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Increasing Shelf Life of Fruits and Vegetables with Combined System of Modified Atmosphere Packaging and Edible Films Coating

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Abstract

After harvest, fruits and vegetables continue to loss their quality under the influence of their ongoing vitality and physical factors occurred during transport, storage and shipment. To bring an alternative and novel solutions to shelf life problems of foods, modified packaging technology (MAP) was developed both for consumers who conscious about food safety and manufacturers who seek products with longer shelf life. MAP is conducted in two ways as active and passive MAP. The more commonly applied active MAP technology involves the aplication of various combinations of gases (N_2, O_2, and CO_2) suitable to type of the product and packaging material. In recent years, MAP has begun to be used with edible film coating. In this way, the permeability of the packaging material is minimized; the microbial, physical and physicochemical degradation of foods can be prevented or decreased and both the aroma-flavor-structures and the quality of the products can be improved. This will have a significant advantage, especially in exports, because it provides a longer shelf life for crops. In this review, the principle of combined system of MAP and edible coating technology, its applicationin to different type of fruit and vegetables and its effects on the quality of the products are aimed to be explained.

Keywords: Edible films and coating, fruit and vegetables, MAP technology.

INTRODUCTION

Packaging is considered to be the first stage in the shelf life of the product, although it is the last process of production. Packaging protects food from external influences such as moisture, light, oxygen, mechanical deformation and rodents. It is the material that protects against the microbial and chemical deterioration; and used to keep the quality of the product until reaching the consumer. The common used packaging materials include wood, glass, paper, plastic, tin or aluminum selected according to the product variety (Robertson, 2013).

There are many recent technologies available for the food packaging. These technologies include vacuum packaging, intelligent and active packaging, modified atmospheric packaging, and application of nanotechnology in to packaging systems (Robertson, 2013; Ahmed et al. 2017). In the vacuum technology, the gas in the product is completely removed and the product is delivered to the consumer after packaged (Robertson, 2013). In intelligent packaging technologies, gas, temperature, humidity, microbial growth and pathogen indicators are added to the package to provide intelligent functionality to the product and to follow the product throughout its shelf life (Roya and Elham, 2016). With the use of nanotechnology, nanomaterials, suitable for foods and compatabile with the regulation, have been added to food and packaging to achieve a shelf-life-enhancing effect (Mihindukulasuriya and Lim, 2014).

When all this packaging method is examined, the superior and positive features of MAP technology have been also revealed and it has proven that modified atmosphere packaging technology has an effect on the shelf life of fruit and vegetables (Oliveria 2015), therefore it has been increasingly used worldwide. In the modified atmosphere packaging method, the gas component in the product is removed from the package and CO_2, O_2 and N_2 gases are supplied to the product in appropriate proportion (Oz and Sufer, 2016; Gaikwad and Lee, 2017; Harris et al. 2017). In MAP technology, CO_2 is used to prevent microbial growth in food products, hence prolonging shelf life of foodswhile maintaining its freshness, N_2 gas is used to prevent oxidation and vacuum conditions in the package as an inert gas and O_2 is usually set at a low level to inhibit growing of anaerobic bacteria and prevent oxidation (Oliveira et al, 2015).

MAP can be combined with chemical treatments including calcium chloride and sitric acid to increase the shelf life of crops by prolonging some of the quality parameters. Calcium chloride is reported to increase the firmness of fruit and vegetables (Martin-Diana et al. 2007). In a study, papaya fruits were immersed in calcium chloride and citric acid solution following packaging at modified atmospheric conditions of 5% O_2, 10% CO_2 and 85% N_2 and storing at 5 °C for 25 days. It was reported that shelf life of coated and MAP packaged fruits increased 25 days more compared to fresh fruits (Waghmare and Annapure, 2013).

Resecent years, MAP has also been successfully combined with the edible film coating technology to increase the shelf life of foods. The processed, unprocessed or minimally processed foods are first coated with an edible film. Then the modified atmosphere packaging process is applied. In this way, the permeability of the packaging is minimized; the microbial, physical and physicochemical degradation of foods can be prevented and both the aroma-flavor-structures and the quality of the products can be improved. This will have a significant advantage, especially in exports, because it provides a longer shelf life for crops (Ghidelli and Pérez-Gago, 2016; Wilson et al. 2017).

In this review, the principle of combined system of MAP and edible coating technology, its application in to different type of fruit and vegetables and its effects on the quality of the products are aimed to be explained.

