Designing composite polysaccharide-based edible coatings to extend the shelf life of berries (black mulberries).

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Abstract

Chitosan and cassava starch are natural biopolymers that have been widely used in edible coating due to their attractive properties, such as biodegradability, biocompatibility and low cost. In a recent research published by our group, we found that a chitosan/cassava starch composite edible coating was able to extend the shelf life of black mulberries stored at 5ºC. The aim of this work was to review the main characteristics of the composite edible coating putting emphasis on gases exchanges and firmness changes of coated black mulberry.

Keywords: Biopolymers, Biodegradability, Biocompatibility, Black mulberries.

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Introduction

Soft fruits, including berries, currants and strawberries, are highly valued by consumers as fresh commodities. They have a short post-harvest life due to their structural fragility, being its harvesting, conservation and distribution a real challenge. Most of them are not sensitive to chilling injuries, despite the near-freezing temperatures recommended for cold storage may have other undesirable effects. Besides, these fruits generally lack external firm protective structures, which makes them also more fragile. Black mulberry is a very attractive fruit due to its dark color and flavour; recognized for its high content of bioactive compounds. However, once removed from the tree, the fruit softens very. Quickly, dehydrates and is susceptible to mold decay, therefore, the postharvest life is relatively short. Different preservation methods are applied to prolong the shelf life of these fruit, being refrigeration the main technology used to delay the deterioration of the product; however, refrigeration alone does not extent the shelf life more than 8-10 days. A promising technology to increase the shelf life of these fruit is the application of edible coatings in combination with refrigeration [1].

Literature Review

Edible coatings are eco-friendly products and could act as a supplementary barrier to oxygen, moisture loss and physical damage, minimizing the postharvest perishability of fruit. Edible coatings could also improve the visual and tactile characteristics of the fruit giving additional gloss effect or decreasing its softening. The design and selection of the best materials for the coating are highly related with the characteristics of the product and the desirable effect; therefore, a comprehensive study for the design of the most suitable coating for each fruit should be considered. Biopolymers like chitosan, alginate, gelatin, starch, carrageenan, and cellulose have been used as edible coatings in several products [2]. Usually, they are applied directly in liquid phase to the fruit surface to form the coating. The selection of the base material would depend on the desirable characteristics, the fruit/coating compatibility, sensorial characteristics, etc. It has many uses due to its special properties such as biodegradability, non-toxicity, ubiquity and low cost. Chitosan based coatings form transparent and semi-permeable films with good antioxidant property and reduced gas exchange, having a broad-spectrum of antimicrobial activity, particularly strong antifungal properties. The major property of chitosan is dictated by the presence of three different functional groups and its water solubility in acidic solutions may be a consequence of the protonation of amino groups on the polymer chains. The antimicrobial activity and physical properties of the coatings, namely viscosity, permeability, thermal stability and thickness are affected by the molecular weight of chitosan solutions and the acid type used for dissolution.

Strawberries coated with chitosan solution at low acid concentration had no changes in astringency and had a good acceptance by consumers. However, depending on the concentration, chitosan edible coatings could have a fish-like smell; therefore the application of chitosan based coatings to berries should be carefully evaluated in order to optimize its sensorial acceptance. Starch is also a traditionally used biopolymer to make edible coatings; it is made up of anhydrous glucose units which formed two types of polymers differentiated by its water solubility, amylose and amylopectin [3]. The starch-based coatings are colorless, odorless, transparent, oil-free appearance and tasteless. They act as a good barrier for oxygen but their permeability to water vapor is relatively high, nevertheless; they were satisfactorily applied to preserve some fruits and vegetables. The functional properties of starch-based coatings are related to the botanical source. Particularly, the amylose / amylopectin content of cassava starch defines its properties, with more than 17% of amylose, some physical attributes are remarkable. The gelification properties are interesting since it is achieved at temperatures near 62°C in water solutions without the need for other chemicals. The resulting solution is translucent, with high viscosity and some tendency to retrograde; all of these properties are interesting if the interaction fruit/coating is considered.

Therefore, considering the individual properties of chitosan or cassava starch based edible coatings, and their performance in maintaining the quality of berry like fruits, it was interesting to study if the combination of these two polymers could enhance their individual effects. In a recent research published by our group, the effects of the application of combined coatings based on chitosan and cassava starch on black mulberries were evaluated. This composite edible coating could represent an interesting postharvest treatment with properties to control microbial spoilage while maintaining fruit quality. Combining anti-microbial properties of chitosan along with physical and biological properties of cassava starch, the resulting composite edible coating had good fruit adherence and increased fruit's glossiness.

Discussion

The combined edible coating did not generate anaerobiosis in the headspace of the package which could be partially explained by the selective permeability of the coating to O_2, CO_2 and water vapor. Cassava starch coatings have low permeability to O_2, however, water can easily migrate from the fruit to the coating and back, and this could help to move O_2 molecules as well. The high moisture content of the coating could also improve O_2 dissolution and diffusion. The interactions and molecular miscibility between starch and chitosan in a composite mixture were previously analyzed by FTIR [4].

On the other hand, chitosan coated fruit exhibited an intense production of CO_2 which could be explained by the abiotic stress caused by chitosan as previously reported. However, when cassava starch was combined with chitosan the production of CO_2 was reduced. The application of composite edible coatings based on chitosan and cassava starch, could generate a modified atmosphere around the fruit, possibly regulating the exchange of O2 and CO_2, delaying respiration rate and slowing deterioration reaction. Although starch is recognized as having low oxygen permeability, which would decrease respiratory activity, the results indicated that when applied to black mulberries the cassava starch coating had no effect on respiratory activity. Another outstanding result of the application of the composite edible coating to black mulberries was evidenced in a significant reduction of weight loss of the fruit during storage. Weight loss in refrigerated fruit is mainly related to water evaporation caused by transpiration and respiration processes. The cassava starch coating alone or combined with chitosan was able to minimize weight loss due to dehydration; contrarily chitosan coating had a weak water resistance and the fruit lost weight during storage. In the composite edible coating, the advantageous effect of starch prevailed, the mixture with chitosan, probably contributed to increase the tortuosity factor for transport water molecules through the film.

Also, the application of the composite coating to black mulberries exhibited the antimicrobial character of the chitosan, which was also observed when applied alone as in other fruits. The precise mechanism of antimicrobial properties of chitosan, particularly anti-mold properties, is probably a consequence of the induction of phenylalanine ammonia-lyase, chitinase or the low internal oxygen level acting as limiting factor for fungal growth and fungal metabolism. In any case, it is remarkable interesting that the composite coating did not reduce the antimicrobial properties [5]. Firmness was also improved in black mulberries treated with the composite coating, although individual application of chitosan and cassava starch coatings did not prevent softening. This result could be explained by the microstructural characteristics and the anti-senescent effect of the coating, which delays the physiological changes of the fruit. Moreover, the electrostatic interactions between negatively charged cassava starch and positively charge chitosan molecules could have a significant effect on the properties of the coating which could particularly affect physical and mechanical resistance.

Conclusion

Finally, the composite chitosan/cassava starch edible coating was able to reduce the quality loss of black mulberries during storage at 5°C. This result was mainly related to a combination of properties of the selected biopolymers since when they were applied individually the results were not so satisfactory.The approach of designing combined edible coating using polysaccharides of natural sources is interesting because the individual or combined properties, biodegradability and biocompatibility, along with low cost, could represent an alternative to reduce fruit loss due to spoilage as well as provide an alternative use of industrial waste or non-traditional materials.

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