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# Effect of deastringency treatment of intact persimmon fruits on the quality of fresh-cut persimmons

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ABSTRACT

The changes in the quality characteristics of the fresh-cut products prepared from intact 'Cheongdobansi' persimmons treated with different deastringency methods (nontreated, carbon dioxide gas, warm water, ethanol vapour) have been investigated for 6 days at 10 °C. Flesh firmness of the persimmons decreased after ethanol vapour treatment. The decrease in $L^*$ value and flesh firmness in the slices prepared from persimmons treated with warm water was retarded. Soluble solids content and titratable acidity of the persimmons decreased after all deastringency treatments. Soluble tannins and radical scavenging activity of the slices from untreated persimmons were maintained at higher concentrations, unlike slices from astringency-removed persimmons. These results suggest that pre-slicing deastringency treatments affect the characteristics of fresh-cut persimmons, and that warm-water treatment could be a useful method to control the browning and softening of fresh-cut persimmons.



## 1. Introduction

*Diospyros kaki*, a deciduous tree of the Ebenaceae family, has been widely cultivated in East Asia. The fruits of *D. kaki*, a healthy traditional form of food, are classified into astringent and nonastringent persimmon varieties according to the presence of astringency in the fruits at harvest (Kim & Ko, 1995). The nonastringent persimmons are consumed commonly as a fresh fruit, while astringent persimmons are subjected to deastringency treatment prior to eating and are processed into dried, soft, and fresh astringency-removed types (Roh, Jang, Park, Byun, & Sung, 1999). 'Cheongdobansi' is an astringent persimmon variety grown in the Cheongdo region of Korea that can be processed into any type, because this is a seedless variety of a relatively superior quality (Roh et al., 1999). The dried and soft types can be maintained under freezing conditions for a long time and can be utilised as materials for processing. Fresh astringency-removed type has the taste of fresh fruits and a better quality than natural nonastringent persimmons; however, these persimmons have a short shelf-life and are consumed mainly as a fresh fruit (Nam, Lee, Hong, Kim, & Kim, 1998). Because the market for fresh-cut fruits is continuously growing due to consumer demand for fresh, convenient to eat, and healthy food options (Jeong, 2012), we need to develop fresh-cut persimmon products of better quality with a long shelf-life. However, little is known about the processing characteristics, including the effect of deastringency methods for intact persimmons on fresh-cut responses.

The physicochemical and physiological changes induced by deastringency treatment in intact persimmons vary according to the variety of the fruit and the deastringency methods, which include warm water treatment (Taira, Itamura, Abe, & Watanabe, 1989), ethanol treatment (Kato, 1984), high $CO_2$ treatment (Arnal & Del Rio, 2003; Seu & Sohn, 1976), and modified atmosphere packaging (Pesis, Levi, & Ben-Arie, 1986). The astringency removal resulting from the deastringency treatments is mainly because of a direct reaction between acetaldehyde, produced during anaerobic respiration developed by the deastringency treatment, and soluble tannins, which form an insoluble product devoid of astringency (Fukushima, Kitamura, Murayama, & Yoshida, 1991; Matsuo, Itoo, & Ben-Arie, 1991). Ethanol treatment and high $CO_2$ treatment are common commercial deastringency methods because of their practicality and better resultant fruit quality as compared to the results of warm water and modified atmosphere packaging treatments (Jeong, Chung, Lee, Seong, & Choi, 2001). The astringency-removed persimmons resulting from ethanol treatment have good flavour and texture, but they show characteristic easy softening and low storability (Taira, Oba, & Watanabe, 1992). On the other hand, the astringency-removed persimmons resulting from $CO_2$ treatment have high storability owing to their harder flesh, but they are not juicy enough (Taira et al., 1992). The effects of deastringency on the quality of astringency-removed persimmons have

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been deciphered. However, the deastringency methods are expected to have different effects on the quality of fresh-cut products prepared from astringency-removed persimmons, and the most efficient method for astringency removal when preparing fresh-cut products can be obtained after further research.

Generally, the shelf-life of fresh-cut products is less than that of intact fruits and vegetables because fresh-cut means the tissues are wounded (Cantwell, 1992). The wounding of plant tissues induces elevated respiration and ethylene production, enzymatic browning, membrane lipid degradation, production of secondary metabolites, and water loss (Watada, Abe, & Yamauchi, 1990). Minimising the consequences of wounding in fresh-cut products will help in increasing their shelf-life (Brecht, 1995). Therefore, combined technologies of chemical and physical treatments, packaging, and control of temperature and atmosphere have been commercially used for preparing various fresh-cut fruits and vegetables (Rico, Martin-Diana, Barat, & Barry-Ryan, 2007; Soliva-Fortuny & Martin-Belloso, 2003). The effects of antioxidants (Ghidelli, Rojas-Argudo, Mateos, & Perez-Gago, 2013), 1-methylcyclopropene (Vilas-Boas & Kader, 2007), and controlled atmosphere storage (Wright & Kader, 1997) in controlling browning and softening in fresh-cut persimmons have already been studied. However, little is known about the effect of pre-slicing deastringency treatments on fresh-cut persimmons; this information, when available can be used as fundamental information for fresh-cut processing.

