresh-cut fruit and vegetable coatings by transglutaminase-crosslinked whey protein/pectin edible films". *LWT - Food Science and Technology* 75 (2017): 124-130.

41. Baysal T., *et al*. "The effect of corn zein edible film coating on intermediate moisture apricot (Prunus armenica l.) quality". *GIDA* 35.4 (2010): 245-249.

42. Debeaufort F and Voilley A. "Edible Films and Coatings to Improve Food Quality". Springer, New York (2009): 135-168.

43. Valencia-Chamorro SA., *et al*. "Effect of antifungal hydroxypropyl methylcellulose-lipid edible composite coatings on penicillium decay development and postharvest quality of cold-stored "ortanique" mandarins". *Journal Food Science* 75.8 (2010): 418-426.

44. Ochoa Reyes E., *et al*. "Evaluation of a Candelilla wax-based edible coating to prolong the shelf-life quality and safety of apples". *American Journal of Agricultural and Biological Science* 6.1 (2011): 92-98.

45. Oregel-Zamudio E., *et al*. "Effect of candelilla wax edible coatings combined with biocontrol bacteria on strawberry quality during the shelf-life". *Scientia Horticulturae* 214 (2017): 273-279.

46. Tomas SA., *et al*. "Effects of mesquite gum-candelilla wax based edible coatings on the quality of guava fruit (Psidium guajava L.)". *Journal de Physique IV* 125 (2005): 889-892.

Volume 14 Issue 1 January 2019