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Hot water treatment and peracetic acid to maintain fresh-cut Galia melon quality

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ABSTRACT

The aim of the present study was to investigate if the use of hot water immersion dipping (HWD) alone or combined with other ecofriendly methods, could replace the use of chlorine in fresh-cut fruits such as melon. Melon pieces were subjected to hot (60 °C) or cold (5 °C) water dipping (60, 90, 120 s or 60 s, respectively) followed by immersion in 80 mg L^{-1} peracetic acid (PAA) for 60 s at 5 °C or in water, packed in polypropylene trays under passive modified atmosphere (7.4 kPa O_2 and 7.4 kPa CO_2 at steady state), and stored up to 10 days at 5 °C. Respiration rate, ethylene emission, microbial load, flesh firmness, polyamine content and sensorial quality were determined. As main conclusions the longer HWD treatment times (90 and 120 s) followed by PAA dip, provided the lowest metabolic activity and helped to control microbial load without affecting the sensorial quality. In addition, both treatments increased the polyamine content helping to maintain the cell membranes integrity.

Industrial relevance: Maintaining quality and microbial safety are the most important concerns of the fresh-cut fruit and vegetables industry. The present study focused on assessing the effect of HWD treatments alone or in combination with PAA, on the respiration rate, ethylene emission, microbial load, flesh firmness, polyamines content and quality retention of fresh-cut Galia melon. According to our results, the use of a heat treatment alone or combined with PAA could replace the use of chlorine, and could be a feasible alternative for fresh-cut industry as a sanitizing method, as or more effective as chlorine.

1. Introduction

Fresh-cut fruit or minimally fresh processed has been a rapidly growing segment of the produce industry and was predicted to exceed U.S. $1 billion by 2008, with fresh-cut melon products being a significant segment of this industry (Clement 2004). However, fresh-cut fruits and vegetables are no longer considered low risk in terms of food safety (Bhagwat 2006). In commercial elaboration processing, the quality maintenance and microbial safety are the most important concerns and an accurate disinfection program should be achieved (Artés, Gómez, Aguayo, Escalona, & Artés-Hernández 2009). The fresh-cut industry has used chlorine as one of the most effective sanitizers to assure the safety of their product. However, there is a trend in substituting chlorine from the disinfection process because of concerns about its efficacy, and the environmental and health risks associated with the formation of carcinogenic halogenated disinfection by-products (Ölmez & Kretzschmar 2009). In this sense, the implementation of heat treatments, alone or in combination with other sanitizing methods, could be a viable alternative to preserve the sensory and microbial quality of the products without leaving chlorine residual.

Heat can be applied to fruit and vegetables, including melon, as hot water dips (HWD), vapor heat, or hot dry air. Moreover, hot water treatments are less costly and easily applied at commercial scale, particularly in treatments of short duration (Hofman, Stubbings, Adkins, Meiburg, & Woolf 2002).

Heat causes changes in fruit ripening, such as inhibition of C_2H_4 synthesis and action of cell wall degrading enzymes, due to changes in gene expression and protein synthesis (Paull & Chen 2000). Heat treatments have been shown to effectively reduce human pathogens and native microflora on whole cantaloupe melon (Annous, Burke, & Sites 2004; Solomon, Huang, Sites, & Annous 2006), and have been used successfully in fresh-cut fruit and vegetables like Amarillo melon (Aguayo, Escalona, & Artés 2008), watermelon (Aguayo, Escalona, Gómez, Rodríguez-Hidalgo, & Artés 2008), mangoes (Djioua et al. 2009), rocket leaves (Koukounaras, Siomos, & Sfakiotakisa 2009) and shredded carrot (Alegría et al. 2010). In all these fresh-cut products heat treatments maintained the microbial and sensory quality.

