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REVIEW ARTICLE

Edible Film and Coating Applications in Fruits and Vegetables

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ABSTRACT

Different preservation and packing techniques are applied to maintain quality and safety during food transportation and storage. Changing in world and increasing consumer demands led to new techniques and procedures in packing. Light, easy opening, eco-friendly, bioplastic and edible packaging materials are improved to resolve problems that occured nowadays. Edible packaging material are environment-friendly because they decompose quickly in nature even if don't consume. In addition edible films increase food's organoleptic properties and support nutritional values when used with inserted supporting member. Fruits and vegetables are high sensitive product; therefore, attention should be paid while transporting and storing and they must be packed in the right way. . Delaying ripening and reducing loss of weight in fruit and vegetable could be supplied with edible films and coatings.

Meyve ve Sebzelerde Yenilebilir Film ve Kaplama Uygulamaları

ÖZ

Gıdaların taşınması ve depolanması esnasında kalite ve güvenliğinin sağlanmasında faklı muhafaza ve ambalaj teknikleri uygulanmaktadır. Modern dünyadaki değişim ve artan tüketici istekleri ambalajlamayı çağdaş tekniklere ve işlemlere itmiştir. Özellikle günümüzde var olan sorunları giderebilmek için hafif, kolay açılabilen, çevreye duyarlı, bioplastik ve yenilebilir ambalaj materyalleri geliştirilmiştir. Yenilebilir ambalaj materyalleri çevre açısından ideal bir ambalajdır. Nitekim tüketilmeseler dahi doğada hızlı bir şekilde parçalanmaktadırlar. Ayrıca içine eklenen komponentlerle desteklenerek uygulandığı gıdanın organoleptik özelliklerini artırmakta ve beslenme değerini de desteklemektedirler. Meyve ve sebzelerde oldukça hassas ve nazik ürünlerdir. Dolayısıyla bunlar taşınırken veya depolanırken çok dikkat edilmeli ve mutlaka en doğru ambalajlar ile ambalajlanmalıdırlar. Yenilebilir filmler ve kaplamalar ile kaplanmış meyve ve sebzelerde olgunlaşma geciktirilebildiği gibi ağırlık kaybında da azalmalar sağlanabilmektedir.

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Introduction

In parallel to increase the product diversity, consumers' demands also tend to change. It is important that the products should be produced in a good quality and under hygienic conditions when changing consumer demands, consumer awareness and food bioterrorism considered.(Üçüncü, 2011; Öksüztepe and Beyazgül, 2015). During storage and marketing process of foods, packing is an important step to protect their sensory, nutritional and hygienic properties. Packing is wrapping goods or placing them in containers using protective materials in order to preserve the goods, to increase their performance and to make them carry out their informing functions. (Üçüncü, 2011). In order to preserve food quality and safety during the period between production and consumption; **G**lass, paper, cardboard, paperboard, aluminum and various type of plastics can be used as packing material (Hecer, 2012 ; Öksüztepe and Beyazgül, 2015). All these materials lead to chemical migration into food at different rate in accordance with the characteristics they have (Öksüztepe and Beyazgül, 2015).As a result of migration, the substances which are harmful to human health migrate from packaging material into food and this requires a packaging material that is as safe as the food (Altuntaş, 2014).

Packing materials are separated into two groups which are synthetic and edible. Synthetic packings are usually petrochemical based and although they are effective in preserving the product and mostly preferred in the industry, it is recomended that the usage of these packing should be reduced due to environmental pollution and migration problems (Ertugay and Sallan, 2011). Edible packagings that obtained from animal and herbal resources, have been offered as alternative to those packings, (Mellinas et al., 2015 ; Yıldız and Yangılar, 2016) and could be used in different foods such as fruits and vegetables, dried nuts, meat and meat products, cereal and dairy products (Işık et al., 2013). Fruits and vegetables may decay quickly as the water content of those products are high leading to respiration and transpiration (Keleş, 2011). Thus, packing of those is important.

