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Guava fruit treated with hot water on microbiological quality of fresh-cut ‘Kimju’ and ‘Pan Srithong’ guava

[1*]Poubol, J., [2]Techavuthiporn, C. and [3]Kanlayanarat, S.

[1]Department of Science, Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom Province, 73140, Thailand
[2]Department of Biological Science, Faculty of Science and Technology, Huachiew Chalermprakiet University, Samut Prakan Province, 1054, Thailand
[3]Division of Postharvest Technology, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Bangkok, 10140, Thailand

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Abstract

The effect of hot water treatment on microbiological quality of fresh-cut ‘Kimju’ and ‘Pan Srithong’ guava was investigated. Guava fruit, cv. ‘Kimju’ and ‘Pan Srithong’ were treated with hot water at 40, 50 and 60°C for 10 and 30 minutes. Fruit was cooled in sterile water at 5°C for 5 minutes and cut into 2 cm^3 cubes, then packed in foam tray and wrapped with polyvinylchloride (PVC) film. Total microbial count, coliforms, lactic acid bacteria and fungi were enumerated after processing and during storage at 10°C for 6 days. Vitamin C content and disorder were determined for quality changes of fresh-cut guava as affected by the heat treatment. The results showed that the hot water treatment significantly reduced total microbial and coliforms counts of ‘Kimju’ cultivar, with the reduction was increased with higher temperature and longer immersion time. Lactic acid bacteria and fungi were below the detection level during 4 days of storage at 10°C, thereafter they were increased at day 6 of storage. Vitamin C content of ‘Kimju’ and ‘Pan Srithong’ guava cubes at the initial day of storage was in the range of 0.8-1.1 and 0.5-0.9 mg/100 g fresh weights, respectively. After storage at 10°C, vitamin C content was slightly decreased in ‘Kimju’ cultivar, whereas it was slightly increased in ‘Pan Srithong’ cultivar. Browning development as indicated disorder was observed on the surface of both cultivars during storage. Browning development increased with an increase in temperature and time. Hot water treatment at 50°C for 10 and 30 minutes could be used to maintain quality and minimized microorganism of fresh-cut guava.

Introduction

Fresh-cut fruit products are increasing in Thailand as it is easy and convenience for human consumption. Guava (*Psidium guajava* L.) is one of a tropical fruit that can be produced all year round in Thailand. ‘Kimju’ and ‘Pan Srithong’ are two cultivars that are famous for their attribute properties in Thailand. ‘Kimju’ is a small fruit, which is a seedless guava cultivar. The fruit is creamy green color, delicious taste and crispy texture. ‘Pan Srithong’ is a seed guava cultivar, which is bigger than ‘Kimju’ cultivar. The fruit is light green color, delicious taste and crispy texture. Guava fruit is rich in vitamin C and fiber contents, which are healthy and nutritious for human. Therefore, fresh-cut guava is marketed widely in Thailand. However, fresh-cut fruit is easily to become soften and loss of its nutritious value just after processing, especially when the fruit is kept at room temperature.

Postharvest treatments using hot water have been reported to maintain quality and microbial safety during storage and marketing of fresh fruit. It has been reported that hot water treatment by immersion of fruit in water at temperatures of 43-53°C for several minutes up to 2 h was applied for quarantine treatments, while commercially hot water treatment by rinsing and brushing fruit in water at 48-63°C for 10-25 s was applied for maintaining fruit quality during storage and marketing (Fallik, 2004). There are a few researches focusing on hot water treatment of guava. McGuire (1997) reported that immersion of guava fruit in hot water at 46.1°C for 35 min increased fruit susceptibility to decay, however it could delayed fruit ripening as compared to untreated fruit. Poubol *et al.* (2013) reported that immersion of fresh-cut guava in hot water at 50°C for 10 and 30 min reduced microbial population without changes in texture or increasing disorders. Fruit treated with hot water before processing and storage of fresh-cut product was beneficial in increasing the firmness of ‘Reticulatus’ cantaloupe melon (Lamikanra and

*Corresponding author.
Email: *faasjtt@ku.ac.th*

Watson, 2007) and 'Rocha' pear (Abreu *et al.*, 2003), maintaining cell membrane integrity and reducing the microbial load of Galia melon (Silveira *et al.*, 2011). On the other hand visual quality, electrolyte leakage, firmness and aroma volatile production were not differed between fresh-cut prepared from hot water or non-hot water treated of 'Kent' mango fruit (Dea *et al*., 2010).

