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Edible Coating as Packaging Strategy to Extend the Shelf-life of Fresh-Cut Fruits and Vegetables

Raffaele Porta[1]*, Giovanna Rossi-Marquez[1], Loredana Mariniello[1], Angela Sorrentino[2], C. Valeria L. Giosafatto[1], Marilena Esposito[1] and Prospero Di Pierro[1]

[1]*Department of Chemical Sciences, University of Naples "Federico II", Naples, Italy*
[2]*Department of Agriculture, University of Naples "Federico II", Naples, Italy*

Food market continuously generates novel products by following the trends of consumers whose preferences are increasing towards ready-to-use foods. Among these, fresh-cut fruits and vegetables are at the top of the list and are stimulating a great effort of research in this area. In fact, their market has grown rapidly in recent years as a result of the changes in consumer habits. Therefore, there is a real need to find new methods for preservation of processed food products able to achieve widespread acceptance by the industry.

Food appearance remains the most required attribute, strongly affecting consumer decision to buy it or not. In addition, food texture is also a fundamental feature determining product acceptability, appearance and texture changes being very tightly linked markers of food deterioration [1]. Both appearance and texture of a fruit or vegetable tissue strictly depend on genetic, environmental, postharvest handling and storage factors. Therefore, the precise knowledge of the processes leading to the appearance and textural modifications is of crucial importance in developing effective approaches to counteract them and, hence, to improve quality and shelf-life of these products.

Most of the changes occurring in fresh-cut fruits and vegetables represent an extension of the normal ripening events leading to their softening, although they are also specifically influenced by the tissue cutting and wounding. Product maturity at the time of processing mostly affects the shelf-life of fruits since they become increasingly soft and susceptible to transport and handling damage during ripening [2-4]. Precise understanding of ripening-related softening, hence, must be carefully taken into consideration when fresh-cut fruits are studied. Conversely, fresh-cut vegetables normally present minor problems because they generally have a much greater proportion of cells with thickened secondary walls and, consequently, are much firmer and less susceptible to deterioration.

However, the consequences of both fruit and vegetable cutting and post-cutting processes have not been extensively investigated. In this respect, it should be enphasized that fresh-cut products are "wounded" tissues and, thus, they deteriorate more rapidly because their behavior significantly differs from that of intact fruits and vegetables. In fact, fresh product cutting may result in several biochemical events such as browning, off-flavor spillage and loss of nutritional value due to release of the intracellular content at the sites of wounding [5]. Also the subcellular compartmentalization is shattered at the cut surfaces, and the mixing of some substrates and enzymes, which are normally separated, gives rise to reactions that in the intact cells do not occur. For instance, fruit injury results in an increased rate of respiration and production of ethylene, with visible effects within minutes to few hours, whereas the development of hardening and lignification is an undesireable effect of vegetable wounding [6]. A further problem in many fresh-cut fruits and vegetables -particularly evident in fruits with a white flesh, such as apples and pears- is the cut-edge browning due to the polyphenol oxidase and phenol peroxidase interaction with polyphenols and oxygen [6]. Furthermore, other two phenomena, namely drying and microbial colonization, may influence fresh-cut fruit and vegetable appearance and texture. Both these factors, having different causes and effects, also lead to unattractive products. Water loss and osmotic changes are the major reasons of postharvest deterioration determining a decay of food crispness and turgor. They occur very rapidly following the exposure of the internal tissues of fresh-cut products [7,8]. It has been demonstrated that, at a given temperature, the rate of water loss from the products strictly depends on the environment relative humidity [9], and it is well known that whereas temperature management is a common practice to delay fruit and vegetable deterioration, post harvest maintenance of the recommended RH is not frequently carried out [10]. Finally, food surface microbial stability is another major determinant of fresh-cut product quality and safety during storage and distribution.

To prolong the shelf-life of fresh-cut fruits and vegetables different technologies have been so far used [11]. Among these numerous chemical and physical preservation strategies were explored to reduce enzymatic browning and tissue softening after cutting. However, almost all of the chemical treatments (sulfite, citric acid, ascorbic acid derivatives, cinnamate, benzoate, and cyclodextrins) confere off flavors, and many of the most effective substances added are recognized as unsafe. Conversely, the strategy based on the manipulation of both temperature and headspace atmosphere is more feasible and reliable. Modified Atmosphere Packaging (MAP), a dynamic system with two gas fluxes, allows the respiration of the fresh products and the gas exchange through a packaging film [12]. MAP gas composition, generally low in O_2 and high in CO_2, primarily depends on package total surface area, product weight and respiration rate, film gas transmission capacity and storage temperature. However, food packaging by MAP at low temperature is usually not sufficient to significantly extend the shelf-life of the majority of the fresh-cut fruits and vegetables.

