6-2016

The effects of Produce Washes on the Quality and Shelf Life of "Cantaloupe" (Cucumis Melo Var. Cantalupensis) and "watermelon" (Cirtullus Lantus Var. Lanatus)

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Abstract

Our research objective was to evaluate the ability of produce washes to maintain the texture and color quality attributes of watermelon and cantaloupe while reducing the levels of natural fungi population on the melon surface. Melons were submerged for 2 min into either water control or water containing quaternary ammonium chloride (300 ppm) or an 18% hydrogen peroxide and 12% peroxyacetic acid combination (100 ppm), or an acetic acid, peroxyacetic acid and hydrogen peroxide combination (0.78%). Microbial analysis and instrumental measurements were utilized to assess the melons on day 0, 7, 14 and 21 in three separate trials. The experimental results indicated no reduction of fungal contaminants and no changes in firmness or color of melons following the applied treatments over the time of the study ($P > 0.05$). Additionally, the results provided evidence of extension of shelf life due to application of the tested washing solutions onto the watermelons or cantaloupe.

Practical Applications

Concerns over microbial safety in the melon industry prompted the use of intervention treatments to reduce foodborne pathogens. New formulations of antimicrobial treatments have created a wide variety of washing treatments that the melons producers can utilize in their production system. Research has shown that many of these formulations have antimicrobial effects, but little data have shown whether quality affects will result. This fact has caused growers' to hesitate using such products. The results of this work indicate that the chosen produce sanitizers did not reduce the quality of whole melons following washing treatments. Information provided by this work will be utilized to communicate benefits of surface washing in the melon industry, and to promote sanitation and safe handling practices through extension education.

Disciplines

Food Chemistry | Food Processing | Food Science | Food Studies | Human and Clinical Nutrition

Comments

This article is published as Svoboda, A., **A. Shaw**, L. Wilson, A. Mendonca, A. Nair and A. Daraba*. 2016. The effects of produce washes on the quality and shelf life of "cantaloupe" (Cucumis melo var. cantupensis) and "watermelon" (Citrullus lantus var. lanatus). *Journal of Food Quality.* 39(6); 773-779. DOI: 10.1111/jfq.12229

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Journal of
Food Quality

Journal of Food Quality ISSN 1745-4557

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Received for Publication June 26, 2015
Accepted for Publication June 15, 2016

10.1111/jfq.12229

ABSTRACT

Our research objective was to evaluate the ability of produce washes to maintain the texture and color quality attributes of watermelon and cantaloupe while reducing the levels of natural fungi population on the melon surface. Melons were submerged for 2 min into either water control or water containing quaternary ammonium chloride (300 ppm) or an 18% hydrogen peroxide and 12% peroxyacetic acid combination (100 ppm), or an acetic acid, peroxyacetic acid and hydrogen peroxide combination (0.78%). Microbial analysis and instrumental measurements were utilized to assess the melons on day 0, 7, 14 and 21 in three separate trials. The experimental results indicated no reduction of fungal contaminants and no changes in firmness or color of melons following the applied treatments over the time of the study ($P > 0.05$). Additionally, the results provided evidence of extension of shelf life due to application of the tested washing solutions onto the watermelons or cantaloupe.

PRACTICAL APPLICATIONS

Concerns over microbial safety in the melon industry prompted the use of intervention treatments to reduce foodborne pathogens. New formulations of antimicrobial treatments have created a wide variety of washing treatments that the melons producers can utilize in their production system. Research has shown that many of these formulations have antimicrobial effects, but little data have shown whether quality affects will result. This fact has caused growers' to hesitate using such products. The results of this work indicate that the chosen produce sanitizers did not reduce the quality of whole melons following washing treatments. Information provided by this work will be utilized to communicate benefits of surface washing in the melon industry, and to promote sanitation and safe handling practices through extension education.