Recently, it has been reported that postharvest hot water dipping induced disease resistance, maintained firmness of muskmelon (Yuan *et al*., 2013) and decontaminated natural microflora and foodborne pathogen such as *Escherichia coli* O157:H7, Listeria monocytogenes and *Salmonella* spp. in raw mung bean sprouts (Phua *et al.*, 2014). However, the microbiological quality of fresh-cut 'Kimju' and 'Pan Srithong' guava from fruit treated with hot water has not been reported. The objective of this work was to determine the microbiological quality of fresh-cut 'Kimju' and 'Pan Srithong' guava as affected by different hot water treatments of the whole fresh fruit.

Materials and Methods

Plant material and hot water treatment

'Kimju' and 'Pan Srithong' guava (Psidium guajava L.) were obtained from an orchard in Nakhon Pathom province, Thailand. Fruit was selected based on uniformity of size, color and free from defects. A 'Kimju' or 'Pan Srithong' fruit about 300 or 400 g/fruit, respectively was washed with 50 ppm chlorinated water for 1 min at 25°C to remove microorganism from the surface of the fruit. Fruits were immersed in water bath that contained sterile distilled water (fruit:hotwater in a ratio of 1:3) at 40, 50 or 60°C for 10 or 30 min. Following the hot water treatment, all treated fruit samples were left for 5 min in sterile distilled water at 5°C to cool down. Fruit was cut into 2 cm^3 cubes. Approximately 100 g of cubes was aseptically placed in foam tray (110×130×15 mm) and wrapped with 13 µm thickness PVC film. The permeability of the film for CO_2 was 292,862 ml/m^2.d at 25°C and 95% RH. All packages were stored at 10°C for 6 days.

Microbial analysis

Fresh-cut 'Kimju' and 'Pan Srithong' guava of 10 g each were macerated in 90 mL sterile saline solution (0.85% NaCl) in a sterile Polypropylene (PP) bag using stomacher (Masticator Nr2557/400, IUL instruments; Barcelona, Spain) for 1 min at room temperature (Poubol *et al*., 2009). Serial dilutions were made in sterile saline solutions as needed to determine and culture the microbial population of guava samples on Plate Count Agar (PCA; Merck; Darmstadt, Germany) for total microbial count, Deoxycholate Agar (HiMedia Laboratories; Mumbai, India) for coliforms count, de Man Rogosa and Sharpe agar (MRS; Merck; Darmstadt, Germany) for lactic acid bacteria count and Potato Dextrose Agar (PDA; HiMedia Laboratories; Mumbai, India) added with 100 ppm chloramphenicol for fungal count. PCA, Deoxycholate and MRS Agar plates were incubated for 2 days at 37°C, while the PDA plates for 5-7 days at 26°C. Microbial populations were expressed as log_{10}colony-forming units per gram (log_{10} CFU/g).

Quality measurement

Vitamin C content was determined as described earlier (Poubol *et al*., 2008). Briefly, a 5 g of sample was macerated with 20 ml of 5% metaphosphoric acid (Merck; Darmstadt, Germany) following the protocol of Roe *et al.* (1948). Disorder as indicated by browning development on the surface of cubes was evaluated using a 9-point scoring scale where 9 = excellent or fresh appearance (no browning), 7 = very good (<20% of the cube surface), 5 = good (20-40% of the cube surface; limit of marketability), 3 = fair (40-60% of the cube surface), and 1 = poor (>60% of the cube surface).

Experimental design and statistical analysis

The experiment was conducted in a completely randomized design with three replications per treatment. Results were analyzed by performing analysis of variance and mean comparison Duncan's multiple range test (DMRT). Standard error of the mean was also calculated.

