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EDIBLE FILMS AND COATINGS: A GOOD IDEA FROM PAST TO FUTURE TECHNOLOGY

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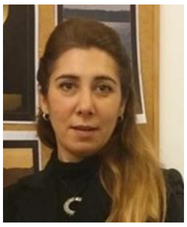

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ABSTRACT

Scientific studies carried out on the use of thin layer edible films and coatings which can be consumed with food, are still maintained today. Edible films and coatings help to preserve the sensory qualities such as taste, aroma and appearance in various food products, prevent oxidative rancidity in meat and products, delaying ripening in fruits and vegetables, keep pigments in food products and extend shelf life in foods. Over the years, a variety of methods have been developed for the application of coatings to food as a result of scientific research conducted on the subject. In the production of these films and coatings, polysaccharides, proteins, lipids are being used as the main components. Resins are used to prevent water vapour permeability in all these used materials, solvents to effect tensile strength, and plasticizers to provide flexibility and permeability. Further studies were needed to be done on topics such as increasing the variety of foodstuffs that can be applied coatings food safety, the development of technological applications and the reduction of costs.

Contribution/Originality: This study documents the recently research studies related with edible films and coatings that promising packaging alternative

1. INTRODUCTION

Packaging materials carry mainly the aim to protect the food materials from surrounding effects and environmental conditions. Over the last years, considerable research has been conducted to improving the idea to apply edible films and coatings in food industry as an alternative packaging system and for providing food safety and food quality (Campos *et al.*, 2011; Işık *et al.*, 2013). The reason of big interest and research activity in edible packaging system is due to the rising consumer preference for healthy and stable foods and also the awareness concerning to the harmful effects of synthetic packaging (Hassan *et al.*, 2018). Edible coatings and films do not pretend to replace traditional packaging materials but to provide an additional help for food preservation and to reduce the cost also the amount of traditional packaging materials (Campos *et al.*, 2011). This alternative packaging system is a good matrix as carrier of antimicrobial agents and brings several advantages against conventional coatings, such as better spreading, diffusivity and solubility (Ramos *et al.*, 2012). Edible films and coatings are defined as a skinny layer for primary packaging of foods including edible components (Hassan *et al.*, 2018). They are capable of providing moisture and gas permeability in foods and can be consumed with food. There is a slight difference in the definition of coating and film in terms of their technology. An edible coating is a thin layer of edible material formed as a coating on a food product, while an edible film is a preformed thin layer, made of edible material, which can be placed on or between food components (Kang *et al.*, 2013; Espitia *et al.*, 2014). The edible coating is liquid in which the food is immersed and the edible film is as solid sheets which is applied as a wrapping the food products (Tavassoli-Kafrani *et al.*, 2016). Edible film and food coatings provide many advantages in the packaging of food products. These advantages can be summarized as improving some of the properties such as flavor components and color, reducing moisture and weight loss, inhibiting oxidative rancidity at high levels of fat content foods such as meat and meat products, being new and attractive for the consumers. Also they can be used as carriers for oxygen and antimicrobials such as lysozyme, nisin, potassium sorbate, EDTA. Besides these advantages, some disadvantages must be taken into account. There may be undesirable photochemical reactions in the case of exposure to light, the high application costs as well as the low number of materials that can be used in the applications (Işık *et al.*, 2013; Oğuzhan Yıldız and Yangilar, 2016). The first recordings of edible films and coatings belong to the 12th and 13th centuries, made in China by wax and applied to oranges. A type of edible film and coating called Yuba, was being obtained by boiling soybeans in Japan in the 15th century and were used to improve the appearance of food products (Tural *et al.*, 2017). The concept of employing edible films and coatings for foods in industrial practice dates back to 1950s (Tavassoli-Kafrani *et al.*, 2016). Apple sugars, chocolate coated candies, edible wax-coated cheeses, edible collagen casings for meat products are some of the examples for edible film and coating varieties which are being used for a long time (Oğuzhan Yıldız and Yangilar, 2016). New objectives have been added for intended use of edible films and coatings as the result of ongoing development studies for these products. Examples for those objectives are to improve the sensory properties of food, to increase the shelf life, to control the permeability of water or gas, to protect the food against microbiological and chemical degradation (Çağrı-Mehmetoğlu, 2010). Edible films and food coatings should carry some common and optimal characteristics which the researchers agree on. Pavlath and Orts (2009) summarized these characteristics as follows: "Contain no toxic, allergic and non-digestible components • Provide structural stability and prevent mechanical damage during transportation, handling, and display • Have good adhesion to surface of food to be protected providing uniform coverage • Control water migration both in and out of protected food to maintain desired moisture content • Provide semi-permeability to maintain internal equilibrium of gases involved in aerobic and anaerobic respiration, thus retarding senescence • Prevent loss or uptake of components that stabilize aroma, flavour, nutritional and sensorial characteristics necessary for consumer acceptance while not adversely altering the taste or appearance • Provide biochemical and microbial surface stability while protecting against contamination, pest infestation, microbe proliferation, and other types of decay Maintain or enhance aesthetics and sensory attributes (appearance, taste etc.) of product • Serve as carrier for desirable additives such as flavor, fragrance, colouring, nutrients, and vitamins. Incorporation of antioxidants and antimicrobial agents can be limited to the surface through use of edible films, thus minimizing cost and intrusive taste. • Last but not least – be easily manufactured and economically viable"

This review presents an overview of the existing studies about edible films and coatings and highlights the possibility of usage these materials as an alternative packaging system.