INTRODUCTION

Melons [cantaloupe (*Cucumis melo* var. cantalupensis) and watermelon (*Citrullus lantus* var. lanatus)] are popular fruits world-wide and combined are the third most consumed fruit in the United States (USDA ERS 2012). Melons have varying surface structures, ranging from a complex network of raised tissue commonly called a "net" to a surface that is naturally smooth and waxy. In recent years, pathogenic microorganisms are of great concern to the melon industry and for food safety researchers due to the increase in foodborne outbreaks attributed to the consumption of these fruit (CDC 2012, 2013). However, Richards and Beuchat identified fungal contaminants (yeasts and molds) as the main cause of postharvest quality loss in whole melons (Richards and Beuchat 2005a,b).

Quality and shelf life of melons are a great concern to growers as shelf life is an indicator of the profits lost due to food waste (Doganis *et al.* 2006). It is estimated that loss of fresh fruit at retail level can range from 11 to 25% for the melon industries (USDA ERS 2009). Quality attributes such as flavor, juiciness, texture and color contribute to a consumer's desire to purchase the fruit; changes in firmness, color and sensory attributes are the determination factor for the end of shelf life (Pardo *et al.* 1997; Ukuku and Fett 2002; Aguayo *et al.* 2004; Fonesca and Rushing 2006). Shelf life of whole cantaloupe and watermelon is generally 14–21 days when those products stored at optimal conditions (cantaloupe at 4C, watermelon at 13C, 90% relative humidity; UC Davis 2013), but is greatly reduced to 7–12 days after transit and sale through the market.

Research has shown that the application of hot water, calcium salts and other antioxidants can improve shelf life for melons (Sapers *et al.* 2001; Ukuku and Fett 2002, 2004; Akins *et al.* 2008), but other research has reported some negative quality attributes of melons. Fan and group (2009) found fungal reductions after sanitizing melons with peroxyacetic acid at 80 ppm, but noted sensory reductions of aroma and appearance. These same effects in melons have been seen in other produce types with losses in color and texture associated with application of acids and hydrogen peroxide (Fonesca and Rushing 2006; Guan *et al.* 2010; Alexandre *et al.* 2012a,b; Lignou *et al.* 2014). Silveira *et al.* (2008) reported that the firmness of the "Galia" melons over a 10 day shelf life decreased significantly after the application of chlorine dioxide at 3 mg/L, peracetic acid at 80 mg/L, hydrogen peroxide at 50 mg/L and nisin at 250 mg/L.

Many other studies have shown that use of produce washes on the surface of melons reduced foodborne pathogens and yeast/mold populations, to improve safety and shelf life. Svoboda *et al.* (2016) showed that produce washes were effectively reduced populations of *Escherichia coli*, *Salmonella,* and *Listeria* spp. and showed good potential for yeast and mold reduction on watermelons and cantaloupes. These sanitizers included; 18% hydrogen peroxide and 12% peroxyacetic acid (100ppm, 1.6–2.3 log reductions depending on pathogen), quaternary ammonium chloride (300 ppm, 0.8–2.4 log reductions depending on pathogen), acetic acid, peroxyacetic acid and hydrogen peroxide combination (0.78%, 0.3–2.8 log reductions depending on pathogen), liquid chlorine dioxide (5 ppm, 0.8–2.1 log reductions depending on pathogen) and hydrogen peroxide (5%, 1.4–2.4 log reductions depending on pathogen). Even with this positive data on the effectiveness of produce washes on cantaloupes and watermelons, growers have reported fears of quality loss and reduction of shelf life due to the higher concentrations of chemicals in the formulations.

Therefore, the objective of this research was to compare three novel produce washes (peroxyacetic acid/hydrogen peroxide combination, peroxyacetic acid/acetic acid/hydrogen peroxide combination and quaternary ammonium) to control water washes and determine their ability to maintain or improve sensory attributes and to improve cantaloupe and watermelon shelf life through yeast and mold reductions. Information provided by this work will be utilized to communicate benefits of surface washing in the melon industry, and to promote sanitation and safe handling practices through extension education.