Results and Discussion

Effect of hot water treatment on microbial counts

Total microbial counts of fresh-cut 'Kimju' and 'Pan Srithong' guava processed from fruit immersed in hot water at 40°C were about 3.3 and 3.7 log CFU/g, respectively (Figure 1). Hot water treatments at 50 and 60°C were shown to decrease the total microbial counts of both cultivars with the reduction for about 0.5-1 log CFU/g. A similar result in reduction of total microbial count was found in fresh-cut 'Kimju' guava immersed in hot water at 50 and 60°C for 10 or 30 min (Poubol *et al*., 2013). After storage at 10°C, total microbial counts of both cultivars were slightly increased. Hot water temperatures at 50-60°C seemed to delay total microbial growth as compared to a hot water temperature at 40°C regardless of immersion time. However, a significant increase of total microbial count after stored at 10°C for 6 days was found in

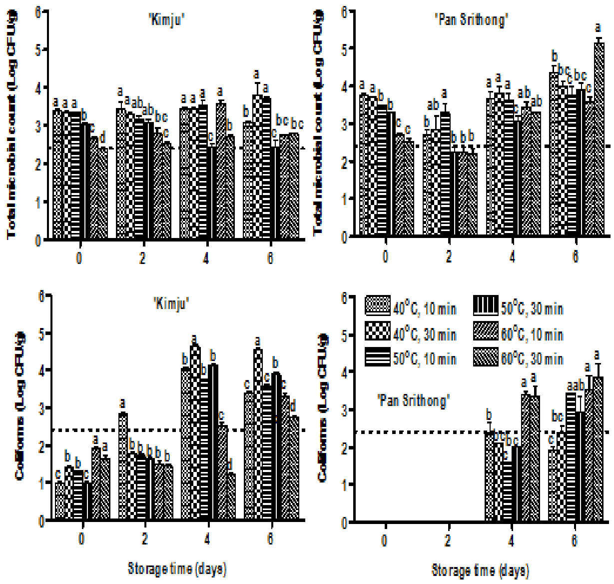

Figure 1. Total microbial and coliforms counts of fresh-cut ‘Kimju’ and ‘Pan Srithong’ guava prepared from fruit immersed in hot water at 40, 50, or 60°C for 10 or 30 min. Guava cubes were stored at 10°C for 6 days. Dotted line represents microbial counts were below the detection level

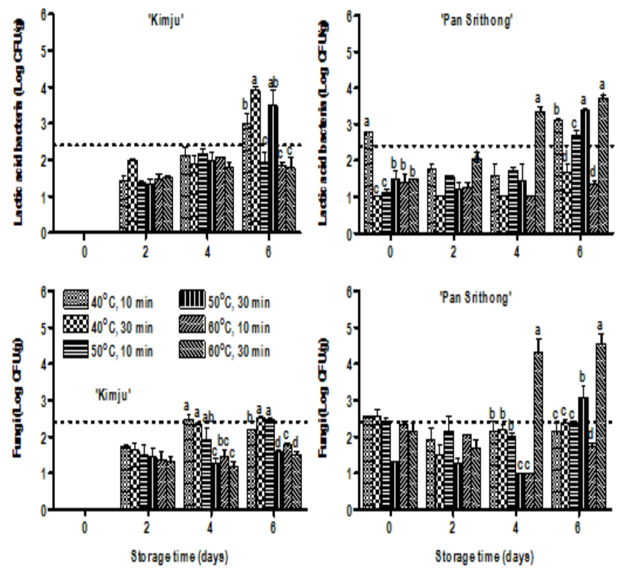

Figure 2. Lactic acid bacteria and fungi counts of fresh-cut ‘Kimju’ and ‘Pan Srithong’ guava prepared from fruit immersed in hot water at 40, 50, or 60°C for 10 or 30 min. Guava cubes were stored at 10°C for 6 days. Dotted line represents microbial counts were below the detection level

‘Pan Srithong’ cultivar treated with hot water at 60°C for 30 min. This result might indicate that the highest temperature and the longest immersion time caused the deterioration of ‘Pan Srithong’ cultivar with a significantly increased of disorder and decreased of vitamin C content in this cultivar. A similar result for the increase of total microbial count was found in coliforms, lactic acid bacteria and fungi counts at the 6th day of storage.

