Effectiveness of Vinegar as a Sanitizing Agent to Maintain the Postharvest Quality of Fresh-cut Pumpkin

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Abstract

Disinfection and color preservation are the main concern with fresh-cut products, and consumers have concerns about chemical residues resulting from procedures to overcome these problems. Thus, this study aimed to find an alternative treatment for controlling microorganisms and maintaining the quality of fresh-cut pumpkins. Fresh-cut pumpkins were immersed in diluted vinegar at 10%, 20% and 40% (v/v) for 3 min then packed in polyethylene bags; samples immersed in distilled water served as controls. All samples were stored at 5 ± 2 °C and 85 ± 2% relative humidity for up to 6 days. Whiteness index (WI), yellow index (YI), weight loss, phenolic and carotenoid contents, and as well as microbial populations were assessed. The results showed that vinegar preserved color which showed as higher YI and lower WI values compared with the control. *E. coli* and fungi were not detected on treated samples at any assessment time, but the colony count of aerobic bacteria showed that populations of other bacteria were lower on pumpkin slices treated with 10% vinegar. This concentration of vinegar was able to maintain the postharvest quality of fresh-cut pumpkins for 6 days.

Keywords: vinegar, fresh-cut pumpkin, color preservation, microorganisms

Introduction

In today's busy world, minimally processed foods (fresh-cut produce) are becoming more prevalent than fully preserved foods. However, to produce a good quality of fresh-cut produce requires that the producer overcomes problems associated with microbial spoilage, discoloration, changes in texture, the development of off-flavors, and nutritional losses. In addition to the convenience, fresh-cut pumpkins, therefore, are a good source of nutrients; however, they have problems associated with their appearance, with color loss, and with microbial contamination. Dry surfaces and color deterioration are a physiological consequence of wounding which encourages the production and deposition of lignin (Howard and Griffin, 1993; Brecht *et al*., 2004). This phenomenon can be observed as the formation of small white spots on plant surfaces. The use of household sanitizers, such as white vinegar, bleach, and lemon juice has been commonly used long time to remove dirt or blemishes because of their low acidity. Diluted household sanitizers can be effective in reducing numbers of *E. coli* and other aerobic, mesophilic bacteria on fresh-cut Iceberg lettuces (Vijayakumar and Wolf-Hall, 2002), and acetic acid has been used to reduce food-borne pathogenic bacteria (Ölmez and Kretzschmar, 2009). Therefore, the objective of this study was to investigate the use of diluted vinegar as a sanitizing agent for disinfection and color preservation of fresh-cut pumpkin, hypothesizing that simple household products (diluted vinegar) can maintain the color due to the production of a low pH.

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Materials and methods

Sample preparation

Whole pumpkins without damage were purchased at a local market in Bangkok, Thailand. Fruits were washed with tap water, the ends were then removed by hand before removing the skin and cutting internal spongy parts into slices of 4 mm in thickness. The sliced pumpkins were then dipped in water (control), or in 10, 20, or 40% diluted white vinegar (acetic acid 5%, AorSorRor, Thailand) for 3 min at room temperature. After immersion, the samples were dried at room temperature. All samples were then packaged into low density polyethylene bags (150 x 230 mm) and then stored 5 ± 2 °C and 85 ± 2% relative humidity for 6 days. Assessments were made after 0, 2, 4, 6 days of storage, with three replications per treatment and storage time.

Weight loss and analysis color and phytonutrients

Percentage weight loss was calculated from initial and final weights. The color of the slices was measured using a handheld colorimeter (L^*, a^*, and b^* values). A whiteness index (WI) was then calculated using the formula of Judd and Wyszecki (1963). A yellowness index (YI) was also calculated based on the formula of Francis and Clydesdale (1975). The content of phenolics (TPC) was determined by the Folin-Ciocalteu method (Folin and Ciocalteu, 1927) and total carotenoids using the method of Luterotti and Kjak (2010).

Microbiological analysis

Microbiological analysis analyzed total counts of aerobic bacteria, total counts of *E. coli*, coliforms, and total fungi on Days 0, 2, 4, 6 using plate count agar, eosin methylene blue agar, and potato dextrose agar, respectively. The number of microorganisms was expressed in log CFU/g.

Statistical analysis

All experimental work was carried out using a completely randomized design, and the results were reported as averages and standard errors. The data were analyzed by one-way analysis of variance (ANOVA) using Turkey's tests to separate means at $P < 0.05$ using Minitab Statistical Software Release 14 (Minitab Inc., PA, USA).