Edible Films and Coatings

The thin layer which is created by edible materials to cover the foodstuff is called edible coating, shaped previously and can be placed on or between food ingredients is called edible film. Edible coatings are in liquid form and applied to the product by plunging it into the solution . Edible films are shaped like solid sheet and then applied by wrapping around the product (Falguera et al., 2011).

Edible films are defined as thin protein, polysaccharide and lipid based layer created between food ingredients or on food surface in order to maintain quality, prevent spoilage, prolong the shelf life and protect sensory properties of food (Yılmaz et al., 2007; Dursun and Erkan, 2009; Aldemir, 2013). In addition to providing barrier properties, these films maintain product quality, biodegradable, consumable, and could be applied at different technologies. When edible coating material is produced, the following point should be considered (Işık et al., 2013):

1. The raw materials should be reliable.
2. It should allow product respiration to be under control.
3. It should provide structural integrity and facilitate mechanical processing.
4. It should combine additives.
5. It should prevent or reduce microbial degradation.

According to the materials that are made from edible films and coatings are generally separated into 3 groups: proteins, polysaccharides and lipids (Falguera et al., 2011; Duran, 2013).

Protein

Proteins with a structure providing a number of functional properties have the potential to form bonds in different positions and to be able to make numerous bonds. As a result of, mechanical properties of protein based films are better than polysaccharid and lipid based films. Besides being used as a film for the product (Duran, 2013), they also increase the nutritional value of the food they are coated with (Bourtoom, 2009). Due to hydrophilic nature, water barrier and mechanical properties of protein films are weaker than synthetic polymer films (Bourtoom, 2009; Duran, 2013).

In this group; animal origin casein, whey protein concentrate and isolate, gelatin, egg albumin, and vegetative corn, soy, wheat, cotton seed, rice and peanut are included (Mellinas et al., 2015).

Polysaccharide

Polysaccharide films show hydrophilic characteristic. Although their highmoisture permeability, their gas permeability is low and they can easily stick on cross sections of fruits and vegetables (Duran, 2013). Cellulose, starch, pectin, seaweed extracts (alginate, carrageenan and agar), gums (acacia, guar), pullulan and chitosan are included in this group (Mellinas et al., 2015).

Lipid

These coatings show a good barrier property against water vapour due to their hydrophobic characteristics. Lipid materials do not stay in a proper fixed positions by themselves as they are unable to polymerise (Duran, 2013). They are used to give brightness on surfaces of fruits and vegetables (Işık et al., 2013). Animal and vegetable oils (coconut, peanut, palm, cacao, butter, fatty acids and mono-, di- triglycerides), waxes (candelilla, carnauba, beewax, jojoba and paraffin), natural resins (gum, guarana and olibanum), basic fatty acids and their extracts (mint, camphor, essential oils of citrus fruits), emulsifiers and surface active agents (lecithin, fatty acids) are included in this group (Mellinas et al., 2015).

Other than basic 3 groups, composite or mixed films formed by different formulations of polysaccharides, proteins and lipids can be created (Işık et al., 2015) Thus, the quality is improved by combining different film components in one single coating (Kandemir, 2006).

Application Methods of Edible Films and Coatings to Foods

Edible films and coatings can be obtained and applied to foods in different ways (Doğan, 2013). In creating film coatings; simple joining, complex joining and gelation mechanisms are used (Kandemir, 2006). In application of edible films to fruit and vegetables, immersion method and spraying method are commonly used.

Immersion method is the dipping food product in coating solution, draining excess coating material on product surface, providing the formation of film and allowing them to dry at room conditions or in a dryer (Işık et al., 2013; Yıldız and Yangılar, 2016).