One of the effects of heat treatment related to stress conditions is the increase in polyamine concentrations like putrescine (Put);

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spermidine, (Spd) and spermine (Spm) as reported by Bouchereau, Aziz, Larher, and Martin-Tanguy (1999). Specifically, accumulation of Put was found in chilling-injured pepper, cucumber, orange, lime and lemon (Martínez-Romero, Serrano, & Valero 2003; Serrano, Pretel, Martínez-Madrid, Romojaro, & Riquelme 1998; Serrano et al. 1996).

As it is well known, current sanitizing methods, mainly the use of chlorine, are not completely effective for reducing microbial load of fresh-cut fruit and vegetable products. For this reason, the combination of different physical and chemical sanitizing methods has been required to successfully maintain microbiological safety. For example, Ukuku, Pilizota, and Sapers (2004) demonstrated that immersion of inoculated cantaloupe in hot water (70 °C for 1 min) combined with 5% H_2O_2 resulted in up to 3.8 log colony forming units per g of sample (cfu g^{-1}) reduction in *Salmonella*. In addition, generally recognized as safe (GRAS) compounds have been applied in hot water to improve the efficiency of their antifungal action (Klaiber, Baur, Wolf, Hammes, & Carle 2005).

Temperatures used for HWD on different fresh-cut products range from 40 to 60 °C, while dipping times range from 1 to 5 min in most published works (Gómez et al. 2008; Paull & Chen 2000).

Peracetic acid (PAA) is a sanitizing agent that does not react with proteins to produce toxic or carcinogenic compounds (Holah, Higgs, Robins, Worthington, & Spencely 1990) as chlorine does. The efficiency of PAA has been studied in several fresh-cut commodities like potatoes, celery and cabbage (Hilgren & Salverda 2000) and Galia melon (Silveira, Aguayo, & Artés 2010; Silveira, Conesa, Aguayo, & Artés 2008). Combining PAA with hot water immersion dipping (HWD) may further enhance its antimicrobial effects.

Consequently, the aim of this work was to determine the effect of the HWD treatment combined with PAA on metabolic activity, microbial and sensory quality changes of fresh-cut Galia melon.

2. Material and methods

2.1. Minimally fresh processed melon

Galia melons (*Cucumis melo* var. *cantalupensis* Naud) of the commercial cv. Cyro, grown in open-air irrigated plantations under the Mediterranean climate of the Campo de Cartagena (Murcia, Spain), were hand harvested in a state of maturity defined using the scale color of Difrusa Export, SA for Galia melon (scale 1 to 9) and according to soluble solids content (SST), expressed as °Brix. The maturity stage corresponded to 6 on color scale and 11 °Brix. This soluble solids content level is considered as corresponding to the optimal commercial ripening stage for allowing the usual time lapse for distribution and retail sale (Artés, Escriche, Martínez, & Marín 1993). Melons were selected in a packinghouse according to their size (almost spherical, of about 1 kg weight) and external skin color, discarding damaged fruit. Sound melons of uniform appearance were transported about 30 km to the Pilot Plant of the Postharvest and Refrigeration Group at the Technical University of Cartagena, where they were stored at 10 °C. The next morning, in a disinfected cold room at 10 °C, minimal processing began by washing the fruits with tap water, draining, and then drying with blotting paper. Melons were hand cut into eight slices, parallel to the longitudinal axis, and blossom and stem-ends discarded. For reaching a good visual appearance of melon pieces, the placenta must be properly separated from the pulp and discarded, avoiding browning. Additionally, the stress produced during processing must be minimized. Consequently, the use of sharp knives for cutting and separating fresh-cut melon pulp from seeds and placenta has been strongly recommended (Aguayo, Escalona, & Artés 2004). Subsequently, the pulp was hand cut into trapezoidal shaped sections (3.4 ± 0.4 cm wide, 4.4 ± 0.5 cm length). Knives were disinfected with chlorinated (0.1 g L^{-1}) water for 30 min before use.

