International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:7, No:7, 2013

Extend of Self-Life of Potato Round Slices with Edible Coating, Green Tea and Ascorbic Acid

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***Abstract*—**The effects of coatings based on sodium alginate (S.A) and carboxyl methyl cellulose (CMC) on the color and moisture characteristics of potato round slices were investigated. It is the first time that this combination of polysaccharides is used as edible coating which alone had the best performance as inhibitor of potato color discoloration during the storage of 15 days at 4^{o}C. When ascorbic acid (AA) and green tea (GT) were added in the above edible coating its effects on potato round slices changed. The mixtures of sodium alginate and carboxyl methyl cellulose with ascorbic acid or with green tea behave as a potential moisture barrier, resulting to the extent of potato samples self–life. These data suggests that both GT and AA are potential inhibitors of dehydration in potatoes and not only natural antioxidants.

***Keywords*—**Ascorbic acid, edible coating, green tea, moisture barrier.

I. Introduction

NOWADAYS consumers have less time to dedicate in cooking and preparation of a meal and in the same time they are looking for healthier and dietary food. In their first choices of appetite are fresh cut vegetables and fruits. However, fresh-cut processing includes unit operations such as peeling, trimming or cutting that alter the integrity of the commodity's tissues and can induce wounding stress [1]. A result of such a stress in fresh cut vegetables and fruits especially in potato and apple is the browning which could lead to changes in quality features such as color and loss of nutritionals. The browning is the result of non-enzymatic and enzymatic reactions, where the tyrosine reacts with oxygen to turn polyphenols into melamine [2].

Edible coatings and films made by mixtures of edible materials are applied on fresh cut fruits and vegetables as a thin layer allowing the extension of their preservation time. Some of the functions, which these edible coatings have, are to protect quality characteristics such as color, taste, flavor, texture etc. More specific, edible films and coatings could act as carriers for food additives such as antioxidants and antimicrobial agents onto the surface of the food, preventing for example moisture absorption [3]. In this research study, edible coatings were applied in fresh-cut potato slices.

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Potato is a starchy, tuberous crop from the perennial *Solanum tuberosum* of the Solanaceae family. In the past there were four basic methods of preserving potatoes: canning, chipping, drying and freezing. In nowadays novel techniques such as the application of edible coatings on the surface of fresh cut potatoes, could extend their self-life by providing a partial barrier to water vapor and gas exchange. The principal of this technique is based on the creation of a modified atmosphere around potatoes surface, which could preserve potatoes quality characteristics [4]. The ability of water-soluble polysaccharides to reduce O_2 and increase CO_2 levels in internal atmospheres of coated fruits and vegetables reduces respiration rates, thereby extending the self-life of fresh produce in a manner similar to modified/controlled atmosphere storage. In this study sodium alginate and carboxyl methyl cellulose were used as the base of the edible coating.

Alginate is a salt of alginic acid, a biopolymer of d-mannuronic acid and l-guluronic acid. It is a hydrophilic colloidal carbohydrate extracted with dilute alkali from various species of brown seaweeds (Phaeophyceae). In molecular terms, it is a family of unbranched binary copolymers of (1→4)-linked β-d-mannuronic acid and α-l-guluronic acid residues of widely varying composition and sequential structure. Alginic acid is the only polysaccharide, which naturally contains carboxyl groups in each constituent residue, and possesses various abilities for functional materials [5], [6]. Alginate salts are biopolymers that could be considered for edible films and coatings because of their unique colloidal properties and their ability to form strong gels or insoluble polymers upon reaction with multivalent metal cations such as calcium.

Carboxymethyl cellulose CMC is a water-soluble polymer which is made up of linear β-(1 → 4)-linked glycanes with polyelectrolyte characteristics. CMC shows amphiphilic characteristics because of the chemistry of its molecule, which contains a hydrophobic polysaccharide backbone with many hydrophilic carboxyl groups. Functional properties of CMC, such as biocompatibility, biodegradability, hydrophilic, and good film-forming ability, allowed it to be used in a large number of edible film formulations. Commercial coatings based on carboxymethyl cellulose have been shown to extend shelf-life and preserve important flavor compounds of many fresh produce products [7], [8].

In many studies, edible films are used to preserve different types of fresh foods and so, film flexibility is important feature due to the variant physicochemical nature of fruits or vegetables. For this purpose glycerol is used in combination with biopolymers, as plasticizer, which improves film flexibility. The clear role of glycerol in an edible film is to increase the free volume or molecular mobility of biopolymers by reducing the internal hydrogen bonding between polymer chains and thus rising intermolecular spacing [9], [10].