MATERIALS AND METHODS

Melons

Melons (cantaloupe, netted type and watermelon) were obtained precooled to approximately 4C from a local wholesaler within 24 h of harvest. No melons utilized in this study had previous antimicrobial treatment applications but one cantaloupe source had been treated with a hot water wash. Immediately prior to use, melons were washed under cool running tap water (approximately 4C) to remove visible soil. All melons were air dried prior to wash application to ensure the stability of washing solution concentrations.

Produce Washing Solutions

The washing solutions used in the experiment were obtained or purchased from their respective suppliers and prepared according to supplier's instructions using sterile deionized water. The tested washing solutions included: quaternary ammonium chloride (quaternary ammonium product, FS Amine Z; diluted to 300 parts per million (ppm) according to manufacturer directions, reference Zep) (Zep, Atlanta, GA); a hydrogen peroxide and peroxyacetic acid combination (18% H_2O_2/12% PAA, SaniDate 12.0; diluted to 100 ppm peroxyacetic acid according to manufacturer directions, reference BioSafe Systems LLC) (BioSafe Systems LLC, East Hartford, CT), and an acetic acid, peroxyacetic acid and hydrogen peroxide combination (Acetic Acid/PAA/H_2O_2, Birkoside MP-2; diluted to 0.78% by weight) (Birko, Henderson, CO). The validation of solutions' concentration throughout the experiment was conducted as recommended by supplier's recommendations. Solutions' pH was checked to determine if any adjustments were needed to maintain an accurate concentration of the solutions during the experiment. Additionally, due to organic matter build up which might modify the washing solutions' concentration, each solution was replaced at every six washed melons to ensure consistency of the solutions throughout the experiment. All concentrations were selected because there met the limit or below of federal standards found in 21 CFR Part 173 for direct application of sanitizers to food for human consumption.

Surface Treatment and Storage of Melons

Melons were surface treated by dipping in the previously prepared washing solutions, using constant agitation for 2 min. A total of six melons (either cantaloupe or watermelon) were treated with each batch of washing solution to ensure that the solutions' concentrations were not modified during the experiment. Following the surface treatments, melons were allowed to air dry for 30 min prior to analysis or storage. All melons were held in bunches of 9, in clean cardboard boxes (cantaloupe at 4C, watermelon at 13C) at 90% relative humidity.

Microbial, Texture and Color Analyses

Following the surface treatment, melons were sampled on days 0 (30 min following treatment), 7, 14 and 21. Quality attributes were compared to those of a no wash and water wash control. Microbial samples were taken by randomly removing approximately 60 rind plugs using a sterile stainless steel apple cork-borer (Mercer Cutlery, Deer Park, NY). The flesh was removed from the rind plugs using a sterile knife and discarded. Rind samples were then collected in sterile blender jar for a total weight of 25 g and homogenized with 225 mL BPW using a sanitized commercial blender (Oster, Sunbeam Products, Boca Raton, FL) at high speed for 1 min. Melon homogenates were then sampled and serial dilutions were performed in buffered peptone water (BPW) (HiMedia, Mumbai, India). For yeast and molds enumeration, the homogenates of rind samples were plated onto selective media, respectively, Dichloran Rose Bengal Chloramphenicol (DRBC) agar (EMD Chemicals Inc., Darmstadt, Germany) and incubated at 25C for 5 days.

