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The influence of edible coatings enriched with citral and eugenol on the raspberry storage ability, nutritional and sensory quality

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ABSTRACT

Due to the high perishability of raspberry fruit, this work was undertaken to study the effect of alginate and pectin based edible coatings enriched with essential oils components on their storage ability. Four formulations of edible coatings, selected in a previous work, were used: sodium alginate (AL) at 2% + eugenol (Eug) 0.1%, AL 2% + citral (Cit) 0.15%, Pectin (PE) 1% + Eug 0.1% and PE 1% + Cit 0.15% + Eug 0.1%. At 0, 5, 10 and 15 d, samples were taken to perform analysis of colour, firmness, soluble solids content (SSC), weight loss, microbial growth, phenolic compounds (total phenolics, flavonoids, anthocyanins), sugars, organic acids, antioxidant activity (TEAC and ORAC), acetaldehyde, CO_2 production and sensory evaluation. Cytotoxicity of the edible coatings was also evaluated on THP-1 and Caco-2 cells. Results of this experiment showed that the edible coatings were not cytotoxic and generally did not significantly affect nutritional quality parameters. They were efficient in controlling microbial food spoilage. Acceptance by consumers of the coated raspberries was good up to 14 d, while control fruit were acceptable only till 7 d. The edible coating that best preserved quality was PE 1% + Cit 0.15% + Eug 0.1%.

1. Introduction

Raspberry (*Rubus idaeus* L.) is a member of the *Rosaceae* family and is grown primarily for its edible berries, which typical flavour makes them easily recognized and appreciated by consumers (Morales et al., 2014).

Consumption of fresh fruit and vegetables is beneficial to human health. However, they are highly perishable and during postharvest handling and storage, losses of vitamins and other phytonutrients are expected, although losses vary by nutrient, genotype, physical damage, temperature and storage environment (Olivas & Barbosa-Cánovas, 2005; Wang, 2007). Because of raspberry high perishability, a rapid decrease in temperature is a critical point for reducing respiration and slowing down senescence (Morales et al., 2014). Besides that, other postharvest technologies can be applied to increase storage ability, such as modified atmosphere packaging and edible coatings (Guerreiro, Gago, Faleiro, Miguel, & Antunes, 2015a; Joles, Cameron, Shirazi, Petracek, & Beaudry, 1994).

Edible coatings are being used to improve food appearance and conservation due to their environmentally friendly nature. They act as barriers to moisture and oxygen during processing, handling, and storage, thus retarding food deterioration. Also, they improve safety, due to their natural biocide activity or to the incorporation of antimicrobial compounds (Hassanpour, 2015).

Alginate is a natural polysaccharide extracted from brown sea algae (*Phaeophyceae*), composed of two uronic acids (β-D-mannuronic acid and α-L-guluronic acid). It is located in the intracellular matrix as a gel containing sodium, calcium, magnesium, strontium and barium ions and is known as a hydrophilic biopolymer that has a coating function due to its colloidal properties, which include its use for thickening, suspension and gel forming and emulsion stabilizing (Acevedo et al., 2012; Gol, Chaudhari, & Rao, 2015). Pectin is a complex anionic polysaccharide composed of β-1,4-linked D-galacturonic acid residues, wherein carboxyl groups of uronic acid are either fully (HMP, high methoxyl pectin, degree of esterification (DE) > 50%) or partially (LMP, low methoxyl pectin, DE < 50%) methyl esterified

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(Galus & Lenart, 2012). The hydrocolloidal and polyelectrolyte properties of pectin determine its unique abilities, such as: strong water retention in colloidal systems together with their stabilization, easy plasticization with glycerol due to its hydrophobic groups ability to adsorb organic lipoid substances and an expressive cation exchange ability forming its restorative action (Baeva & Panchev, 2005). Pectin is an important polysaccharide with application in foods, pharmaceuticals, and a number of other industries. Its importance in the food sector lies on its ability to form a gel in the presence of Ca^{2+} ions or a solute at low pH (Thakur, Singh, & Handa, 1997).

A new approach is the use of antimicrobial agents, such as essential oils, into edible coatings or packaging material (Emiroğlu, Yemiş, Coşkun, & Candoğan, 2010). As part of an edible coating, they can reduce microbial growth and improve the quality of the fruit (Jo et al., 2014; Raybaudi-Massilia, Mosqueda-Melgar, & Martín-Belloso, 2008).

The aim of this study was to evaluate the effect of 4 formulations of edible coatings selected in a previous work, AL 2% + Eug 0.1%, AL 2% + Cit 0.15%, PE 1% + Eug 0.1% and PE 1% + Cit 0.15% + Eug 0.1%, on the preservation of the sensory and nutritional quality attributes of raspberries through cold storage.

2. Materials and methods

2.1. Material

Raspberries were obtained from a local producer at the harvest day (Algarve, Portugal), then immediately transported to the Postharvest laboratory at the University of Algarve where fruits were selected for uniformity of size and freedom from pathological and physiological defects for use in the experiments.

