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Study on the efficacy of edible coatings on quality of blueberry fruits during shelf-life

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ABSTRACT

Edible films or coatings could be used as an alternative way of conservation, because of their ability to reduce respiration and transpiration rate, maintain firmness and generally delay fruit senescence. The aim of this research was to evaluate the influence of different types of coating: sodium alginate (Al), pectin (Pe) and sodium alginate plus pectin (Al + Pe), on some blueberries quality characteristics, cell viability and microbial growth during 14 days of storage at 4 °C.

Blueberry samples differently coated did not show significant differences in weight loss, pH, soluble solid and dry matter content. However, the application of Al, Pe and Al + Pe improved the firmness of blueberry samples as compared to the uncoated one. Changes in the surface reflection properties in the coated blueberries induced a general lower lightness and a more intense blue hue colour than the control sample. The microbiological results indicated that the coating of blueberry, in particular with Al or Pe, significantly reduced the growth kinetics of yeasts and mesophilic aerobic bacteria.

1. Introduction

Blueberries are appreciated for their rich composition in bioactive compounds such as flavonoids, phenolic acids, tannins and anthocyanins giving them nutraceutical properties. However, fresh fruit deteriorate rapidly due to loss of water and juice (product of superficial lesions), mould and/or putrefaction (Yang et al., 2014). The shelf-life of fresh blueberries usually is in the range of 10–40 days depending on different factors such as fruit maturity, cultivar, harvest method and storage conditions (Abugoch et al., 2016). Various technologies are used to reduce spoilage, extend the shelf-life and retain the nutritional value of fruit products; among this group particular attention can be given to refrigeration, UV irradiation, ozonation and modified packaging atmosphere (Duan, Wu, Strik, & Zhao, 2011). The use of edible films or coatings represents an alternative way of preservation because of their ability to reduce moisture, solute migration, respiration and transpiration rate, to maintain firmness and generally delay senescence (Tezotto-Uliana, Fargoni, Geerdink, & Kluge, 2014). The efficiency and stability of edible coatings or films depend on their compositions. Edible films and coatings are generally based on biological materials such as proteins, lipids and polysaccharides, alone or, more often, in combination.

Sodium alginate is a natural linear polysaccharide obtained from brown seaweeds and has many important physical and biological properties, such as moisture retention, gel-forming capability, good biocompatibility, low price and high availability (Pei, Chen, Li, & Zhou, 2008).

Pectin is a complex of acidic polysaccharides that form an interpenetrating network in the plant cell wall; it is one of the most important citrus by-products that are industrially extracted from apple pomace and citrus peels. Generally it is used to increase viscosity and gel strength of food products (Krochta & Mulder-Johnston, 1997).

Some studies confirm that the application of edible coatings on fruit surface can increase the shelf-life of different fruits, for example raspberries (Tezotto-Uliana et al., 2014) and tropical fruits (Cerqueira, Lima, Teixeira, Moreira, & Vicente, 2009). However, there are few works about coatings effects on blueberries (Chiabrando & Giacalone, 2015; Duan et al., 2011). In both papers,

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the authors showed that the use of alginate coating on berries had a positive effect on firmness, titratable acidity and maintained surface lightness of coated fruit products. However, to the best of our knowledge there are no papers presented in the literature on the effect of pectin-based coating on blueberries.

Although edible films are not intended to completely replace conventional packages, the efficiency of food protection can be improved by combining both actions. The objectives of this study were to investigate the effectiveness of sodium alginate, pectin and both of these polysaccharides based coatings in improving some qualitative characteristics of blueberry fruits during shelf-life.

2. Material and methods

2.1. Fruit material

Organic blueberries were purchased once from local market. Berry fruits were kept at 0 ± 1 °C until they were used, for no longer than one week, as suggested by Perkins-Veazie, Clark, Collins, & Magee, 1995 and Jackson, Sanford, Lawrence, McRae, & Stark, 1999. Fresh blueberries with the same colour and size and no damages were selected for the experiments.

2.2. Preparation of coating solutions

Three different coating solutions were prepared, each of them contained 15 g/kg of glycerol (≥99.5% Sigma-Aldrich, St. Louis, MO USA) and 2 g/kg of Tween® 20 (Sigma-Aldrich, St. Louis, MO USA) and solved in distilled water. In a first solution, sodium alginate (Al) (Sigma-Aldrich, St. Louis, MO USA) was added in the quantity of 20 g/kg. The second one was enriched by 20 g/kg of pectin (Pe) from citrus peel (Galacturonic acid ≥ 74.0% Sigma, St. Louis, MO USA), and the third one was prepared by combination of Sodium Alginate and Pectin (Al + Pe) in equals amounts of 10 g/kg + 10 g/kg. Afterwards, all coating solutions were homogenised at 5000 rpm for 2 min in order to remove air bubbles.

