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The use of polysaccharide-based edible coatings enriched with essential oils to improve shelf-life of strawberries

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ABSTRACT

Edible coating formulations have been developed to increase shelf-life of some horticultural products. The objective of this research was to study the effect of edible coatings based on sodium alginate (AL) and pectin (PE) enriched with essential oils constituents (citral and eugenol) on the shelf-life extension of strawberries. AL and PE were tested at 1 and 2% (w/v) and were enriched with eugenol (Eug) at 0.1 and 0.2% and citral (Cit) at 0.15 and 0.3%. Strawberries were dipped in those solutions for 2 min, then stored at 0.5 °C. Measurements of color CIE (L*, a*, b*, h°, C*), firmness, soluble solids content (SSC), weight loss, trolox equivalent antioxidant capacity (TEAC), microbial growth and taste panels were accomplished at 0, 7 and 14 d storage. With those quality characteristics, hierarchical cluster analysis formed 3 groups either for AL or PE based edible coatings. Taking into account the mean closest values to the one at harvest for color, higher value for firmness, SSC and antioxidant activity, and lower value for weight loss and microbial spoilage, the best group was selected. From the selected groups, the 2 edible coating formulations which had higher score on taste panels were considered the best for preserving quality through shelf-life of strawberries. Those edible coatings were for AL the AL 2% + Eug 0.1%; AL 2% + Cit 0.15% + Eug 0.1% and for PE the PE 2% + Eug 0.1%; PE 2% + Cit 0.15%.

1. Introduction

Strawberry (*Fragaria* × *ananassa* Duch.), a very appreciated fruit worldwide, is highly perishable with a short postharvest life mainly due to their high metabolism and microbial decay (Gol et al., 2013). The shelf-life of fresh strawberries at temperatures from 0 to 4 °C is usually around 5 d (Vargas et al., 2006). Many preservation techniques including refrigeration, modified or controlled atmosphere and heat treatments have been applied to strawberries to increase their shelf-life (Harker et al., 2000; Velickova et al., 2013).

The use of edible coatings enriched with antimicrobial or antioxidants has proved to be efficient in preserving the quality during storage of many fruit (Antunes et al., 2012; Campos et al., 2011; Guerreiro et al., 2015; Oms-Oliu et al., 2010; Zúñiga et al., 2012). Polysaccharide-based edible coatings, such as alginate (AL) and pectin (PE), are often used due to their capacity to form rigid and stable gels (Campos et al., 2011; Salmieri and Lacroix, 2006).

The essential oils, which are bioactive compounds have been used as food preservatives (Jo et al., 2014) and can be added to edible coatings to increase their effect in preserving fruit quality and reducing microbial spoilage, thus increasing their storage life (Guerreiro et al., 2015; Salmieri and Lacroix, 2006; Vu et al., 2011). Eugenol and citral are examples of plant-derived essential oils which have been reported as good antimicrobial agents in edible films for extending the shelf-life of fresh-cut fruits (Hyldgaard et al., 2012; Raybaudi-Massilia et al., 2008a,b; Rojas-Graü et al., 2007a,b).

Some edible coatings based on chitosan have been studied to improve strawberry fruit shelf-life (Vargas et al., 2006; Velickova et al., 2013; Vu et al., 2011). Vu et al. (2011) report the addition of essential oils to chitosan edible coatings and their effect on strawberry fruit decay. However, essential oils can change sensory or nutritional properties, thus reducing consumer's acceptability. Also, essential oils composition can change from year to year due to plant cultural practices, being the use of sole compounds a better approach to obtain an efficient edible coating (Guerreiro et al., 2015; Miguel, 2010).

The objective of this study was to determine the effect of citral (Cit) and eugenol (Eug), when incorporated in polysaccharide edible coatings based on AL and PE, on the shelf-life extension of strawberries.

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2. Material and methods

2.1. Material

Strawberries were purchased from a local market (Algarve, Portugal) at the harvest day, then immediately transported to the Postharvest laboratory at the University of Algarve. Then fruit were selected for uniformity of size and freedom of defects and treatments were applied within six hours after harvest in the laboratory environment set at 18 °C.

Food grade sodium alginate (AL), pectin (PE), calcium chloride, citral (Cit), eugenol (Eug) and 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid and 2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) were purchased from Sigma–Aldrich Chemic, Steinhein, Germany. Ascorbic acid was from Scharlau, Barcelona, Spain.

Plate count agar medium and dicloran rose-bengal cloranfenicol agar were purchased from Biokar, Paris, France.

2.2. Methods

2.2.1. Edible Coatings

The edible coating formulations were done as described in Guerreiro et al. (2015). As for the previous authors, ascorbic acid 1% was added as anti-browning agent and calcium chloride 1% was used to induce cross linking reaction (Robles-Sánchez et al., 2009).

The concentrations of Cit and Eug were based on a previous determination of the minimum inhibitory concentration (MIC) for main food borne pathogens (Guerreiro et al., 2015).

The treatments were control (no addition of coating), AL or PE 1%, AL or PE 1% + Cit 0.15%, AL or PE 1% + Cit 0.3%, AL or PE 1% + Eug 0.1%, AL or PE 1% + Eug 0.2%, AL or PE 1% + Cit 0.15% + Eug 0.1%, AL or PE 2%, AL or PE 2% + Cit 0.15%, AL or PE 2% + Cit 0.3%, AL or PE 2% + Eug 0.1%, AL or PE 2% + Eug 0.2% and AL or PE 2% + Cit 0.15% + Eug 0.1%.