Coliforms count of ‘Kimju’ cultivar was below the detection level (2.4 log CFU/g) at the initial day of storage, whereas coliforms count of ‘Pan Srithong’ cultivar was not detectable (Figure 1). On the 2nd day of storage at 10°C, hot water treatments at 50 and 60°C significantly delayed an increase of coliforms count of fresh-cut ‘Kimju’ guava as compared to hot water treatment at 40°C for 10 min, with the counts were below the detection level. Coliforms count of ‘Pan Srithong’ guava was detected on the 4th day of storage with the count were below the detection level in guava cubes treated with hot water at 40 and 50°C. Coliforms counts of both cultivars increased during storage to be higher than the detection level. Hot water treatment at 60°C seems to delay coliforms growth of fresh-cut ‘Kimju’ guava, whereas hot water treatment at 40°C seemed to delay coliforms growth of fresh-cut ‘Pan Srithong’ guava. The different in hot water temperatures had different effect on coliforms count in guava cultivars. This might due to the different in structural surface and physicochemical properties between two cultivars. Therefore, the effectiveness of hot water treatment to minimizing microorganism was varied between cultivars.

Lactic acid bacteria and fungi counts of ‘Kimju’ cultivar were not detectable at the initial day of storage, whereas the count of ‘Pan Srithong’ cultivar treated with hot water, except for hot water treatment at 40°C for 10 min were below the detection level (Figure 2). A slight increase of lactic acid bacteria and fungi counts of both cultivars were found during storage. Hot water treatments at 50-60°C seemed to delay lactic acid bacteria and fungi growth of fresh-cut ‘Kimju’ guava, whereas hot water treatment at 40-50°C seemed to delay lactic acid bacteria and fungi counts of fresh-cut ‘Pan Srithong’ guava. The different in hot water temperatures had different effect on lactic acid bacteria in guava cultivars. This might due to the different in structural surface and physicochemical properties between two cultivars.

Initial total microbial, coliforms, lactic acid bacteria and fungi counts of fresh-cut guava were varies between cultivars. Therefore, the effect of hot water treatment to minimize microorganism was varies between fruit cultivars. It has been reported that hot water rinsing and brushing at 56°C for 20 s or 62.8°C for 15 s reduced decay of orange cv. Shamouti (Porat *et al*., 2000) and cv. Torocco (Smilanick *et al*., 2003), respectively. In our research, hot water treatment at 50°C for 10 and 30 min seemed to minimize the microorganism growth of fresh-cut ‘Kimju’ and ‘Pan Srithong’ guava prepared from fruit immersed in hot water. The mechanism of heat treatment to inhibit microbial pathogen was reported

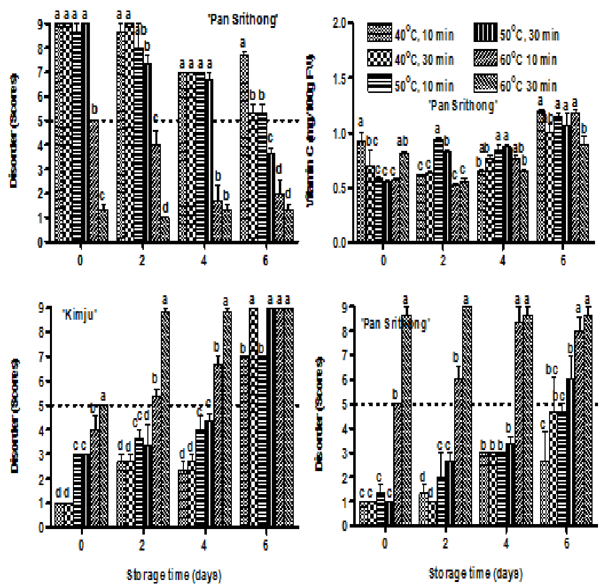

Figure 3. Vitamin C content and disorder of fresh-cut 'Kimju' and 'Pan Srithong' guava prepared from fruit immersed in hot water at 40, 50, or 60°C for 10 or 30 min. Guava cubes were stored at 10°C for 6 days. Dotted line indicates limit of consumer acceptability

to induce defense mechanisms in the outer layers of epicarp of fruit (Ben-Yehoshua *et al*., 1997) and the high temperature affected the cell wall, enzymes, protein, DNA and RNA of bacterial cell (Russell, 2003). Therefore, hot water treatment could be used to minimize microbial contaminated on fresh-cut produce.