EDIBLE FILM COATING TECHNOLOGY

Edible coatings are defined as *"the thin layers of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings and to provide a barrier to moisture, oxygen, and solute movement for the food"* (Dhall, 2012). Edible film coating technology is a technology aimed to extend the shelf life by retarding some quality parameters of fruits and vegetables (Chaple et al. 2017; Bal and Kocak, 2016; Gomes et al. 2017), including browning (Lee et al. 2003) and by compressing the factors needed for growth of microorganism without using chemical preservatives. After coating, a thin layer is formed on the outer part of the food.

In coating technology, many plant and animal originated agents derived from lipids, polysaccharides and proteins are used both as a single material and as a mixture. In terms of their function, lipid derived agents including waxes and glycerides are used to reduce water transfer, while polysaccharide derived agents including starch and its derivatives, cellulose and its derivatives, alizinate, pectin (Sanchis et al. 2017), chitosan (Severino et al. 2015), gums are used to control the passage of gas. Protein derived agents including keratin, collagen, gelatin, egg white protein, casein, whey protein, wheat gluten, soya protein are preferred in order to increase the strength of the films.

In addition, solvents such as water, ethanol, acetone, plasticizer, emulsifier, flovoring, colorant, antioxidant and antimicrobial agents are used (Yildiz and Yangilar, 2016; Tural et al. 2017; Dhall, 2012; Marquez et al. 2017).

There are four main different methods reported in the literature regarding coating techniques. In the dipping method, a layer is formed on the surface of the food following immersion in to the solution of the coating agent. It cannot be considered as an advantageous method for large surface foods. Spraying method is based on coating of the surface as a thin layer by a sprayer device. Although the method can be considered as advantageous based on the principle of completely covering the surface, it has also disadvantageous since it consumes more coating material than usual. In the dyeing method, the coating of the food is performed by painting its surface with a liquid coating solution. Short drying time and completly covered product can be given as an example to its advantageous features. In the pouring method, a proper solution in a desired thickness is pouredon a smooth surface, and then the film is formed following spreading and drying the solution. The method has disadvantageous of consumption of more coating material. The extrusion method is based on the thermoplastic properties of polymers. In this method, plasticizers such as polyethylene, glycol and sorbitol are added to the polymers at ratio ranging from 10% to 60%. It can be considered more proper for industrial applications than other methods, due to not requiring drying process and solvent addition (Dhall, 2012; Yildiz and Yangilar, 2016; Tural et al. 2017; Guillen et al. 2007).

COMBINED APPLICATION OF MAP AND EDIBLE COATING

The combined effect of mixture of essential oils including eugenol, thymol, and carvacrolas an edible film and MAP on the quality of the product including weight loss, color changes and firmness was investigated for grapes. The samples tretaed with combined system of MAP and edible film coating were compared with the control samples, and it was observed that the stems were green in the samples treated with combined MAP and edible film, whereas they were brown in the control samples. Moreover, it was observed that the microbiological count decreased (Guillen et al. 2007).

Avci (2016) studied the combined system of Aloe veragel coating and MAP packaging as a postharvest treatment for Black Amber plum cultivar, the combined system was compared with fruits packaged under modified atmospheric conditions without coating and control fruits non-treated with neither of the methods. Weight loss, respiration rate, oxygen and carbon dioxide gas concentration, ethylene production, fruit flesh hardness, fruit shell and flesh color and decay rate were investigated as quality parameters, moreover the changes in total pehnolics, antioxidant activity, and total flavonoid content were studied. During cold storage and shelf life of fruits, decrease in weight loss was observed in both coated and uncoated fruits packed under modified atmospheric conditions. On the other hand, weight loss was found higher in fruits just coated with Aloe vera gel without packaging. Compared with the control samples, approximately 70% lower ethylene production was measured during storage of the fruits coated with Aloe vera gel and packaged under modified atmosperic conditions, while approximately 35% lower ethylene production was measured in fruits packed under modified atmospheric conditions but uncoated with Aloe vera gel. It was concluded that all MAP applications in the study showed more positive effect on the preservation of quality characteristics and biochemical content of the fruits during cold storage and shelf life periods.

Despite of the positive expectation on the method including coating fruits with Aloe vera gel alone in the light of the previous reported studies for other type of fruits, the results indicated that the treatment was not advantageous compare to untreated control samples of plum. Therefore, it was recommended to carry out future studies with different concentrations of Aloe vera gel.