Spraying method is commonly applied by high pressure spray applicators or air blast systems in order to coat a certain part of the product's surface or obtain a uniform thin layer (Işık et al., 2013). The electro-spraying is one of the spraying method technique, and not well known for food application (Khan et al., 2012). It has many advantages such as being able to obtain droplets which are quite small and have narrow size distribution and being a single-step, easy operable and cheap method. In this method, the liquid flowing out of the capillary sprayer is held under high electrical potential to provide a pushing force that allows a distribution in the form of very tiny droplets (Badıllı and Tarımcı, 2009). Spraying is a suitable method for lipid-based films and coatings (Khan et al., 2012).

In addition to immersion and spraying methods, the pouring method is applied by pouring the film solution onto the region to be coated, the dripping method which is based on the technique to apply the coating material to foodstuff from above in drops and then drying the food on the rotating brush bearings by the help of fans, foaming method which the foam applied to foodstuff moving on the cylinder is distributed on the surface by the help of brush; are the other possible methods of forming edible coatings on the surfaces of food (Işık et al., 2013).

Advantages of Edible Films and Coatings

- Improving the appearance by providing brightness to the surface of fruit (Ayhan, 2013)
- Reducing losses of weight (Yaman, 2013; Ütük, 2016)
- Protecting fruit texture (Çetin, 1999; Yaman, 2013; Salinas-Roca et al., 2016)
- Reducing respiration speed and ethylene production and thus delaying the ripening (Dhall, 2012)
- Protecting fruits and vegetables from chilling injuries, providing basis for post-harvest chemical applications and reducing the usage of synthetic materials (Dhall, 2012)
- Reducing microbiological degredation (Aguayo et al., 2016; Villafañe, 2016; Guerreiro et al., 2017)
- Protecting aroma components, vitamins and antioxidants (Pagliarulo et al., 2016), anthocyanins (Badawy et al., 2017), pigments and reducing their browning reactions (Guerreiro et al., 2017; Supapvanich et al., 2016)
- Improving the organoleptic properties of coated food by incorporating various additives such as flavour, pigments and sweeteners (Hashemi et al., 2016)

Disadvantages of Edible Films and Coatings

In application of edible films and coatings; factors such as allergic reactions, food safety, cost increase, lack of information and machine using, scarcity of the material could be used, need for a second packing material in most cases for consumer health because they have lesser physical and chemical resistance compared to petroleum-derived materials, less inhibition of migration resulting in a limited product diversity; are among the encountered disadvantages (Dhall, 2012).

Applications in Fruits and Vegetables

In a study on pomegranate arils coated with chitosan and ascorbic acid mixture and stored at 5±1 ^{0}C , no significant difference was observed in sugar, anthocyanin and organic acid compound compared to the control while it was reported that coating material helped protecting the material color, delayed bacterial and fungal development until day 21 and flavor, aroma and color parameters were at acceptable level on 25th day (Özdemir and Gökmen, 2017).

Minimally processed apples with different edible films were packed in polystyrene plates and coated with PVC films.

At the end of storage process at 4 ^{0}C for 13 days, it was reported that turnip extract could be an alternative coating for its properties such as being natural, easily obtained, cost effective and contributing to nutritional quality, (calcium ions having a resource etc.) (Borges et al., 2016).

Khalifa et al. (2016) investigated the applicability of olive oil wastes combined with chitosan films on apple and strawberry; it is seen that microbiological properties of both fruits is reduced and their inhibition characteristics is improved against pathogenic strains and spoiling, and is recommended as a natural edible coating for apple and strawberry.

It was demonstrated that microbiological development was inhibited by coating fresh-cut apple, potato and carrot with edible coating consisted of whey protein/pectin film and transglutaminase, and on the other hand carrot's carotenoid and phenolic contents were also protected. Moreover no changing in hardness and chewiness was observed' (Marquez et al., 2016).