Alginate based coatings and edible films have been used in several previous studies in fresh cut fruits but never in potatoes, [9]. In another study it was found that water vapor permeability was significantly higher when alginate based edible films containing glycerol, became the coatings of fresh-cut apple and papaya cylinders. Alginate films in the same research played also the role of carrier of viable bifidobacteria, demonstrating the feasibility of alginate- based edible coatings to carry and support viable probiotics on fresh-cut fruit. Also, antibacterial alginate-based edible films have been studied by incorporation of garlic oil up to 0.4% v/v as a natural antibacterial agent. These edible films and coatings were characterized for antibacterial activity against *Staphylococcus aureus* and *B. cereus*, water vapor permeability, mechanical and physical properties [11]. Finally, from the above experiments, it was revealed that garlic oil, had a good potential to be incorporated into alginate in order to make antimicrobial edible films or coatings for various food applications.

The objectives of this study were to investigate for the first time a) the effects of edible coating based on Sodium Alginate (S.A.) and Carboxyl Methyl Cellulose (CMC) on the color and moisture characteristics of potato round slices & b) the roles of Green Tea (GT) and Ascorbic Acid (AA) when were added into the above edible coating. Until now both the extract of GT and the AA were evaluated only as potential antioxidants agents and it is the first time that GT was introduced in the edible coating solutions used in preservation of fresh cut potatoes.

II. Materials and Methods

Potatoes (Faluca, size 60/80mm, class A) have been supplied from the local market. Then potatoes were, washed, peeled, sliced in cylinder with specific size (7mm width and 4.9cm diameter). The slices of potatoes where cut with a stainless steel slicer and then immediately were treated in one of the follow solutions:

S.A. + CMC + G : sample being immersed in solution of 1% w/w sodium alginate, 0,5 w/w carboxyl methyl cellulose (CMC) and 1% glycerol, (referred as Edible Coating).

Edible Coating + AA: sample being immersed in solution of Edible Coating + 0,5 w/w % of ascorbic acid was added.

Edible Coating + GT: sample being immersed in solution of Edible Coating + an extraction of 0, 5% w/v green Greek tea (GT).

Control: sample without being immersed in solution to extend the shelf-life.

All samples (control and treaded) were stored in 4^oC for 15 days on plastic trays and rapped with high quality of recycled polyethylene membrane.

A. Materials

The materials used for this study were Sodium Alginate, (Sigma, ALDRICH, and Germany). Edible glycerol from plant derived, Ascorbic acid (Natural organics laboratories, USA) derived from natural sources, Carboxyl Methyl Cellulose (SIGMA, Germany), and Green Tea, which was supplied from the local market from the region of Pelio Magnesia in Greece.

B. Analyses

The color analysis was carried out with miniscan XE plus by HunterLab based on parameters L* (lightness), a* (red color intensity) and b* (yellow color intensity) of the CIE - "Comission Internationale de L΄Eclairage" system. The observer's reading angle was 10°, illuminant D 65, specular reflectance included, with calibration of standard white nr. VM 03500, V (X=80.3 Y=85.1 Z=91.0) and black [12]. The results presented as whiteness index (WI)

WI = 100 - [(100 - L*)2 + a*2 + b*2]1/2

The diameters of potato slices during storage were measured to estimate the degree of shrinkage. The measurements of all the samples were in triplicates.

III. Results and Discussion

Blackening of raw potatoes, could appeal negatively to consumer's senses. This quality problem results from the oxidation by polyphenol oxidase of phenolic compounds which are present in the tubers. Also, in the same time several non-enzymatic processes occur such as polymerization, oxidation and reactions of proteins to form brown and finally black melamine pigments [1]. The rations of these processes are highly affected by many factors such as atmospheric oxygen and/or pH.