Instrumental measurements of firmness were utilized for melon quality analysis as described previously (Beaulieu *et al.* 2004; Lignou *et al.* 2014), with minor modifications as described below. Texture analysis (firmness) was conducted on both the rind surface and the flesh using an Instron Universal Testing Machine, model 5566 (Instron Corporation; Norwood, MA). A five-point star probe 1 cm across, on a 10 kN load cell was utilized with a crosshead speed of 200 mm/min. The probe was penetrated 20% into the thickness of the melon, and maximum force required to penetrate the surface and flesh was recorded. For the melon rinds, three random locations of the surface of the melon were sampled by turning the melon 1/4 turns and avoiding locations softened by direct contact of melons with the ground. Flesh analysis was conducted similar to Pardo and group (1997), with slight modifications as described below. Following the rind analysis, the same melon was cut down the center (slip location), and the flesh firmness was measured by puncturing a total of six locations in a clockwise rotation starting from the area below the slip. Flesh measurements were taken 2 cm inward from the rind of the melon to avoid inconsistencies in flesh firmness close to the rind edge, while still maintaining distance from the seeded center for the cantaloupe. For watermelon, samples were prepared in the same manner as cantaloupe, but care was taken to avoid seeds if located in the flesh.

Color analysis was conducted by measuring Hunter L^*, a^* and b^* scores in three locations on the surface of each melon. The measurements were performed in triplicate, using a MiniScan portable colorimeter (HunterLab, Reston, VA), standardized with a white control tile (X 79.6, Y 84.5, Z 90.6) using D65 lighting source with a 10° viewing angle. Care was taken to sample watermelon randomly to analyze both green and white stripes in sampling to achieve an overall average color reading of samples.

Statistical Analysis

Analysis was conducted in triplicate for both cantaloupe and watermelon for each tested washing solution. For all analysis, counts and values were obtained, and means and standard deviations were calculated within replicate analysis. Bacterial reduction, rind and flesh maximum force and rind color was analyzed using PROC GLM for mean separation for washing treatments. Analysis was performed using SAS 9.3 software (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Our study showed no significant changes occurred in melon's rind or in the flesh firmness (Table 1), in Hunter color scores (Tables 2 and 3) over the sampling times or between washing treatments up to day 21 for the cantaloupe and 14 for the watermelon. Specifically, Table 1 shows that for cantaloupes, the firmness values of the rind were between 2–9 Kgf and the flesh 0–3 Kgf during the 21 day trial. The firmness values decreased as the days progressed regardless if they were treated with a produce wash or the water control. Similarly, the values for watermelon firmness on the rind were between 10–14 Kgf and on the flesh were 0–3 Kg/f during the first 14 days. On day 21, the watermelons overall quality attributes were not acceptable to consumers (e.g., excessive softness of the rind, fragile rind and juice loss due to rind breakdown). Therefore the watermelon data were collected through day 14 of the study in both the control and treatment groups. The watermelons were obtained from various regions of the U.S. through a produce distributor within 1 day of harvest and were randomly assigned to control and treatment groups therefore the reduction of shelf

TABLE 1. RIND AND FLESH FIRMNESS (KG OF FORCE; KGF) OF CANTALOUPE AND WATERMELON FOLLOWING SURFACE TREATMENT WITH WASHING SOLUTIONS AND STORED AT 4C AND 13C, RESPECTIVELY, FOR 14–21 DAYS