Strawberry (*Fragaria ananassa*) and japanese plum (*Eriobotrya japonica*) fruits were coated with different tree resin film solutions, and it was reported that shelf life of the coated fruits extended, their aromas did not change, their appearances improved and the best practice was coating with cherry tree resin (Ergin, 2015).

In the study conducted by Örnek (2015), natural coating was applied on two different types of nectarine where nectarines were stored at 0-1 ^{0}C temperature and 90-95% relative humidity for 25 and 50 days, and some quality properties were examined such as fruit flesh hardness, brix, amount of titrable acidity, pH, peel and pulp of fruit, loss of weight, rate of wooliness, fungal or bacterial spoiling rate, total amount of phenolic compound. It was stated that sucrose ester (1% and 2%) application was the most effective application in terms of all parameters other than fungal or bacterial rotting which is followed by Aloe vera (4%), and that lecithin (2%) application was also effective.

In another study on preservation the quality of fresh-cut nectarines were reviewed, it was observed that sodium alginate prevented loss of hardness and reduction of titrable acidity and delayed browning as well as inhibited PPO activity throughout the storage. Besides, it was observed that chitosan coating reduced development of mould and yeast (Chiabrando and Giacalone, 2016).

In another research, minimal processed indian fig was coated with the edible films named Food coat and Pomfresh, and stored in easy opening polylactic acid packing (biodegradable polymer) at 4 ^{0}C for12 days. Consequently, it was reported that Pomfresh coating was more successful than the other applications in prolonging shelf-life and preserving nutraceutical effects (Palma et al., 2015).

Chrysargyris et al., (2016) got positive results in post-harvest storing of tomatoes by applying different concentrations of aloe vera gel in tomatoes. In order to prevent mold growth in tomatoes, adding savory oil to pectin film prevented the development of *Alternaria alternata*, and increased antioxidant activity compared to control samples at the end of storing without making any negative effect on sensory properties of tomatoes.

Wang et al. (2015) coated fresh-cut carrots with a film consisted of carrot mash, chitosan, corn starch, gelatin, glycerol and cinnamaldehyde, and it was consequently determined that ripening was delayed, defects on outer view decreased and total carotenoids were kept compared to control samples.

After edible coating treatment to broccoli, carrot, cauliflower, zucchini, celery, carrot and chayote vegetables (2% low methoxyllated pectin, 1% carnauba wax, 1.5% glycerol and 0.05% ascorbic acid), heat treatment was applied for 2 min at 60 ^{0} C and at the end, it was observed that vegetables protected their sensorial qualities (Hernández et al., 2014).

After irrigating the mushrooms with malic and citric acid, Sedaghat and Zahedi, (2012) coated them with emulsified gum arabic and it was observed at the end that loss of weight and hardness reduced.

In another study, effect of chitosan, glucose and chitosan-glucose complex effect on the quality of shiitake mushroom was examined; it was seen that effect of chitosan-glucose complex protected the texture hardness, reduced respiration rate and microorganism load as well as delayed the change in the contents of ascorbic acid and water soluble dry matter (Jiang et al., 2012).

It was determined that 10% sodium alginate edible film application to Welsh onion (*Allium fistulosum L.*) showed positive effects on properties of edible film such as loss of weight, pH, titrable acidity (Rozo et al., 2016).

Conclusion

Edible films and coatings are useful practices in terms of producer, consumer and environment. Its capacity to be applied in different forms and the capacity of coating materials in different rates to increase each other's effects by being mixed increases their using opportunity in food industry. Furthermore, their replacing of chemical origin package materials create positive effects both on environment and on people. By this application, in perishable and aspirating products like fruits and vegetables, both ripening is delayed by reducing the respiration and shelf life can be prolonged. With developing technology, the works for producers regarding in which amount and how different edible film and coating materials shall be applied to different fruits and vegetables should be increased. Thus, it will be possible to produce cheaper and less harmful edible films and coatings which will facilitate consumers to access more quality, healthy foods with long shelf-life.

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Alınteri