According to our results the edible coating (S.A. + CMC) protects fresh-cut potato slices from atmospheric oxygen, during the first four days and keeps their color stable for the following eleven days (four to fifteen days, Figs. 1-3). It is remarkable to mention that the edible coating (S.A. + CMC) alone and not as a carrier of food antioxidants agents (GT or AA) has the best performance in keeping potato color during long storage. On the other hand the addition of the Ascorbic Acid in the edible coating (Edible coating +AA) reacts as the best inhibitor factor and retards the discoloration only for the first 4 days (Figs. 1 and 2) at refrigeration temperature. This result is in agreement with a previous research [4] where a cellulose-based edible coating was used as carrier of antioxidants and preservatives in order to extend the storage life of cut potatoes, for about one week. Also the introduction of ascorbic acid into the coating formulation based on cellulose, showed a great anti- browning activity for the first 4 days of storage at refrigeration temperature. Similar results were found and in another research [18] in cherries. The edible coating based on CMC was used to elongate the self life and quality of cherries during cold storage. It was demonstrated that the edible coating was responsible in cherries for their retain of firmness, ascorbic acid content and skin color for longer time, compare to control cherries without edible coating. In our research, the addition of AA in the edible coating based on sodium alginate was shown a similar anti-browning activity in our round potato slices, for 4 days of storage in the same conditions. The enhancement of ascorbic acid's anti-browning activity could be due to its less oxidative degradation within the mixture of the edible coating that we have used, (sodium alginate and carboxyl methyl cellulose), compared to an aqueous solution or to simple cellulose coating [4]. Probably the low oxygen permeability in potato slices due to the edible coatings should be responsible for the prevention of oxidation of ascorbic acid and the preservation of potato slices bright appearance. Also, the effect of low temperature reduced the ascorbic acid loss. Clearly the edible coatings and the low temperature, delayed the activities of the responsible enzymes for the enzymatic browning.

During further storage at the same conditions, the samples of potatoes slices lose their color gradually, because of the biochemical reactions and oxidation, which takes place due to natural substances such as the natural obtained ascorbic acid in potato matrix. Further addition of Ascorbic acid (AA) in the edible coating (S.A. + CMC) which has been applied on the surfaces of potato slices showed a remarkable drop in the bright color of the slices, after the 4^{th} day. Potato matrix is a much more complicated system compare to the edible coating of sodium alginate -carboxyl methyl cellulose and glycerol gel. Probably the larger amount of AA on the surface of the potato round slices could be oxidized in a more rapid rate compare to the A. A. which is trapped into potato tissues. Thus why the edible coating (S.A. + CMC) protects for longer time fresh-cut potato round slices from atmospheric oxygen, compare to the same coating with A. A.

The edible coating (S.A. + CMC) with GT has the worst performance in protecting potatoes color for sort and for long period of time, (4 days & 15 days, respectively) at refrigeration temperature, (Figs. 1-3). Although the low oxygen permeability in potato slices due to the coverage of the edible coating, the nature of GT is probably the responsible factor for potatoes browning activity. GT naturally contains colorful substances such as tannins, pheophytins a & b, chlorophylls a and b, beta carotene and lutein etc. [14], which probably have been absorbed by the potato tissues due to their long application on their surfaces. Potato round slices blackening in this case is more complicated as it is due both to enzymatic and non enzymatic factors, to intrinsic (e.g. oxidation of the natural obtained AA in potato tissue) and external parameters (e.g. GT dyes).

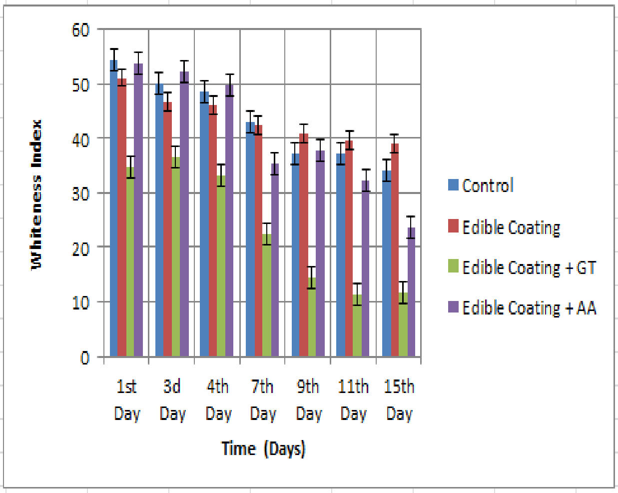

Fig. 1 Effects of storage in Whiteness index in fresh-cut potato slices after 15 days in 4 samples: a) control b) edible coating c) edible coating + GT d) edible coating + AA

Fig. 2 Samples of potato slices after four days of storage in 4^oC: a) control b) edible coating c) edible coating + GT d) edible coating + AA

Fig. 3 Samples of potato slices after fifteen days of storage in 4°C: a) control b) edible coating c) edible coating + GT d) edible coating + AA