Sampling Day [a]	Washing solutions	Cantaloupe Rind	Cantaloupe Flesh	Watermelon Rind	Watermelon Flesh
Day 1	Control-Water only	6.93 ± 2.63	1.21 ± 0.39	11.69 ± 1.30	0.96 ± 0.55
	18% H_2O_2/12% PAA	7.40 ± 1.72	1.00 ± 0.38	11.52 ± 1.26	0.96 ± 0.15
	Acetic Acid/PAA/H_2O_2	7.11 ± 2.07	0.97 ± 0.41	12.70 ± 2.59	1.02 ± 0.19
	Quaternary Ammonium	7.16 ± 2.19	1.39 ± 0.61	11.99 ± 2.57	0.78 ± 0.08
Day 7	Control-Water only	7.30 ± 4.45	1.25 ± 0.66	11.02 ± 1.21	0.92 ± 0.17
	18% H_2O_2/12% PAA	7.11 ± 1.63	1.05 ± 0.54	10.86 ± 0.97	0.95 ± 0.15
	Acetic Acid/PAA/H_2O_2	5.78 ± 0.95	1.06 ± 0.34	11.11 ± 0.20	0.87 ± 0.22
	Quaternary Ammonium	4.72 ± 0.89	0.94 ± 0.27	11.85 ± 2.35	0.86 ± 0.21
Day 14	Control-Water only	5.61 ± 1.19	0.93 ± 0.30	11.12 ± 2.16	0.83 ± 0.10
	18% H_2O_2/12% PAA	6.42 ± 2.35	1.49 ± 0.31	12.28 ± 2.87	0.91 ± 0.08
	Acetic Acid/PAA/H_2O_2	5.54 ± 1.69	1.21 ± 0.65	12.25 ± 7.07	1.04 ± 0.60
	Quaternary Ammonium	3.56 ± 1.36	0.91 ± 0.35	11.02 ± 1.62	0.88 ± 0.10
Day 21	Control-Water only	4.75 ± 1.15	1.04 ± 0.54	N/A	N/A
	18% H_2O_2/12% PAA	3.50 ± 1.97	0.91 ± 0.13	N/A	N/A
	Acetic Acid/PAA/H_2O_2	4.08 ± 0.42	0.91 ± 0.24	N/A	N/A
	Quaternary Ammonium	4.69 ± 0.74	0.91 ± 0.44	N/A	N/A

[a]No significant differences were seen in maximum force measurements for cantaloupe or watermelon treatments between washing solution treatment or across sampling days ($P > 0.05$).

life was not due to the treatment conditions. With regards to the color of the rind of the cantaloupe and the watermelon (Tables 2 and 3) did not have a significantly change over time nor between treatments for the L^* (lightness) or b^* (blue to yellow). Although not significant, with the a^* (red-green) there was a noticeable change with the cantaloupe having an increase in green-ness, while the watermelon turning more red over time.

Our studies results was supported by Ukuku research group (2004) which found no change in cantaloupe and honeydew melon appearance and acceptability when treated with hydrogen peroxide at 2.5% and 5% as well as research performed by Venkitanarayanan *et al.* (2002) who reported no sensory or quality degradations of produce treated with a 1.5% hydrogen peroxide/1.5% lactic acid combination, both using similar research design. Our results are in contrast to previous study results (Fan *et al.* 2009) where negative effects to firmness and color were reported. In that study the cantaloupes were submerged in water, 180 ppm of chlorine, acidified calcium sulfate (ACS: 1.2%Safe2O-ACS50), 1,000 ppm

TABLE 2. VARIATION OF COLOR VALUES (HUNTER L^*, A^* AND B^*) OF CANTALOUPE RIND FOLLOWING SURFACE TREATMENT WITH WASHING SOLUTIONS AND SUBSEQUENTLY STORED AT 4C FOR 21 DAYS

Sampling Day [a]	Washing solutions	L^*	a^*	b^*
Day 1	Control-Water only	68.08 ± 2.70	0.79 ± 3.73	26.55 ±5.32
	18% H_2O_2/12% PAA	67.96 ± 1.76	1.53 ± 1.83	25.74 ± 2.10
	Acetic Acid/PAA/H_2O_2	68.53 ± 1.34	1.78 ± 3.20	28.87 ± 6.27
	Quaternary Ammonium	66.70 ± 1.23	2.45 ±2.98	28.49 ± 2.98
Day 7	Control-Water only	69.20 ± 1.85	1.82 ± 1.84	26.33 ± 2.26
	18% H_2O_2/12% PAA	70.39 ± 1.36	1.53 ± 1.83	29.06 ± 1.37
	Acetic Acid/PAA/H_2O_2	69.88 ± 0.61	2.67 ± 2.34	28.46 ± 2.03
	Quaternary Ammonium	69.90 ± 1.60	3.30 ± 1.92	28.81 ± 0.44
Day 14	Control-Water only	67.35 ± 1.99	2.25 ± 2.04	27.67 ± 2.94
	18% H_2O_2/12% PAA	66.42 ± 1.11	2.72 ± 1.21	27.24 ± 0.43
	Acetic Acid/PAA/H_2O_2	64.79 ± 3.28	2.01 ± 2.56	25.46 ± 4.51
	Quaternary Ammonium	65.17 ± 0.69	2.37 ± 1.61	25.92 ± 3.05
Day 21	Control-Water only	65.83 ± 3.14	2.37 ± 2.33	25.81 ± 5.25
	18% H_2O_2/12% PAA	61.56 ± 6.88	2.54 ± 1.09	23.98 ± 4.03
	Acetic Acid/PAA/H_2O_2	67.78 ± 3.20	2.94 ± 0.55	28.78 ± 0.76
	Quaternary Ammonium	68.26 ± 2.43	1.85 ± 0.83	26.70 ± 2.86