Results and discussion

The WI of all pumpkin slices increased with time in storage and significant ($P < 0.001$) reductions in this index occurred with increasing concentrations of vinegar (Fig. 1a). The slices treated with 40% vinegar had the lowest WI, and the WI of the slices in all vinegar treatments were lower than those of the controls. On Day 6 of storage, the average WI of controls was 76.0 and for the 40% vinegar treatment was 72.7. The original color of the pumpkin slices ranged from yellow to orange, but after storage, they became noticeably lighter, and the YI increased with increasing vinegar concentration (Fig. 1b). Hence, WI and YI are inversely related. Again, there were significant differences among the treatments with the slices in the 40% treatment being significantly ($P < 0.001$) more yellow that the other treatments; there were no significant differences among the other treatments. At the end of the storage period the average YI of the control was 109.5 and for the slices in the 40% treatment was 118.5. According to Howard and Griffin (1993), surface discoloration of carrots occurs due to lignification. Under biotic stresses, plant pathogens accelerate lignin production by their host; therefore, inhibiting the growth of microorganisms is method of maintaining the appearance of fresh-cuts. Meireles *et al*. (2016) considered organic acids including acetic acid, to reduce microbial spoilage and do not produce carcinogenic compounds reducing microbial spoilage compared with sodium hypochlorite, a common disinfectant used in the fresh-cut produce industry.

No significant differences were found in weight loss, and the contents of total phenolics and carotenoids ($P > 0.05$ in all cases). However, at the end of storage time, percentage of weight loss of slices treated with 40% vinegar and control had the highest of 0.57 and 0.56, respectively (Fig. 1c). By contrast, using 10% vinegar for sanitizing showed the lowest percentage of weight loss at the same assessment time. It means that higher acidity may injure plant cells by creating a high osmotic pressure that is usually recognized of water loss. The change of total phenolic contents is showed at Fig. 1d. Similar to the change of using ascorbic acid for fresh-cut grapes by Shiri *et al*. (2011), total phenolic contents was raised because that acid promoted synergistic effect of phenolics. Comparison of the total carotenoid profile (Fig. 1e) with those of other studies, our finding is fairly similar to that of Habibunnisa *et al*. (2001) who found carotenoid value range 590.08 – 606.95 (µg/100g). In our case, the difference in TPC, and carotenoid illustrate the dependency of biochemical composition on genotypes, climate condition, maturity and agricultural handling system.

During the storage period, total colony counts of aerobic bacteria (Fig. 1f) on pumpkin slices treated with 10% vinegar were always lower than other treatments. While total bacterial count increased but the result was still under Hong Kong's microbiological guideline (Tsang, 2002) of ready-to-eat "acceptable" label (below than 10^5 CFU/g). At the end of the storage period (Day 6), total *E. coli*, coliform, and fungi experiment were not detected any colony of treated pumpkins. According to Lianou *et al*. (2012), the simple structure and small molecular size of organic acid can enter bacterial cells easily to change their internal components causing death cells.

