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Effect of different anti-browning agents on quality of minimally processed early potatoes packaged on a compostable film

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ABSTRACT

Nowadays, there is a growing interest in bio-based compostable packaging also for fresh fruits and vegetables. We evaluated the influence of two different packaging: a bio-based compostable film (BIO) and a conventional coextruded polyamide/polyethylene (CONV), combined with 3 anti-browning solutions (sterile water - SW, 0.2 g kg^{-1} sodium bisulphite - SB; 20 g kg^{-1} ascorbic acid + 20 g kg^{-1} citric acid - AA + CA) on the physico-chemical and microbiological traits of minimally processed potatoes of cvs. 'Bellini' and 'Marabel' during storage at 4 °C for 9 days. Preliminary results showed that the BIO film was less suitable to guarantee quality (i.e., higher browning, fresh weight loss and microbial growth) of minimally processed potato tubers than CONV film. This result was reasonably related to the drastically modified barrier properties of compostable polymeric film by migration of water from potatoes, more markedly in 'Bellini' than in 'Marabel' cultivar. Dipping in AA + CA solution allowed containing microbial growth during whole storage time, more efficiently in CONV than in BIO bags.

1. Introduction

Potato (*Solanum tuberosum* L.) is the third largest food crop in the world, with an annual global production of tubers of about 360 Mt (FAO, 2012). In several countries of the Mediterranean Basin, such as North African countries, Cyprus, Turkey and southern Italy (Sicily, Campania and Apulia), potato is grown in off-season crops for production of "early potatoes". Early potatoes are highly appreciated and mainly exported to northern European countries with considerable profit (Ierna, 2010). Minimally processed potatoes would be very convenient for commercialization because of reducing transport costs, storage space and preparation time (Cabezas-Serrano, Amodio, Cornacchia, Rinaldi, & Colelli, 2009). However, operations such as peeling, cutting, shredding or slicing greatly increase tissue damage of minimally processed potato tubers, which have a limited shelf life of 5–7 days at 4–5 °C, as a result of physiological ageing, biochemical changes and microbial spoilage (Cantos, Tudela, Gil, & Espin, 2002; Ma, Wang, Hong, & Cantwell, 2010). Fresh-cut potatoes are particularly exposed to rapid enzymatic browning occurring after cutting, which can be reduced by several chemical inhibitors (Cacace, Delaquis, & Mazza, 2002; Limbo & Piergiovanni, 2006). Additionally, packaging may preserve shelf life of minimally processed products (Del Nobile, Licciardello, Scrocco, Muratore, & Zappa, 2007). Nevertheless, the extensive use of plastic packaging raises serious environmental concerns. Nowadays, there is a growing interest in packaging of fresh fruits and vegetables in order to replace petrochemical-based polymeric films with biodegradable and compostable materials (Tharanathan, 2003; Siracusa, Rocculi, Romani, & Dalla Rosa, 2008). So far, many studies have been focused on the properties of biodegradable films from renewable raw materials. Nevertheless, the evaluation of their performance as packaging materials for minimally processed products is still limited (Conte, Scrocco, Brescia, Mastromatteo, & Del Nobile, 2011; Del Nobile, Conte, Cannarsi, & Sinigaglia, 2008; Del Nobile et al., 2009) and, until now, it has not been evaluated for potatoes. We studied the effects of a bio-based and compostable packaging film compared to a conventional one, combined with three anti-browning treatments, on physico-chemical and microbial characteristics of minimally processed early potatoes.

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2. Materials and methods

2.1. Plant material and management practices

Tubers of potato (*Solanum tuberosum* L.) cultivars Bellini and Marabel, traditionally grown in the Mediterranean regions for early potato production, were used in the experiments (Mauromicale, Signorelli, Ierna, & Foti, 2003). The plants were grown during 2015 on the coastal plain, south of Syracuse (37°03′ N, 15° 18′ E, 15 m a.s.l.), a typical area for early potato cultivation in Sicily. On December 13, disease-free non pre-sprouted seed tubers were planted at 4.8 plants m^{-2}. Standard crop management was applied, involving Chlorpyrifos (30 kg ha^{-1}) before planting, mineral fertilization, water irrigation, post-emergence weeding with Linuron and pest control when needed. Harvest was carried out when leaves (about 80%) were dry, about 110 days after plant appearance.

2.2. Post-harvest treatments and sampling

About 20 kg of marketable tubers (Φ 35–70 mm) for each cultivar were selected for their uniform shape and lack of mechanical damage and transferred to the laboratories of CNR-IVALSA, Catania. Within 3 h of harvest, tubers were washed with tap water to remove any dirt and dried carefully with paper towels. The day after, tubers were hand-peeled by a knife to remove any residual skin and then were cut into 5.0 mm (±0.5 mm) slices manually. Immediately after cutting, the slices were rinsed in 0.2 g kg^{-1} NaOCl solution for 3 min. The slices were then strained on a draining board to reduce the water content on the potato slices surface. Potato slices were dipped for 2 min in three different freshly prepared solutions: 1) sterile deionized water (SW) - control; 2) 0.2 g kg^{-1} sodium bisulphite (SB) that is currently used in the fresh–cut potato industry; 3) ascorbic acid (20 g kg^{-1}) + citric acid (20 g kg^{-1}) (AA + CA), which provided best results in previous studies (Ierna, Pellegrino, Di Silvestro, & Buccheri, 2016). The ratio between sliced potatoes and the treatment solution was 1:3. All the chemicals were of analytical grade (Sigma-Aldrich Co.) The whole process was carried out at 15 ± 1 °C under sanitary conditions (in an environment treated with UV light to reduce microbial activity). After each dipping treatment, potato slices were gently dried for 1 min with a domestic salad drainer. Uniform slices were selected and broken pieces were discarded. Then, about 300 g of slices were packaged into bags (15 cm × 20 cm). Bags were hermetically sealed by a packaging machine (Cibra TIS400 TG) and stored at 4 ± 1 °C, 95% RH, for 9 days. At each sampling time (0, 3 and 9 days of storage) three bags (three replicates) for each packaging material, anti-browning dipping and cultivar were considered for analysis.