The objectives of this study were to develop a deastringency method for preparing high quality fresh-cut persimmons from intact astringent fruits, and to investigate the effects of several deastringency methods on the changes in post-slicing quality characteristics of persimmon fruits.

## 2. Materials and methods

### 2.1. Materials

Astringent persimmons (*Diospyros kaki* T. cv. Cheongdobansi) from a commercial farm in the Cheongdo region of Korea were harvested at commercial maturity and graded according to their size and their defects. Sound and uniform sized fruits (120 ± 5 g) were used for the following experiments. Folin–Ciocalteu reagent was purchased from Junsei Chemical Co. (Tokyo, Japan), and catechin and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were purchased from Sigma–Aldrich Chemical Co. (St. Louis, MO, USA). Other chemicals used for analyses were high-purity grade

### 2.2. Deastringency treatment

Astringent persimmons were treated to remove their astringency by using 3 different methods. We used effective treatment conditions for the deastringency treatments, as per those reported in previous studies (Kato, 1984; Seu & Sohn, 1976; Taira et al., 1989). Sets of 10 kg astringent persimmons were submitted to three different treatments: (a) 2 days at 20 °C in 80% $CO_2$ atmosphere in a gas tight glass jar (15 L), (b) 2 days at 35 °C in a water bath, and (c) 6 days at 20 °C in an atmosphere of 35% ethanol in a gas-tight glass jar (15 L). The untreated fruits were used as the controls.

### 2.3. Slice preparation

Astringency-removed persimmons that had been treated using different methods were washed in sodium hypochlorite solution (100 μL $L^{-1}$, pH 6.5, 5 °C) for 2 min, dried for 15 min, then peeled and sliced into 4 wedges by using a sharp stainless steel knife. Twenty 200-g lots of the slices obtained from every deastringency method were then immediately placed in a plastic tray, covered with unsealed individual polyethylene film bags, and kept at 10 °C for up to 6 days. Three replicates from each treatment set were analysed regularly at 1-day intervals. Twenty untreated 200-g lots of slices were placed on a plastic tray, covered with unsealed individual polyethylene film bags, and kept at 10 °C for up to 6 days and used as the control.

### 2.4. Analysis of surface colour

The colour properties of the persimmon slices were analysed using a colorimeter (CR-200, Minolta Co., Osaka, Japan) fitted with a CIE illuminant C and an 8-mm-diameter measuring aperture, which was calibrated using a standard white plate ($L^*$ = 97.79; $a^*$ = −0.38; $b^*$ = 2.05). Three readings of $L^*$, $a^*$, and $b^*$ were recorded for each sample. The $L^*$ value represents lightness, and the $a^*$ and $b^*$ values represent redness and yellowness, respectively. The $L^*$, $a^*$, and $b^*$ values for each sample were converted into $h^\circ$ and $C^*$ values according to the following equations. The $h^\circ$ value expresses the colour tone, and is defined as red–purple: 0°, yellow: 90°, bluish-green: 180°, and blue: 270°, and was calculated as $h^\circ = \tan^{-1}(b^*/a^*)$. The $C^*$ value is a measure of the purity or saturation of the colour and was calculated from the equation $(a^{*2} + b^{*2})^{1/2}$.

### 2.5. Analysis of flesh firmness

Persimmon flesh cylinders (diameter, 20 mm; height, 10 mm) were prepared from the persimmon fruits using a cork borer. The firmness of the 10 cylinders obtained from each deastringency treatment was measured using a rheometer (Compac-100 II, Sun Scientific Co., Ltd., Tokyo, Japan) equipped with a 5-mm-diameter probe. The penetration depth and table speed were 6 mm and 60 mm $min^{-1}$, respectively.

### 2.6. Analysis of soluble tannin content

The content of the soluble tannins was determined using the Folin–Ciocalteu procedure (Singleton & Rossi, 1965). Five grams of the persimmon slices were homogenised in deionised water, and the homogenate was centrifuged. A portion (1 mL) of the diluted supernatant was then transferred into a volumetric flask. Folin–Ciocalteu reagent (2 mL) was added, and mixed thoroughly. After 5 min, 2 mL of 10% $Na_2CO_3$ solution were added and the mixture was allowed to stand for 1 h. The absorbance of the resulting solution was measured using a spectrophotometer (Evolution 201, Thermo Fisher Scientific Inc., Madison, WI, USA) at 760 nm. Content of the soluble tannins was determined by comparing with the absorbance of (+)-catechin used at different concentrations as the standard.

### 2.7. Analysis of radical scavenging activity

Radical scavenging activity of the persimmon slices was determined using DPPH radical (Blois, 1958). A 0.2 mL sample of the persimmon slice extracts was added to 0.8 mL of 0.4 mmol/L DPPH radical in ethanol. The mixture was shaken vigorously and allowed to stand for 10 min. The absorbance of the resulting solution was measured at 525 nm using a spectrophotometer (Thermo Fisher Scientific). The radical scavenging activity was calculated using the following formula: DPPH radical scavenging activity (%) = [1 − (absorbance of sample/absorbance of DPPH)] × 100.

### 2.8. Analyses of soluble solids and titratable acidity

The persimmon slices were homogenised and centrifuged, and the supernatant was used as a sample for analysing the soluble solids content and the titratable acidity. The soluble solids content was