2.3. Sample preparation

Blueberry fruits were sanitized with sodium hypochlorite water solution (0.2 g/kg), rinsed in distilled water and dried with absorbing paper. Whole fruits were dipped in coating solutions, in two process steps, each one of 30 s duration. The berry samples were drained in a ventilated oven at 25 ± 1 °C for 30 min following the first step dipping, and for 60 min following the second step dipping. Blueberries dipped in distilled water with the same procedures were used as control. Coated berry samples were then placed in plastic trays (PET) closed in micro-perforated bags (PLA) and stored at 4 °C for 14 days. Coated samples and control ones were analysed at 0, 2, 4, 6, 10 and 14 days of storage. Totally 4 samples were obtained: 3 differently coated blueberry samples (Al, Pe, Al + Pe) and 1 not coated control sample. For each sample 540 blueberries were used. Three trays for every sampling time were made, containing 30 blueberries each, from which fruits were taken randomly from the three trays and used for analytical determinations.

2.4. Quality determinations

2.4.1. Weight loss, dry matter, pH and soluble solid content

Weight loss (WL) of blueberry samples during storage was measured by weighting fruits in the trays before storage and at every day of analysis, following the standard method of AOAC (1994).

Dry matter content was determined gravimetrically by difference in weight before and after drying at 70 °C, until a constant weight was reached (AOAC International, 2002).

pH was determined at 20 °C with a pH meter CRISON GLP21 (Shinghai Shilu-Instruments, China).

Soluble solid content (SSC) analysis were performed at 20 °C by measuring the refractive index of blueberry juice with digital hand refraktometer mod. DR301-95 (Kruess, Germany).

For each treatment-time condition, dry matter was determined in triplicate from 8 blueberries from each tray; pH and SSC were determined also in triplicate on three different juice samples each obtained from 10 berries from each tray, after filtering through Whatman #1 filter paper.

2.4.2. Colour and texture

Surface colour of blueberry was measured using spectrophotocolorimeter HUNTERLAB ColorFlexTM, mod. A60-1010-615 (Reston, Virginia). For each sample L*, a* and b* parameters from CIELAB scale were measured and Hue angles (h°) index was calculated.

Penetration test was performed with a Texture Analyser mod. TA-HDi500 (Stable Micro Systems, Godalming, UK) equipped with a 50N load cell and a 2 mm diameter stainless steel probe. Penetration test speed was 0.5 mm s^{-1}, the test ended when a maximum deformation of 80% was reached. Results were expressed as average of 12 measurements carried out on 12 blueberries for each treatment-time condition.

2.4.3. Cell viability

The cell viability test was performed on blueberries slices obtained from 9 different blueberries using fluorescein diacetate (FDA, Sigma-Aldrich, USA, λ_{ex} = 495 nm, λ_{em} = 518 nm), as described by Tylewicz, Romani, Widell, and Galindo (2013). Viable cells could be easily identified by a bright fluorescence. Observations were performed under a fluorescent light in a Nikon upright microscope (Eclipse Ti-U, Nikon Co, Tokyo, Japan) equipped with a Nikon digital video camera (digital sight DS-Qi1Mc, Nikon Co, Tokyo, Japan) at a magnification of 4×.

2.4.4. Microbial growth

The total loads of mesophylic aerobic bacteria, lactic acid bacteria, yeasts, moulds and total coliforms were evaluated according to the methods reported by Siroli et al. (2015). Briefly, 10 g portion of each sample were used (around 6 berries), suspended in 90 ml of sterile saline solution (9 g/l NaCl) and homogenized using a Stomacher for 2 min at room temperature; serial dilutions were made. The microbiological analyses were performed in triplicate immediately after treatments and during storage.

2.4.5. Data analyses

Analysis of variance (ANOVA) and the test of mean comparison, according to Fisher's least significant difference (LSD) were applied on all obtained data. Level of significance was $p < 0.05$.

The statistical software used was STATISTICA, v 8.0 (StatSoft, Tulsa, Okhlaoma).

3. Results and discussion

3.1. Weight loss, dry matter, pH and soluble solid content

The fruits weight loss during storage usually is caused by the migration of the water from the fruit to the surrounding environment. As reported in Table 1, all samples underwent a slight loss of weight during 14 days of storage. Coated samples did not show any significant differences in weight loss as compared to the control. These results are probably due to a slight loss of water undergone