2. TECHNOLOGICAL ASPECTS IN EDIBLE FILM AND FOOD COATINGS APPLICATIONS

Mainly five methods are being used to apply the edible films and coatings to products in food industry. Those are; dipping, brushing, spraying, solvent casting and extrusion methods (Dhanapal *et al.*, 2012; Tural *et al.*, 2017). In order to select method of applying firstly wettability values of the coating formulations should be evaluated then the values of other relevant properties (e.g. high or low water vapor, oxygen or carbon dioxide permeability, good mechanical resistance, etc.) should be determined depending on the kind of food and on the desired effects (Dhanapal *et al.*, 2012). *Dipping* is accepted as a common method for applying coatings on fruits and vegetables. The coating is made by dipping the food in a coating solution with properties such as density, viscosity and surface tension, as well as food withdrawal speed from the coating solution (Dhanapal *et al.*, 2012). Brushing is applying the coating material on the surface of food with the help of brush in industrial or conventional scale. The brushing method for the application of film solution to fresh beans and strawberries was found to be better than wrapping and dipping methods in terms of reducing the moisture loss (Ayranci and Tunç, 1997). *Spraying* is used if only one side of the product is to be coated or if a thin layer is sufficient. The coating material is sprayed on the surface of food. With the development of air-blowing systems, this method has become a popular method for fruit and vegetable coatings (Işık *et al.*, 2013). Spraying is the conventional method generally used when the coating forming solution is not very viscous. Nowadays, programmable spray systems are available for automation during such operations. *Solvent casting* is the most used technique to form hydrocolloid edible films. Water or water– ethanol solutions or dispersions of the edible materials are spread on a suitable substrate and later dried (Dhanapal *et al.*, 2012).

3. MATERIALS USED IN EDIBLE FILMS AND FOOD COATINGS

Besides the other benefits to use edible films and coating, it is important to take into account that they can act as a carrier of active ingredients e.g. with antimicrobial and antioxidant properties. When considered from this point of view, the diversity of materials that can be used in coating systems is also increasing. The performance of edible films and coatings is dependent on the materials used and their main characteristics such as solubility, density, viscosity, and surface tension (Costa *et al.*, 2018). As a general rule, lipids are used to reduce water transfer, polysaccharides to control the passage of oxygen and other gases, and proteins to impart mechanical strength to the films. Those materials are accepted as principal groups of ingredient to form any type of coating or film (Tural *et al.*, 2017). Besides these three main materials in coating and film production, solvent, plasticizer, emulsifier, antioxidant and antimicrobial agents are also used (Ustunol, 2009). The most important feature of many polysaccharides and their derivatives is being structurally stable and allowing the passage of oxygen slowly. They are widely used in the production of edible films and coatings due to their low cost, easy availability and good film forming properties. Starch and its derivatives, cellulose and its derivatives, alginate, pectin, chitosan and gums are used in the production of polysaccharide based edible film and food coatings (Robertson, 2013; Tural *et al.*, 2017).

Protein coatings are the least developed materials as coatings, since they are generally hydrophilic and sensitive to moisture absorption. For this reason, they are very much affected by humidity and external temperature. They have good barrier properties against mechanical durability, oxygen, carbon dioxide, aroma and lipid transfer, and are resistant to water vapor permeability. The main herbaceous proteins are corn zein, wheat protein, soy protein and proteins of animal origin are keratin, collagen, gelatin, casein, fish myofibril protein, egg white protein, protein whey protein (Tural *et al.*, 2017). Lipids are good barriers against moisture loss, effective on surface gloss of fruits and vegetables, resistant to gas and vapour passage. On the other hand, solvent and high temperature should be taken into consideration when processing lipids as a coating. Lipid compounds such as natural and synthetic waxes and glycerines are mainly lipid-based coatings (Tural *et al.*, 2017). Mixed formulations are known as heterogeneous coatings in which hydrophobic particles are present in a hydrophilic mixture. They are developed to obtain a water-soluble coating with water vapour barrier properties. The most commonly used material for making composite films is cellulose ether (Tural *et al.*, 2017). Coatings prepared with resins are effective in preserving the natural colour of the fruit, reducing water loss and preventing some physiological disorders. Water, ethanol and acetone are the most common solvents used in the production of edible films and coatings. Films obtained when ethanol is used have better tensile strength than films prepared using acetone. Solvents may exhibit better behaviour in highly humid environments. Plasticizers; are low molecular weight compounds incorporated to improve mechanical properties of the films and coatings. They affect both flexibility and tensile strength as well as permeability in film and food coatings. Other additives in edible film and food coatings are antioxidants and antimicrobials, emulsifiers, anti-browning agents, flavouring agents, colorants, antimicrobial substances and other functional ingredients (Tural *et al*., 2017). Probiotics have been also incorporated into edible films and food coatings to develop active food packaging as an alternative method for controlling foodborne microorganisms, improving food safety, and providing health benefits (Espitia *et al*., 2014). Application of probiotic to edible films and coatings provides forming a good type of functional food.