Effect of hot water treatment on vitamin C content

Vitamin C content of 'Kimju' and 'Pan Srithong' guava cubes at the initial day of storage was in the range of 0.8-1.1 and 0.5-0.9 mg/100g FW, respectively (Figure 3). 'Pan Srithong' cultivar had vitamin C content lower than 'Kimju' cultivar. After storage at 10°C, vitamin C content was slightly decreased in 'Kimju' cultivar, whereas it was slightly increased in 'Pan Srithong' cultivar. The increase in vitamin C content might occur in the injured tissue of fresh-cut guava as reported in potato tubers which was due to ascorbate synthesis as it was induced by L-galacto-ɤ-lactone dehydrogenase (Oba *et al.*, 1994). In contrast, the decrease in vitamin C content in 'Kimju' cultivar might due to the ripening was higher progressed in 'Kimju' cultivar than in 'Pan Srithong' cultivar. Therefore, vitamin C content trended to decrease more than increase of ascorbate synthesis. At the end of storage, vitamin C content of 'Kimju' and 'Pan Srithong' guava cubes was in the range of 0.6-1.0 and 0.8-1.1 mg/100g FW, respectively. Hot water treatment at 40-50°C for 10 or 30 min found to maintain vitamin C content of both cultivars as compared the other treatments. A similar result for the decrease of vitamin C content in fresh-cut fruit treated with hot water during storage was reported in fresh-cut 'Keitt' mango processed from whole fruit dipped in hot water at 46 and 50°C for 30 and 75 min and stored at 6°C (Djioua *et al.*, 2009). They reported that heat treatment induced a decrease in the amount of vitamin C content as compared to non heat treatment, whereas fresh-cut 'Kent' mango prepared from hot water treated fruit at 46°C for 75 or 90 min was slightly increased in vitamin C content during storage at 5°C (Dea *et al*., 2010). The change of vitamin C content of fresh-cut fruit was varying between fruit cultivar and storage conditions.

Effect of hot water treatment on disorder

At the initial day of storage, browning development as indicated disorder of fresh-cut guava cubes was observed on the surface of both guava cultivars (Figure 3). Browning development rapidly increased in 'Kimju' cultivar than that of 'Pan Srithong' cultivar. The development of browning was increased with an increase in hot water temperature and immersing time (Figure 3). Browning development in 'Kimju' cultivar was related to the decrease of vitamin C content as it could protect their cell from browning reaction on oxidative system. Moreover, the ripening of 'Kimju' cultivar as affected by hot water treatment might enhance the loss of cell wall structural and allowing enzymatic browning to reacting with a substrate, which leaded this cultivar had a higher browning than in 'Pan Srithong' cultivar. At heating temperature of 40°C, the process delayed the development of browning on fresh-cut 'Kimju' guava as compared to those of 50-60°C, whereas the application of heating temperatures of 40-50°C delayed the development of browning on fresh-cut 'Pan Srithong' guava as compared to that of 60°C. On the 2nd day of storage, fresh-cut 'Kimju' guava cube prepared from fruit treated with hot water at 60°C showed the development of browning to be higher than the consumer acceptability score (5 scores) and limited the shelf life of fresh-cut 'Kimju' guava. Fresh-cut 'Pan Srithong' guava treated with hot water at 40-50°C showed the development of browning which was lower than the score of consumer acceptance. The shelf life of fresh-cut 'Pan Srithong' was about 6 days.

Hot water treatment at 40-50°C could be used to delay disorder of both fresh-cut guava cultivars. The darker color on fresh-cut fruit processed from hot water treated fruit was found on 'Kent' mango (Dea *et al*., 2010). They reported that fresh-cut mango had slightly water-soaked with darker color veins, which limited marketability of fresh-cut mango. In our previously research, fresh-cut 'Kimju' guava cube dipped in hot water at 60°C for 10 min had a browning development on cube (Poubol *et al*., 2013) similar as was found in 'Kimju' guava cube prepared from fruit treated with hot water. The effect of hot water treatment on quality of fresh and fresh-cut produce is widely varied on fresh produce. Hot water treatment at a temperature of 40-60°C reported to enhance physical quality of fresh produce by inhibiting enzymatic reactions in paprika and potatoes (Sivakumar and Fallik, 2013) whereas it had undesirable effect on color of bean sprouts (Phua *et al.*, 2014). In this studied, the microbiological quality of fresh-cut guava treated with hot water would be better than the sample without hot water treatment (fruit was immersed in sterile distilled water at 25°C) as in our preliminary studied (data not presented). The hot water treatment could be minimized microorganism than untreated sample.

Conclusions

Hot water treatment at 50°C for 10 and 30 minutes could be used to maintain quality and minimized microorganism of fresh-cut 'Kimju' and 'Pan Srithong' guava, respectively.

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