When the combined effect of coating with chitosan and sodium chloride and MAP conditions including 10% CO_2 and 10% O_2 on the quality characteristics of minimally processed Pomelo fruit was investigated, the combined application inhibitated the microbial growth in fruits, reduced weight loss, kept sensorial quality of the fruits (Ban et al. 2015).

A study on two different types of avocado fruit was conducted by combining MAP (8% CO_2, 2% O_2) and thyme oil coating technology. Coated and packed fruits were allowed to be maturated for 5-10 days at 25 ºC following the storage period of 10 ºC for 18 days. The effects of the application on quality parameters of fruit including color, firmness, weight loss, sensory properties including taste, texture, aroma and general acceptability, total phenolic compound content, flavonoid content and antioxidant activity were investigated in the study. At the end of the storage period; the applied conditions increaased total phenolic compound content, flavonoid content and antioxidant activity, and decreased weight and firmness loss Moreover,taste, texture and aroma were also maintained (Sellamuthu et al. 2013).

In the study with sliced melon, application of vanillin and cinnamic acid in an aqueous solution and their combinations with active MAP technology were investigated. It was stated that both antimicrobial agents were effective especially against mesophilic bacteria and Enterobactericeae. The use of MAP in combination with cinnamon was recomended to be a new approach for the industry as it would bring a new perspective to obtain safe product (Silveira et al. 2015).

Carrots which is a source of beta carotene were coated with chitosan through the use of spraying and dipping techniques. Following the coating, baby carrots were packaged under modified atmospheric conditios and stored at 4 °C. The study revealed that the combined application postponed the microbial decay while keeping the colour and texture acceptable (Leceta et al. 2015).

The other study on carrot conducted by Guimaraes et al. (2016) included coating fresh cut-carrots with natural smectite montmorillonite (MMT) and starch followed by a passive MAP. The dispersal of MMT clay was dispersed as nanoparticiles into edible coating of starch in order to change its barrier properties to decrease the mass transfer from fruits and vegetables. The study revealed that combined system of coating film with starch nanoparticles and a modified atmosphere preserved the total antioxidant activity, the volatile and organic acids of the carrots.

Severino et al. (2015) studied the antibacterial activity of chitosan based nanoemulsions of essential oils including carvacrol, mandarin, bergamot and lemon essential oils, gamma irradiation, modified atmosphere packaging (MAP), alone or in combinations, against Escherichia coli O157:H7 and Salmonella Typhimurium inoculated in grean beans. To modify citosan, it was N-acylated using palmitoylchloride. The most effective antibacterial agent among these emulsions was reported as carvacrol. It was observed that the combined treatment of antimicrobial coating, gamma irradiation and MAP caused the reduction of microbial population to undetectable levels duringthe whole storage period for E. coli and from day 7 to the end of storage for S. Typhimurium.

Ginseng is consumed as food supplement. Due to sensitivity to environmental degredation, fresh ginseng was studied by Jin et al. (2016) to increase its shelf life by application of edible antimicrobial coating and MAP technology in comination. The study results proved that using chitosan 0.5% with multiple organic acids including lactic, levulinic and acetic acids as edible films extended the shelf life more than thirthy eight weeks if they were packed by MAP.

Oz and Sufer (2016) studied on fungi by immersing it in alginate solutions at different concentrations (1%, 2% and 3%) for 2 minutes. Coated samples were then packed with 100% O_2 (high oxygen modified atmosphere) and store for 16 days at 4 °C. The optimum experimental condition was selected as 2% alginate concentration. The findings showed that the method decreased the formation of browning reactions; moreover the shelf life of fungi was extended to 16 days.

Sanchis et al. (2017) studied the effect of a pectin-based edible coating and low oxygen MAP on controlling enzymatic browning and reducing microbial growth in fresh-cut persimmon. The treatment included the packing under 5 kPa O_2 (MAP) following dipping in to coating material. It was observed that coating application combined with active MAP significantly reduced the CO_2 emission and O_2 consumption in the package and browning of fruits decreased in addition to inhabitation of the growth of mesophilic aerobic bacteria.

CONCLUSION

Combination of modified atmospheric packaging with edible films has proved to positively affect the shelf life of fruits and vegetables. It was observed that the combined system prevented the deterioration of the fruit and vegetables and prolonged the shelf life compared the application of both technique alone. On the other hand, consumer sensory acceptance test should be carried out and the feasibility of combined applications in terms of cost should be taken in to account for industrial application.

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