Food grade sodium alginate (AL) and pectin high methoxyl DE > 74% (PE) (Sigma-Aldrich Chemic, Steinhein, Germany) were the biopolymers used for coating formulations. Essential oils components citral and eugenol were from Sigma-Aldrich Chemic, Steinhein, Germany. Calcium chloride (Sigma-Aldrich Chemic, Steinhein, Germany) was used to induce cross linking reaction and ascorbic acid (Scharlau, Barcelona, Spain) as anti-browning agent.

2.2. Edible coatings preparation

The coating forming solutions based on AL and PE, were formulated as described by Guerreiro, Gago, Faleiro, Miguel, and Antunes (2015c). Ascorbic acid 1 g 100 mL^{-1} was added to all edible coatings as anti-browning agent and $CaCl_2$ at 1 g 100 mL^{-1} was used as final dip for cross-link.

The treatments were: Control (uncoated fruit), AL 2 g 100 mL^{-1} (AL2%) + Eug 0.1 g 100 mL^{-1} (Eug 0.1%), AL2% + Cit 0.15 g 100 mL^{-1} (Cit 0.15%), PE 1 g 100 mL^{-1} (PE 1%)+ Eug 0.1% and PE 1% + Cit 0.15% + Eug 0.1%.

The fruits were dipped into the edible coating solution for 2 min, allowed to drip for 30 s, and dipped in the calcium chloride solution for 1 min, then drip again. Afterwards, 8 randomly raspberries were placed in polypropylene plastic boxes (8 cm × 10 cm × 4 cm), clamshell type, perforated in the lid, and stored at 0.5 °C and 95% relative humidity for 15 d. Controls did not have any kind of treatment. On days 0, 5, 10 and 15, three trays per treatment (replications) were taken for quality evaluation. Sensory evaluation was performed at harvest and after 7 and 14 d.

2.3. Quality parameters

Colour of fruits was measured in 3 points of the fruit by a Minolta Chroma meter CR-300 (ECMinolta, Japan) using the CIELab scale (L*,h°*,C*) (Guerreiro, Gago, Faleiro, Miguel, & Antunes, 2015b; McGuire, 1992).

The firmness of the pulp was determined by puncture, through the fruit, with a Chatillon TCD200 and Digital Force Gauge DFIS50 (Jonh Chatillon&Sons, Inc. USA) using a piston cylinder of 4 mm diameter at a depth of 7 mm. The soluble solids content (SSC) (°Brix) was measured using a digital refractometer PR1ATAGO CoLTD (Japan), in raspberry juice. Weight loss was expressed as percentage of initial weight by the formula.

$$Weight\ loss(\%) = \frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

2.4. Microbial counts

Counts of aerobic mesophilic microorganisms were done as well as counts of moulds and yeasts, according to Guerreiro et al. (2015b). Experiments were done in triplicate. Results were expressed as Log_{10} CFU (Colony Forming Unit) per gram fresh weight.

2.5. Sensory evaluation

A sensory panel was performed with 20 semi-trained panelists on the base of a 7-point hedonic scale (1—dislike very much, 2—dislike, 3—dislike slightly, 4—neither like nor dislike, 5—like slightly, 6—like, 7—like very much) for the sensory parameters: Appearance, aroma, texture, sweetness, acidity, flavour and overall acceptance (Velickova, Winkelhausen, Kuzmanova, Alves, & Moldão-Martins, 2013).

Panelists were selected among Faculty staff and students, who are already used to do sensory evaluation of fresh produce. Those members were trained at the beginning of the experiment to become familiar with the characteristics of this fruit.

2.6. Total phenolics content

Total phenolics content were determined according to the Folin–Ciocalteu colorimetric method (Singleton & Rossi, 1965) modified for microplates. The sample (80 μL of raspberry juice) and 20 μL of sodium carbonate (75 g L^{-1}) were added to 100 μL of 10% (w/v) Folin–Ciocalteu reagent. After 30 min of reaction at room temperature (~23 °C), the absorbance was measured at 765 nm (Tecan Infinite M200, Swiss). Gallic acid was used as standard for calibration curve.

2.7. Flavonoids content

The content of this group of compounds was quantified as described by Miguel, Nunes, Dandlen, Cavaco, and Antunes (2010) and modify for using in microplates of 96 wells. Sample or standard (100 μL) was added to 100 μL of 2% $AlCl_3$ ethanol solution. After 1 h at room temperature, the absorbance was measured at 420 nm (Tecan Infinite M200, Swiss). Quercetin was used as a standard for the construction of the calibration curve.

2.8. Anthocyanins

The total anthocyanins content was measured using a modified pH differential method (Guerreiro, Gago, Miguel, & Antunes, 2013; Lee, Durst, & Wrolstad, 2005). Absorbance of anthocyanins at 520 nm and 700 nm in different pH buffers (pH 1.0 and 4.5) was measured, respectively. Absorbance readings were converted to total mg of cyanidin 3-glucoside per 100 g fresh weight of fruit sample.