2.3. Packaging materials

Two plastic films were selected: one bio-based and compostable (BIO) and the other one traditional (CONV). BIO film was the NatureFlex™ E946 (InnoviaFilms Ltd, UK), with thickness 30 μm, O_2 permeability 55 cc/m^2/24 h/atm, CO_2 permeability 95 cc/m^2/24 h/atm, and water vapour permeability 200 g/m^2/24 h. CONV packaging was a polyamide (PA)/polyethylene (PE) coextruded film (System Packaging, Siracusa, Italy), with thickness 85 μm (65 μm PE and 20 μm PA), O_2 permeability 79 cc/m^2/24 h/atm, CO_2 permeability 347 cc/m^2/24 h/atm, and water vapour permeability 8 g/m^2/24 h.

2.4. Physico–chemical measurements

Tuber fresh weight loss was assessed weighing all bags by a digital precision balance (±0.01 g) (Gibertini Europe, Italy) just after packaging (time 0), after 3 and 9 days, before opening for further analytical determinations. Fresh weight loss, after 3 and 9 days of storage, was expressed as percent of the sample weight at time 0. Composition analysis of headspace gasses (O_2 and CO_2 concentration) was monitored in the headspace of each bag (about 10 cm^3) by a portable gas analyser (Dansensor CheckPoint, PBI, Ringsted, Denmark). To avoid modifications in the headspace gas composition due to gas sampling, each package was used only for a single determination of the headspace gas composition. Immediately after, 10 g of pulp from each bag were aseptically sampled for microbiological analyses, mentioned below. Afterwards, bags were transferred in a room with standardized light conditions for browning degree. Colour measurements were assessed on three slices per bag using CR 300 Chroma Meter (Konica Minolta, Singapore), in the L*a*b* mode (CIE, 1986, pp. 1–83); numerical values of a* and b* were directly converted into hue angle calculated from the formula: Hue (h) = $\tan^{-1}$ (b/a). Firmness was evaluated in the middle part of three slices per bag by a digital penetrometer (model 53205, TR Turoni & C. snc, Forlì, Italy) fitted with a cylindrical probe of stainless steel with a tip screwdriver. Data are the mean of the maximum force (N) required penetrating the tip into 3 mm. Water content was determined on three slices per bag after drying at 105 °C in a thermo-ventilated oven (Binder, Milan, Italy) until constant weight. Total soluble solids content was determined by a portable refractometer (Bertuzzi, Brugherio, Italy) at 20 °C on sample homogenized to a mash in a commercial hand blender (Braun Multiquick MR400, Kronberg im Taunus, Germany).

2.5. Microbiological evaluation

Samples for microbiological analyses were homogenized with a stomacher (Bag Mixer 400 vw Interscience, Saint Nom, France) for 90 s in sterile 400 Lab stomacher bags (BagFilter, Interscience, Saint Nom, France) in a 1:10 dilution with sterile 1% peptone buffered water (AES Laboratoire, Combourg, France). Total aerobic mesophilics and total psychrotrophic bacteria were enumerated by the standard plate count method using plate count agar (PCA) and incubating plates at 30 ± 1 °C for 48 h and at 4 ± 1 °C for 7 days, respectively. Lactic acid bacteria were isolated using Man, Rogosa and Sharpe (MRS) agar and incubating plates at 30 ± 1 °C for 48 h. Counts of mould and yeast were performed in Sabouraud dextrose agar by incubation at 25 °C for 5–7 days. All culture media were purchased from Liofilchem s. r.l (Roseto degli Abbruzzi-Teramo, Italy). Microbial counts were expressed as log CFU/g.

2.6. Statistical analyses

All data were subjected to Bartlett's test for homogeneity of variance and analysed by ANOVA (Snedecor & Cochran, 1989) based on a factorial combination of packaging film (2) × storage time (3) × anti-browning dipping treatment (3) × cultivar (2). Means were compared with Duncan's test, when the *F*-value was significant. Percent values were transformed to arcsin $\sqrt{x}$ (Bliss transformation) prior to analysis and then subjected to ANOVA; untransformed data were reported and discussed. CoStat Version 6.003 (CoHort Software, Monterey, CA USA) was used. A 5% significance level was used for all statistical comparisons.

3. Results and discussion

Data on physico-chemical and microbiological traits of minimally processed potato tubers as affected by packaging film, storage time, anti-browing dipping solution and cultivar are shown in Table 1.