[a]No significant differences were seen in Hunter value measurements for cantaloupe between washing solution treatment or across sampling days ($P > 0.05$).

L^*: lightness, a^*: red-green-ness, b^*: blue-yellow-ness.

TABLE 3. VARIATION OF COLOR VALUES (HUNTER *L**, *A** AND *B**) OF WATERMELON RIND FOLLOWING SURFACE TREATMENT WITH WASHING SOLUTIONS AND STORED AT 13C, FOR 14 DAYS

Sampling Day [a]	Washing solutions	*L**	*a**	*b**
Day 1	Control-Water only	41.10 ± 8.96	−11.91 ± 4.76	20.08 ± 11.99
	18% H_2O_2/12% PAA	41.37 ± 8.26	−13.31 ± 3.76	22.77 ± 9.25
	Acetic Acid/PAA/H_2O_2	41.82 ± 10.12	−12.51 ± 3.13	21.77 ± 8.22
	Quaternary Ammonium	40.75 ± 9.28	−11.83 ± 3.20	20.32 ± 8.98
Day 7	Control-Water only	41.17 ± 3.82	−13.78 ± 3.52	23.68 ± 8.25
	18% H_2O_2/12% PAA	41.49 ± 12.73	−12.67 ± 2.84	22.13 ± 10.63
	Acetic Acid/PAA/H_2O_2	44.65 ± 8.55	−14.03 ± 2.30	25.33 ± 6.17
	Quaternary Ammonium	42.05 ± 8.36	−15.55 ± 2.01	28.51 ± 8.58
Day 14	Control-Water only	40.78 ± 12.03	−13.39 ± 4.12	24.53 ± 11.13
	18% H_2O_2/12% PAA	62.72 ± 31.90	−12.65 ± 1.55	23.94 ± 6.33
	Acetic Acid/PAA/H_2O_2	38.38 ± 5.45	−13.63 ± 3.80	24.78 ± 9.49
	Quaternary Ammonium	48.67 ± 3.47	−14.18 ± 2.35	32.36 ± 3.97

[a]No significant differences were seen in Hunter value measurements for watermelon between washing solution treatment or across sampling days ($P > 0.05$).
*L**: lightness, *a**: red-green-ness, *b**: blue-yellow-ness.

of acidified sodium chlorite (ASC), 80 ppm of peroxyacetic acid (PAA), and a combination of ACS and PAA for 10 min. The quality depletion reported in the Fan and group study can be explained by differences in our treatment of the cantaloupes. One major difference is the application time of the produce wash. Fan and group submerged the melons for 10 min in contrast to our study in which the cantaloupes were submerged for only 2 min to mimic the treatment time used in the produce industry. Additionally, in the Fan and group's experiment, cantaloupes were inoculated with *Salmonella* Poona, subjected to drying and when subjected to the sanitizer treatments prior to quality assessment, which is different from our study in that we did not inoculate with a foodborne pathogen and allow for drying period.