The application of edible coatings is increasingly demonstrating to be a relatively new and simple technology effective in preventing the appearance and textural deterioration of several products. The use of different types of films based on a variety of single biopolymers, or on their combinations, results to be extremely advantageous even though all data obtained so far indicate that the coatings need to be tailored and optimized for each kind of foods [13-18]. More than twenty years ago

***Corresponding author:** Raffaele Porta, Department of Chemical Sciences, University of Naples "Federico II", Naples, Italy, Tel: +390812539473; E-mail: raffaele.porta@unina.it

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Nisperos-Carriedo et al. [19] demonstrated that edible coatings based on cellulose gums effectively delay ripening in some climacteric fruits like mangoes, papayas, and bananas and significantly reduce enzymatic browning on sliced mushrooms. Ten years later Le Tien et al. [20] showed that milk protein coatings are able to counteract oxidative degradation of cut fruits and vegetables through polyphenol oxidase inhibition. From then several polysaccharides (chitosan, alginate, methylcellulose or pectin) and proteins (casein, collagen, gelatin, phaseolin, zein, soy or whey proteins), or mixtures of them, were shown to give rise to edible films effective as water vapor and gas barriers for a wide range of food products and as carriers for antimicrobials [17,21-25]. In particular, antimicrobial containing films are recently gaining potential interest in reducing the deleterious effects caused by also minimal cut processing of fresh fruits and vegetables [26,27]. Some of the most commonly used antimicrobials include benzoic acid, sorbic acid, lysozyme, bacteriocins and plant-derived secondary metabolites, such as essential oils and phytoalexins. In particular, Mastromatteo et al. [28] recently found that the combined use of ethanol pretreatment and edible coating prolonged shelf-life of minimally processed kiwi fruits.

Moreover, edible coatings may serve as carriers also for a wide range of food additives, including anti-browning agents, colorants, flavors, nutrients, spices that not only extend the shelf-life of the products, but also improve their safety and acceptability [29-32]. An example derives from the fresh-cut carrots, one of the most consumed vegetables, whose marketing is limited by their fast physiological changes during storage, developing characteristic odors of anaerobic catabolism due to higher respiration rate and microbiological deterioration. Thus, minimally processed carrots quickly lose their firmness and bright orange color and develop a white blush on the surface, thereby reducing consumer acceptability [6,33,34]. It was recently demonstrated that dipping into a hydro-alcoholic solution after fresh-cut carrot coating with sodium alginate, followed by a final packaging into a microperforated polypropylene film under passive or active MAP, prevents dehydration and microbial proliferation, delays the respiratory activity and enhances the quality of the product stored at 4°C [35]. In addition, from the sensory point of view, coated carrots were appreciated for about two weeks, whereas all the uncoated ones were refused after only two days.

In addition, the effectiveness of soy protein coatings in reducing oxidative browning and moisture loss of cut apples and potatoes during their storage at 4°C was recently reported [36]. This kind of coating was shown to have antioxidative activity and the addition of carboxymethyl cellulose to the formulation was found to significantly improve its effect. In fact, browning in control cut potatoes was increased by 106.6% in contrast to 35.2% for soy protein-coated samples, and moisture barrier effect was significantly improved after treatment. Soy protein coatings reduced moisture loss in apples and potatoes by 21.3 and 29.6%, respectively, over the control.

Similar results were recently obtained in our laboratories (unpublished data) by coating fresh-cut apples, carrots and potatoes with a pectin/whey protein film containing the enzyme transglutaminase. The ability of such hydrocolloid film to act as an effective barrier to water vapor allowed coated fruit and vegetables to markedly decrease their water loss and to counteract the microbial growth during their storage at 4°C for 10 days. In addition, food texture was assessed both at the harvest of the products and after storage by acquiring their mechanical profiles. An almost stable physiological situation was depicted between the two stages (at harvest and after storage), with a practically unmodified pattern of both product hardness and chewiness, when apples, potatoes and carrots were coated with the edible films.