Strawberries were dipped into the edible coating solution for 2 min and allowed to drip off for 30 s. Then, they were dipped in a calcium chloride 1% (w/v) solution plus ascorbic acid 1% (w/v) for 1 min and dripped again. After that, 8 fruits per replication/treatment were placed in polypropylene plastic trays (8 cm × 10 cm × 4 cm), which were perforated in the cover, and stored at 0.5 °C until analyses. Sample analysis were performed just before treatments (day 0), and after 7 and 14 d storage. Three trays per treatment (replications) were used for each sampling time. Experiments were repeated twice.

2.2.2. General Quality Parameters analysis

A Minolta Chroma meter CR-300 (EC Minolta, Japan) was used to measure the color of the strawberries using the CIELab scale (L^*, a^* and b^*). The L^* represents color lightness (0 = black and 100 = white). Hue was calculated as h° = arctan (b^*/a^*) and color saturation (chroma) as $C^* = (a^{*2} + b^{*2})^{0.5}$ (McGuire, 1992). The firmness of strawberries was measured by puncture with a Chatillon TCD200 and a Digital Force Gauge DFIS 50 (Jonh Chatillon & Sons, Inc., USA) using a piston cylinder of 4 mm diameter at a depth of 7 mm. For the determination of the soluble solids content (%) was used a digital refractometer PR1 ATAGO CoLTD (Japan), in the fruit's juice. Fruit weight was measured at every sampling time in the same fruits and weight loss was expressed as the percentage of the initial weight.

2.2.3. Trolox Equivalent Antioxidant Activity (TEAC)

The preformed radical monocation of 2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) was produced according to Re et al. (1999) with modifications Guerreiro et al., (2015). 10 μL of the juice was added to 990 μL of ABTS radical cation solution. The absorbance was spectrophotometrically monitored at 750 nm for 6 min in a Shimadzu spectrophotometer 160-UV, Tokyo, Japan. The antioxidant activity was considered using the following equation: scavenging effect% (SE%) = (1 − As/Ao) × 100, where Ao stands for the absorbance of the control at time 0 and As for the absorbance in the presence of the sample after 6 min. The values were compared with the curve for several Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) concentrations in mM Trolox equivalent antioxidant capacity.

2.2.4. Microbial analysis

Microbial analysis included the counts of aerobic mesophilic and psicrophilic bacteria and molds and yeasts. The counts of aerobic mesophilic and psicrophilic were done according to the standard Portuguese NP-3788 (2002) using the Plate Count Agar medium (Biokar, Paris, France). The count of molds and yeasts was performed according to ISO 21527-2:2008 using Dicloran Rose-Bengal Cloranfenicol Agar (Biokar, Paris, France). The incubation temperature for yeasts and molds was 25 ± 1 °C during 48–72 h, for aerobic mesophilic bacteria was 30 ± 1 °C during 24–72 h and 6.5 ± 1 °C during 5 to 10 d for psychrophilic bacteria. Experiments were done in triplicate. Results were expressed as Log_{10} CFU (Colony Forming Unit) per gram fresh weight.

2.2.5. Sensory analysis

The sensory analysis included a taste panel constituted by 15 semi-trained panelists on the base of a 7-point hedonic scale: 1-dislike definitely; 2-dislike; 3-dislike mildly; 4-neither like nor dislike; 5-like mildly; 6-like; 7-like definitely. Sensory parameters evaluated were appearance, texture, aroma, taste and overall liking. Overall liking was calculated as a mean of the sensory parameters evaluated.

Panelists were recruited from Faculty students and staff to who was ministered a training at the beginning of the experiments to become familiar with the fruits.

2.2.6. Statistical analysis

Statistical analysis was carried out with the SPSS 20.0 software (IBM, Corp.). Two-way ANOVA and Duncan's multiple-range test ($P < 0.05$) for comparisons among treatments was performed. Hierarchical cluster analysis (HCA) was utilized to investigate the similarities and dissimilarities among the formulations. For classification, Ward's minimum variance method was utilized, with the squared Euclidean distance as dissimilarity measure. The grouping derived from HCA was used to interpret the results of the dendogram.

3. Results and discussion

3.1. Quality parameters

The L^* value of color (variation between 0 = black and 100 = white) of strawberries showed small changes along 14 d shelf life at 0.5 °C, changing from 38.97 to 45.65 for AL and from 39.70 to 46.2 for PE (Tables 1 and 2). Although with significant differences in some treatments, maximum changes for each treatment did not exceed the value 4.5 for L^*, which did not alter significantly the color parameter. There were no significant differences between AL and PE ($P = 0.088$). Similar behavior was observed for hue color value (Tables 1 and 2).

Strawberry fruit of 7 cultivars stored at 0 °C for 7 d become darker but h° value did not change (Sacks and Shaw, 1993). In our case, we found no significant changes either in L^* or h° through 14 d storage in non-coated fruit. Although there were statistically significant changes in some edible coating treatments, they were not of significance in terms of quality change.