No significant reductions in yeast and mold counts were observed between the washed treatments and the control sample at a given day, or across the duration of the shelf life study (Table 4). Yeast and mold counts ranged from 2 to 9 log cfu/g over the shelf life for the cantaloupes and watermelons. These results are similar to those reported by Silveira *et al.* (2008) who found similar results of no reduction in molds, mesophilic, psychotropic, or enterobacteriaceae populations after treatments with chlorine dioxide at 3 mg/L, peracetic acid at 80 mg/L, hydrogen peroxide at 50 mg/L and nisin at 250 mg/L on "Galia" melons. In addition, treatment with hydrogen peroxide at 2.5% has been reported to have minimal reductions (0.5 log or less) of yeast and mold populations on whole cantaloupe (Ukuku 2006). Additional studies have found that produce washing solutions (chorine, acidified sodium chlorite, acidified calcium sulfate), modified atmosphere (chlorine dioxide gas treatment, and high oxygen, high carbon dioxide), antimicrobial films (encapsulated essential oils) in packaging, and use of biopreservatives such as natural fruit microbiota have also reported improved shelf life extension of melons resulting from decreased microbial contaminants with no significant reductions in sensory quality (Mahmoud *et al.* 2008; Fan *et al.* 2009; Zhang *et al.* 2013; Abadias *et al.* 2014; Moreira *et al.* 2014).

Although the use of quaternary ammonium product or hydrogen peroxide and peroxyacetic acid combinations as washing solutions did not indicate an improvement in shelf life of watermelon and cantaloupe by the reduction of concentration in fungi, the tested washing solutions did not

TABLE 4. THE NUMBERS OF YEAST AND MOLD PRESENT (LOG_{10} CFU/GRAM) ON CANTALOUPE AND WATERMELON SURFACES FOLLOWING SURFACE TREATMENT WITH WASHING SOLUTIONS AND SUBSEQUENTLY STORED AT 4C AND 13C, RESPECTIVELY, FOR 21 DAYS

Sampling Day [a]	Washing solutions	Cantaloupe	Watermelon
Day 1	Control-Water only	5.3 ± 0.7	3.7 ± 1.0
	18% H_2O_2/12% PAA	5.4 ± 0.9	3.9 ± 0.6
	Acetic Acid/PAA/H_2O_2	4.4 ± 1.4	3.7 ± 1.2
	Quaternary Ammonium	4.6 ± 0.7	4.4 ± 1.0
Day 7	Control-Water only	5.4 ± 1.0	5.5 ± 1.4
	18% H_2O_2/12% PAA	5.2 ± 1.5	5.8 ± 0.9
	Acetic Acid/PAA/H_2O_2	4.7 ± 1.8	4.3 ± 0.6
	Quaternary Ammonium	6.0 ± 1.5	5.2 ± 0.8
Day 14	Control-Water only	5.2 ± 0.5	4.7 ± 1.3
	18% H_2O_2/12% PAA	7.2 ± 1.3	3.5 ± 0.9
	Acetic Acid/PAA/H_2O_2	6.0 ± 2.5	5.2 ± 1.2
	Quaternary Ammonium	6.9 ± 0.9	5.7 ± 1.0
Day 21	Control-Water only	6.2 ± 1.6	N/A
	18% H_2O_2/12% PAA	6.2 ± 1.4	N/A
	Acetic Acid/PAA/H_2O_2	6.3 ± 1.9	N/A
	Quaternary Ammonium	6.9 ± 0.5	N/A

[a]No significant differences were seen in yeast/mold presence for cantaloupe or watermelon between washing solution treatments or across sampling days ($P > 0.05$).

affect the quality characteristics (firmness and color). The results of this study will be communicated with melon producers, as a reassurance that the utilized washing solutions to improve melons' safety will not negatively affect the product quality, but also may not substantially improve melon shelf life.

ACKNOWLEDGMENT

We would like to thank Lofredo Produce for supplying melons for the study, BioSafe Systems and Birko companies for donating produce washes, and students Kara Helterbran, Amber Roy, and John Dzubak for their assistance in the project.

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