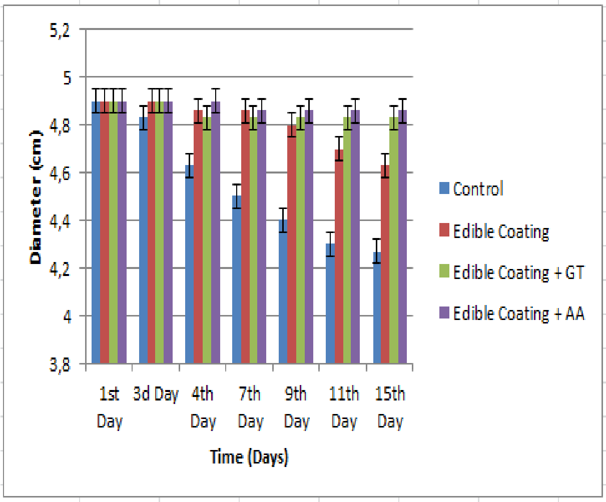

Fig. 4 Effects of storage in diameter of round potato slices after 15 days in 4 samples: a) control b) edible coating c) edible coating + GT d) edible coating + AA

In a previous research edible coatings made from alginates + Ca + acetylated monoglyceride, were used to investigate their capacity to preserve the quality of minimally processed 'Gala' apples, [13]. It was found that alginate coatings can preserve the quality (browning & water loss) of apple slices without causing any anaerobic respiration in the fruits for the first 2 days of storage at refrigeration temperature. In agreement with our results in potato slices, the sodium alginate based coating formulations (S.A. + CMC) gave longer protection in potato slices, for 15 days of storage, compare to the edible coatings made from alginates + Ca + acetylated monoglyceride, which were applied to apple slices under similar conditions. In addition the sodium alginate based coating formulations which were used in this research (S.A. + CMC) formed strongly attached, continuous films on the surface of the round potato slices and the translucent coatings gave a bright appearance for the whole period of 15 days at 4°C [13]. It should be mentioned that it is the first time that this combination of polysaccharides is used as edible coating on fresh cut potatoes and it had the best performance as inhibitor of potato color discoloration.

Edible films also, play important roles and as moisture barriers, resulting to the extent of fresh vegetables or fruits self–life. In this research potato round slices were treated with the edible coatings and stored from day one (1) to day fifteen (15). During storage potato slices treated or not, with solutions, dehydration took place. Diameter measurements of potato samples gave clear indications of dehydration levels. A previous study [15] on the effect of potato shapes (shrinkage) during drying showed that isotropy exists in potato shapes during drying or dehydration processes. It was also found that the contained moisture in potato cylinders samples was reflected to samples diameters. In our research was found that all samples treaded with solutions had the less moisture loss, compared to the control (Fig. 4). During the fifteen days of storage, the samples of potatoes round slices, covered with the edible coating (S.A. + CMC) & GT or the edible coating (S.A. + CMC) & AA retain the value of their diameters in the same levels as the first day of their treatment. On the other hand control samples and samples of potatoes which were covered only by the edible coating (S.A. + CMC) couldn't keep the moisture, into potato matrix and dramatic decreases in potatoes diameters were measured during storage (Fig. 4). It is clear that GT and AA play important roles as barriers to moisture loss in fresh-cut potato round slices, which have been stored at 4°C for 15 days.

In previous studies [16] the effects of carboxyl methyl cellulose coatings on the respiration rate, firmness, acidity, pH, total soluble solids and desiccation rate of peaches were investigated. The coatings of the peach samples which were based on methyl cellulose influenced the rate of changes in some chemical and physiological properties of the peaches, during storage. The respiration rate, moisture loss and changes in quality parameters were much lower in coated peaches as compared with the control. In our investigation we found similar results especially in the edible coatings (S.A. + CMC) with GT and AA, which probably, were acting as physical barriers for the gas exchange between the potato and the environment.

During the fifteen days of storage, the samples of potatoes round slices, covered with the edible coating (S.A. + CMC) & GT or the edible coating (S.A. + CMC) & AA showed probably an essentially better controlled rate of ripening during the whole period of 15 days at 4°C. The addition of GT & AA in the coating treatments may be generate the energy required to drive the biochemical reactions associated to potato ripening and cause a ripening delay [17]. Clearly sodium alginate based coatings treatments predominantly reduced physicochemical spoilage in potato slices and increased the overall quality, compared to uncoated control sample.

IV. Conclusion

The edible coating of sodium alginate (SA), CMC and glycerol (G), alone and not as a carrier of food agents (GT or AA) has the best performance in keeping potato color during long storage in 4^{o}C (15 days). On the other hand, when ascorbic acid is added to the edible coating (SA, CMC, and G) its functional role as inhibitor of potato color discoloration is increased but only for the first four days of storage at 4^{o}C. The nature of green tea (GT) when it is added to the solution of the edible coating (SA, CMC, G), doesn't allow any protection in potatoes color, as pigments from tea were absorbed by potato tissues. Finally, it is the first time that GT and the AA behave as potential moisture barriers of potato samples, when were added to edible coating (SA, CMC, G), during long storage at 4^{o}C.

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