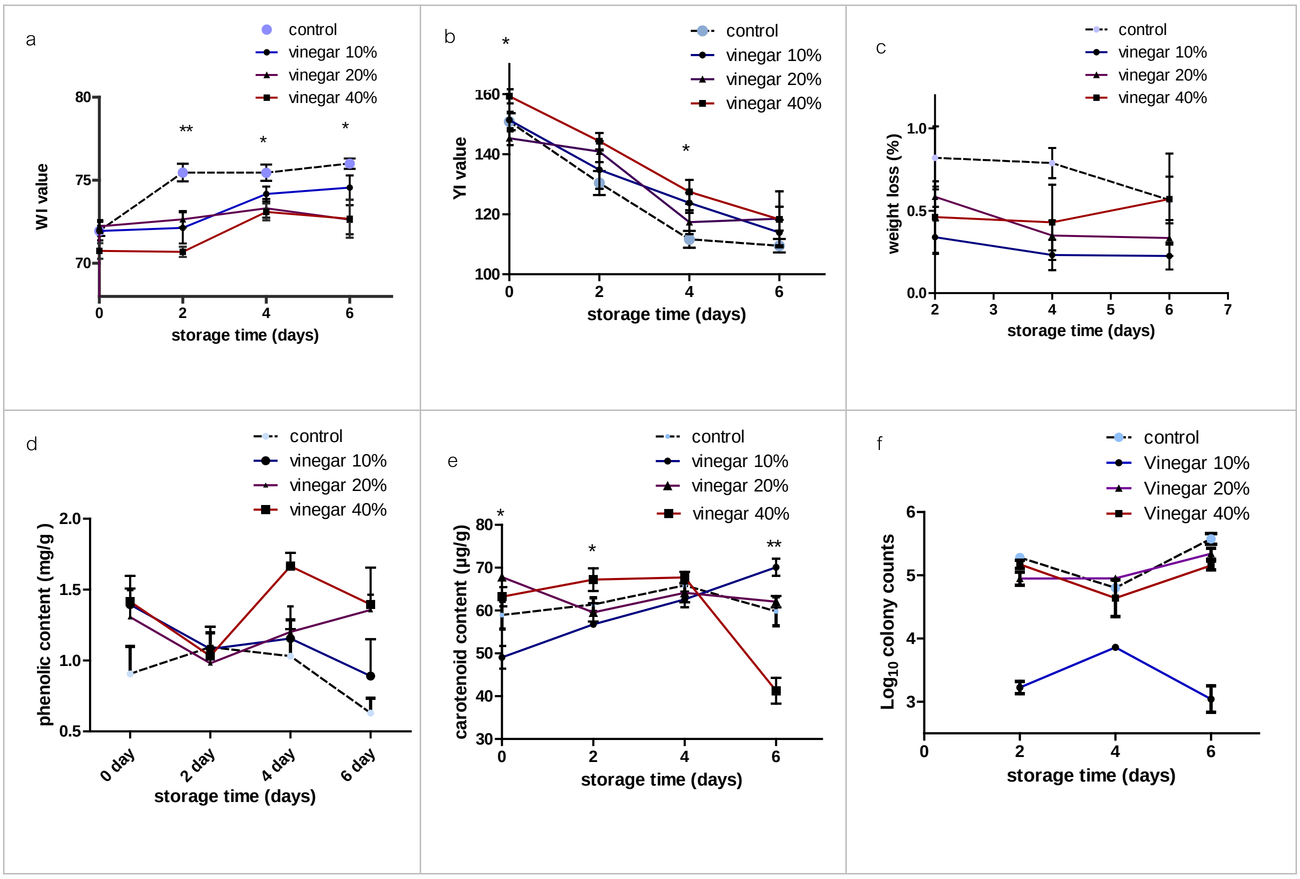

Figure 1 Average (n = 3) values of (a) WI, (b) YI, (c) percentage weight loss and (d) total phenolic content (e) total carotenoid (f) numbers (log_{10} transformed) of bacterial colonies on plate count agar of fresh-cut pumpkin dipped in water (control) or in 10, 20 and 40% vinegar solutions and kept at 5ºC.

Conclusions

At a retail cold chain temperature of 5 ± 2°C, sliced pumpkin treated with 10% diluted vinegar could be the best treatment to maintain quality. The mild acidity from diluted vinegar can reduce microorganism contributing to color preservation and can minimize spoilage.

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References

Brecht, J., M. Saltveit, S. Talcott, K. Schneider, K. Felkey and J Bartz. 2004. Fresh-cut vegetables and fruits. Horticultural Reviews 30: 185-251.

Folin, O. and V. Ciocalteu. 1927. On tyrosine and tryptophane determinations in proteins. Journal of biological chemistry 73(2): 627-650.

Francis, F. J. and F. M. Clydesdale. 1975. Food colorimetry: theory and applications: AVI Publishing Co. Inc.

Habibunnisa, M., B. Revathy, P. Rajendra and M. Krishnaprakash. 2001. Storage behaviour of minimally processed pumpkin (Cucurbita maxima) under modified atmosphere packaging conditions. European Food Research and Technology 212: 165-169.

Howard, L. and L. Griffin 1993. Lignin formation and surface discoloration of minimally processed carrot sticks. Journal of food science 58(5): 1065-1067.

Judd, D. and G. Wyszecki. 1963. Color in Business, Science and Industry. ed. 2. New York: John Wiley & Sons, Inc.

Lianou, A., K. Koutsoumanis and J. Sofos. 2012. Organic acids and other chemical treatments for microbial decontamination of food. pp. 592-664. In A. Demirci and M.O. Ngadi (Eds.). Microbial decontamination in the food industry. Woodhed Publishing, UK.

Luterotti, S. and K. Kljak. 2010. Spectrophotometric estimation of total carotenoids in cereal grain products. Acta Chimica Slovenica 57(4): 781-787.

Meireles, A., E. Giaouris and M. Simoes. 2016. Alternative disinfection methods to chlorine for use in the fresh-cut industry. Food Research International 82: 71-85.

Ölmez, H. and U. Kretzschmar. 2009. Potential alternative disinfection methods for organic fresh-cut industry for minimizing water consumption and environmental impact. LWT-Food Science and Technology 42(3): 686-693.

Shiri, M. A., M. Ghasemnezhad, D. Bakhshi and M. Saadatian 2011. Effects of ascorbic acid on phenolic compounds and antioxidant activity of packaged fresh cut table grapes. Electronic Journal of Environmental, Agricultural & Food Chemistry 10(7): 2506-2515.

Tsang, D. 2002. Microbiological guidelines for ready to eat food. Road and Environmental Hygiene Department, Hongkong. pp. 115-116.

Vijayakumar, C. and C.E. Wolf-Hall. 2002. Evaluation of household sanitizers for reducing levels of Escherichia coli on iceberg lettuce. Journal of food protection 65(10): 1646-1650.