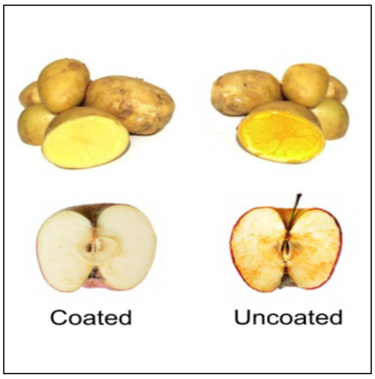

Figure 1: Browning and softening degrees between uncoated and coated apple and potato samples after 10 days of storage at 4°C.

The picture below clearly shows the different browning and softening degrees between uncoated and coated apple and potato samples after 10 days of storage at 4°C, thus suggesting that milk whey, often considered only as a polluting dairy by-product, could effectively be used as a natural component of antioxidative and moisture barrier coatings to enhance the shelf-life of fresh-cut fruits and vegetables (Figure 1).

In conclusion, we want to highlight that a relatively simple technology, such as the application of edible coatings obtainable from inexpensive raw materials, is effective against both browning development and textural deterioration happening during the management and storage of fresh-cut products. The use of various combinations of treatments may be certainly advantageous, even though they should be optimized for each plant species and sometimes probably even for each cultivar.

References

1. Cantwell MA, Suslow TV (2002) Post harvest handling systems: fresh-cutfruits and vegetables. In: Postharvest Technology of Horticultural Crops, Kader AA (3rd edn), Agric Natural Res Publ, CA,USA.
2. Beaulieu JC, Ingram DA, Lea JM, Bett-Garber KL (2004) Effect of harvest maturity on the sensory characteristics fresh-cut cantaloupe. J Food Sci 69: S250-S258.
3. Soliva-Fortuny RC, Alos-Saiz N, Espachs-Barroso A, Martin-Belloso O (2004) Influence of maturity at processing on quality attributes of fresh-cut conference pears. J Food Sci 69: S290-S294.
4. Lana MM, Tijskens LMM, van Kooten O (2005) Effects of storage temperature and fruit ripening on firmness of fresh cut tomatoes. Post harvest BiolTechnol 35: 87-95.
5. Saltveit ME (2003) Fresh-cut vegetables. In: Post harvest Physiology and Pathology of Vegetables, Bartz JA, Brecht JK, Marcel Dekker Inc, USA.
6. Toivonen PMA, Brummell DA (2008) Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. Postharvest BiolTechnol 48: 1-14.
7. Shackel KA, Greve C, Labavitch JM, Ahmadi H (1991) Cell turgor changes associated with ripening in tomato pericarp tissue. Plant Physiol 97: 814-816.
8. Saladié M, Matas AJ, Isaacson T, Jenks MA, Goodwin SM, et al. (2007) A reevaluation of the key factors that influence tomato fruit softening and integrity. Plant Physiol 144: 1012-1028.
9. Kays SJ (1991) Post harvest physiology of perishable plant products. Van
10. Paull RE (1999) Effect of temperature and relative humidity on fresh commodity quality. Postharvest BiolTechnol 15: 263-277.
11. Rojas-Graü MA, Oms-Oliu G, Soliva-Fortuny R, Martín-Belloso O (2009) The use of packaging techniques to maintain freshness in fresh-cut fruits and vegetables: a review. Int J Food SciTechnol, 44: 875-889.