4. EDIBLE FILM AND COATING APPLICATION IN MEAT AND MEAT PRODUCTS

Meat and meat products are in the animal originated food group which is highly perishable and is needed to be taken special attention. Three mechanisms are determined in meat and meat products: microbial spoilage, lipid oxidation, and enzymatic autolysis. Depending on these facts, it is reported that there is an increased interest in the use of edible films and coatings to preserve meat quality for longer shelf life periods while maintaining food safety (Cagri *et al*., 2004; Ustunol, 2009). Antimicrobial substances included packaging can be a promising way of protecting meat from pathogens by direct contact of the package with its surface. The gradual release of an antimicrobial substance from a packaging to the food surface for extended period may be more advantageous than incorporating the antimicrobial into foods (Ye *et al*., 2008). Usage of this packaging system in meat and meat products dates back to old years. In England lard or fats were used coating for extending shelf life of meat products in the 16th century. This process was also known as "larding" in Europe. In the nineteenth century, a US patent was issued in relation to preservation of meat products by gelatine coatings (Cagri *et al*., 2004; Sánchez-Ortega *et al*., 2014). Detailed data was given on practical application and research results of edible films and coating usage in meat product in the review paper of Cagri *et al.* (2004). Dursun and Erkan (2009) stated in their study that, the shelf life of aquaculture products could be extended with coatings obtained from vegetable or animal protein sources. Kilincceker *et al.* (2009) observed that the sensory properties of salmon filet coated with edible film from gluten, xanthan, wheat and corn were positively improved. In another research it was concluded that, no significant change was obtained in the natural flavour characteristics of the products, a decrease was detected in the total number of viable cells and the shelf life was prolonged in meat and meat products which were coated with chitosan-based coatings (Baranenko *et al*., 2013). Abdallah *et al.* (2017) reported that a reduction in moisture content, total viable, yeast and mould counts was observed with the application of chitosan-based edible film and coating on pastrami samples.

5. EDIBLE FILM AND COATING APPLICATION IN MILK AND MILK PRODUCTS

This alternative packaging system is being researched to be used especially with variety types of cheeses. Yeasts, moulds and bacteria may occur on cheese surface due to the external environmental conditions, which considerably reduce cheese quality and demands for the development of tailored packaging materials to avoid spoilage (Fajardo *et al*., 2010; Costa *et al*., 2018). As an alternative packaging of cheeses edible coatings and films provide development in organoleptic and nutritional properties of cheese and extension of shelf life of the product due to the composition of edible film and coating that used (Artiga-Artigas *et al*., 2017). Costa *et al.* (2018) have provided detailed information in their review paper about researches on edible films and coating usage in cheese technology. Ayana and Turhan (2009) reported that the number of *S. aureus* was reduced by 24.5% in kashar cheese slices coated with methylcellulose films containing olive leaf extract. Fajardo *et al.* (2010) noted that the application of chitosan coating containing natamycin to semi-hard saloio cheese, reduced mould and yeast growth and prolonged the shelf life. Di Pierro *et al.* (2011) stated that chitosan and whey based edible film and coating can extend the shelf life, inhibit the proliferation of microbial contaminants and delay the development of undesirable acidity of ricotta cheese. They also concluded that no change in the organoleptic characteristics was occurred in the product. In another study conducted by Mei *et al.* (2013) microbiological growths were reported to be delayed in Mongolian cheese by adding perillium oil to edible starch-chitosan film. Also it is concluded that weight loss was decreased and shelf life was prolonged. Coatings prepared by adding chitosan, sodium alginate and soy protein isolates were tested on mozzarella cheese and the results of physicochemical analysis of cheese samples coated with sodium alginate were reported to be better (Zhong *et al.*, 2014).

6. CONCLUSION

Due to their edibility, edible coatings and films are a promising investment as an alternative packaging system to the existing conventional and synthetic materials based packaging systems existing petroleum-based coatings that are used in cheese surface protection.

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