2.2. Hot water dipping and packaging

After cutting, melon pieces were treated by HWD at 60 °C for 60, 90 or 120 s followed by an immersion in 80 mg L^{-1} PAA (Sigma-Aldrich, Germany) at 5 °C for 60 s. Two control treatments were used, the first used melon pieces dipped in water at 5 °C during 60 s followed by immersion in 80 mg L^{-1} PAA at 5 °C for 60 s. In the second control, melon pieces were treated by HWD at 60 °C for 60 s followed by immersion in tap water at 5 °C for 60 s.

For HWD, a special bath designed and constructed by the Postharvest and Refrigeration Group was used. The bath consisted of a plastic box of 190 L capacity equipped with an electrical resistance element (Selecta, Barcelona, Spain) to heat the water, and a recirculation water mechanism connected to a 50 L deposit which maintained the water temperature homogenized using a pump and thermostat. When the water achieved the selected temperature (60 °C), the melon pieces were put in a wire mesh (previously disinfected), and the corresponding HWD treatment was applied. To confirm the temperature maintenance in melon, a thermometer was inserted in the centre of a piece of melon. The thermal difference in the center of the melon pieces before and after the HWD was no higher than 2 °C.

For all treatments, after washing, melon pieces were drained in a colander, and samples of 145–150 g were packaged into polypropylene (PP) trays of 0.250 L. Trays were heat-sealed (Barket, Befor Model, Chassieu, France) with an oriented polypropylene film (OPP) of 35 μm thickness to generate a passive modified atmosphere packaging (MAP) by the interaction between the respiration of the product and the permeability of the selected film. Permeability of this film at 23 °C and 75% RH was 5.5 L m^{-2} d^{-1} atm^{-1} for O_2 and 10 L m^{-2} d^{-1} atm^{-1} for CO_2 (data provided by Plásticos del Segura, Murcia, Spain). These trays were stored up to 10 d at 5 °C. The final gaseous concentration found inside the MAP trays was 7.4 kPa O_2 plus 7.4 kPa CO_2. Three repetitions (trays) were evaluated for each treatment on day 0, 3, 7 and 10 of chilling storage.

2.3. Respiration rate and ethylene emission

Samples of 150 g cut melon from each treatment were placed into 1 L glass jars at 5 °C. Jars were connected to a gas flow panel (Postharvest and Refrigeration Group, Cartagena, Spain) with an air flow of 0.1 to 0.2 L h^{-1}, humidified to 95% RH. The jars were closed for 2 h and then the increase in CO_2 was measured by taking a 0.5 mL gas sample from the headspace through a silicone septum using a plastic syringe. This sample was injected into a gas chromatograph (Thermo Finningan Trace, Thermo-Quest, Milan, Italy) equipped with a thermal conductivity detector. The measurements were done every 1 or 2 days during 10 days at 5 °C. Between measurements, jars were flushed with humidified air in order to avoid CO_2 accumulation higher than 0.3 kPa (Artés et al. 1993).

2.4. Microbial analysis

From each replicate, 3 random samples of 30 g of fresh-cut melon were collected from trays and homogenized for 2 min in 270 mL of sterile peptone buffered water (Scharlau, Barcelona, Spain) in a sterile stomacher bag with a Colorworth Stomacher 400 (Steward Laboratory, London UK). Serial dilutions were prepared in the same peptone solution. Mesophilic, psychrotrophic aerobic bacteria and *Enterobacteriaceae* were quantified on days 0, 3, 7 and 10. Plate count agar was used for enumeration of mesophilic and psychrotrophic aerobic bacteria, incubated for 48 h at 30 °C or 7 days at 7 °C, respectively. Violet-red bile dextrose agar, overlaid with the same medium and incubated at 37 °C for 24 h was used for *Enterobacteriaceae*. Microbial counts were expressed as $\log_{10}$ cfu g^{-1}. Microbial quality of the product was evaluated by following the Spanish microbial legislation for minimally fresh processed vegetables (RD 3484/2000 2001). According to this, the maximum microbial loads tolerated are 7 log cfu g^{-1} for aerobic bacteria.