12. Van de Velde K, Kiekens P (2002) Biopolymers: overview of several properties and consequences on their applications. Polymer Testing 21: 433-442.
13. Olivas GI, Barbosa-Cánovas GV (2005) Edible coatings for fresh-cut fruits. Crit Rev Food Sci Nutr 45: 657-670.
14. Shon J, Eo JH, Eun JB (2010) Effect of soy protein isolate coating on quality attributes of cut raw Han-Woo (Korean cow) beef, aerobically packaged and held refrigerated. J Food Quality 33: 42-60.
15. Plackett D (2011) Biopolymers: New materials for sustainable films and coatings. John Wiley & Sons, USA.
16. Porta R, Di Pierro P, Sorrentino A, Mariniello L (2011) Promising perspectives of transglutaminase in "bioplastics" production. J Biotechnol Biomater doi:10.4172/2155-952X.1000102e.
17. Porta R, Mariniello L, Di Pierro P, Sorrentino A, Giosafatto CV (2011) Transglutaminase crosslinked pectin- and chitosan-based edible films: a review. Crit Rev Food Sci Nutr 51: 223-238.
18. Rojas-Graü MA, Salvia-Trujillo L, Soliva-Fortuny R, Martín-Belloso (2012) Edible films and coatings. In: Decontamination of fresh and minimally processed produce,Vicente M. Gómez-López, John Wiley & Sons Inc, USA.
19. Nisperos-Carriedo MO, Baldwin EA, Shaw PE (1991) Development of an edible coating for extending postharvest life of selected fruits and vegetables. Proc Florida State Hort. Soc 104:122-125.
20. Le Tien C, Vachon C, Mateescu MA, Lacroix M (2001) Milk protein coatings prevent oxidative browning of apples and potatoes. J Food Sci 66: 512-516.
21. Shon J, Haque ZU (2007) Efficacy of sour whey as a shelf-life enhancer: use in antioxidative edible coatings of cut vegetables and fruit. J Food Quality 30:581-593.
22. Shon J, Chin KB (2008) Effect of whey protein coating on quality attributes of low-fat, aerobically packaged sausage during refrigerated storage. J Food Sci 73: C469-C475.
23. Di Pierro P, Sorrentino A, Mariniello L, Giosafatto CVL, Porta R (2011) Chitosan/whey protein film as active coating to extend Ricotta cheese shelf-life. LWT-Food Sci Technol 44: 2324-2327.
24. Porta R, Mariniello L, Di Pierro P, Sorrentino A, Giosafatto VC, Rossi Marquez G, Esposito M (2012) Water barrier edible coatings of fried foods. J Biotechnol Biomater doi:10.4172/2155-952X.1000e116.
25. Rossi Marquez G, Di Pierro P, Esposito M, Mariniello L, Porta R (2013) Application of transglutaminase-crosslinked whey protein/pectin films as water barrier coatings in fried and baked foods. Food Bioprocess Technol doi:10.1007/s11947-012-1045-9.
26. Conte A, Scrocco C, Brescia I, Del Nobile MA (2009) Packaging strategies to prolong the shelf life of minimally processed lampascioni (Muscari comosum). J Food Eng 90:199–206.
27. Del Nobile MA, Conte A, Scrocco C, Laverse J, Brescia I, et al. (2009). New packaging strategies to preserve fresh-cut artichoke quality during refrigerated storage. Innov Food Sci EmergTechnol10: 128-133.
28. Mastromatteo M, Mastromatteo M, Conte A, Del Nobile MA (2010) Combined effect of active coating and MAP to prolong the shelf life of minimally processed kiwi fruit (*Actinidia deliciosa* cv. Hayward). Food Res Int doi:10.1016/j.foodres.2010.11.002.
29. Cagri A, Ustunol Z, Ryser ET (2004) Antimicrobial edible films and coatings. J Food Prot 67: 833-848.
30. Pranoto Y, Salokhe V, Rakshit KS (2005) Physical and antibacterial properties of alginate-based edible film incorporated with garlic oil. Food Res Int 38: 267-272.
31. Eswaranandam S, Hettiarachchy NS, Meullenet JF (2006) Effect of malic and lactic acid incorporated soy protein coatings on the sensory attributes of whole apple and fresh cut cantaloupe. J Food Sci 71:S307-313.
32. Rojas-Graü MA, Soliva-Fortuny R, Martín-Belloso (2009) Edible coatings to incorporate active ingredients to fresh-cut fruits: a review. Trends Food Sci Technol 20: 438-447.
33. Peiyin L, Barth MM (1998) Impact of edible coatings on nutritional and physiological changes in lightly-processed carrots. Postharvest BiolTechnol14: 51-60.
34. Barry-Ryan C, Pacussi JM, O'Beirne D (2000) Quality of shredded carrots as affected by packaging film and storage temperature. J Food Sci 65: 726-730.
35. Mastromatteo M, Conte A, Del Nobile MA (2012) Packaging strategies to prolong the shelf life of fresh carrots (Daucus carota L.). Innov Food Sci Emerg Technol 13: 215-220.
36. Shon J, Choi Y-H (2011) Effect of edible coatings containing soy protein isolate (SPI) on the browning and moisture content of cut fruit and vegetables. J Appl Biol Chem 54: 190-196.

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