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Effect of cutting styles on quality and antioxidant activity in fresh-cut pitaya fruit

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ABSTRACT

The effect of different cutting styles on the quality and antioxidant activity of pitaya fruit during 4 d of storage at 15 °C was investigated. Pitaya fruit was cut into slice, half-slice and quarter-slice, all in 1 cm of thickness, with corresponding wounding intensity (A/W) of 2.0, 2.9 and 3.7 $cm^2 g^{-1}$, respectively. *Results:* showed that cutting styles had little influence on fruit quality parameters such as vitamin C, soluble solids, titratable acidity and flesh color. While total phenolic content, antioxidant activity, and phenylalanine ammonia-lyase activity increased significantly with cutting wounding intensity at the first 2 d of storage. In addition, fresh-cut processing induced the reactive oxygen species (ROS) generation and enhanced the activity of antioxidant enzymes including catalase, superoxide dismutase and glutathione reductase at the initial storage time. These results demonstrated that cutting styles didn't have much adverse effect on the organoleptic quality, but significantly induced the biosynthesis of phenolics and improved the antioxidant activity of fresh-cut pitaya fruit. Moreover, ROS may act as signaling molecules in the accumulation of phenolics in fresh-cut pitaya fruit.

1. Introduction

Cutting is an essential procedure that divide intact products into smaller pieces in fresh-cut fruits and vegetables processing. This cutting operation will inevitably cause the tissue to suffer from wounding stress, which may accelerate the deterioration processes including water loss, oxidative browning, tissue softening and development of off-flavours, thus limiting the shelf-life of fresh-cut produce (Gil et al., 2006; Hodges and Toivonen, 2008). It is generally recognized that two types of phenolic metabolism responses will be triggered in plant tissues when a wounding stress occurs (Rhodes and Wooltorton, 1978). Firstly, the breakage of the plasma membrane induces the oxidative enzyme systems to react with the existing phenolic compounds, causing the oxidation of phenolics and the browning of tissues, which is adverse for maintaining of the produce quality (Saltveit, 2000). Secondly, when wounding stress occurs, plants produce injury signals to induce the production of more secondary metabolites including phenolic antioxidants to defense and heal the wounding damage (Ryan, 2000; Rakwal and Agrawal, 2003; Cisneros-Zevallos, 2003). Therefore, the wounding stress caused by cutting may increase the phenolic content and improve the antioxidant activity of fresh-cut fruits and vegetables depending on the balance between phenolic synthesis and oxidation (Reyes et al., 2007). This phenomenon has been confirmed in a number of fresh-cut produce such as carrot (Torres-Contreras et al., 2014; Surjadinata and Cisneros-Zevallos, 2012), celery (Vina and Chaves, 2006), lettuce (Zhan et al., 2012), broccoli (Benito Martinez-Hernandez et al., 2013), mushroom (Oms-Oliu et al., 2010), onions (Berno et al., 2014) and mangoes (Maribel Robles-Sanchez et al., 2013).

The fruit of pitaya is a non-climacteric fruit with green scales on the rosy-red peel. The pulp is delicate and juicy and is interspersed with numerous small seeds (Sim et al., 2012). In recent years, pitaya fruit have drawn more attention worldwide, not only because of its sensorial properties and economic importance, but also for its high antioxidant activity owing to its high phenolic antioxidants content (Beltran-Orozco et al., 2009). Since the size of pitaya fruit is relatively large, fresh-cut produce may be more convenient for consumers. Previous study has shown that the increase of phenolic content and antioxidant activity in fresh-cut fruits and vegetables relies on the type of produce tissue (Reyes et al., 2007). Furthermore, the increase of phenolic compounds and enhancement of antioxidant activity in fresh-cut carrot increased with wounding severity (Surjadinata and Cisneros-Zevallos, 2012). However, no study has been done about the effect of cutting styles on quality and antioxidant activity in fresh-cut pitaya fruit.

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Therefore, we investigated the effect of cutting styles with different intensities on main quality parameters, total phenolics content, antioxidant activity and the production of ROS in fresh-cut pitaya fruit.

2. Materials and methods

2.1. Fruit material and processing

Pitaya fruit (*Hylocereus undatus* cv. Shuijing) were obtained from local market in Nanjing, selected, washed and sterilized in 0.02% (v/v) of sodium hypochlorite (pH 6.5). Three different cutting styles were performed as shown in Fig. 1. The fruit were peeled manually, cut into slice (1 cm thickness), half-slice (1/2 section from a slice of 1 cm thickness) and quarter-slice (1/4 section from a slice of 1 cm thickness), with whole fruit serving as the control. The wounding intensity calculated by the method of Surjadinata and Cisneros-Zevallos (2012) was 2.0, 2.9 and 3.7 $cm^2\,g^{-1}$ for slice, half-slice and quarter-slice, respectively. All the fruit were then packaged in 15 cm × 10 cm × 4 cm polypropylene containers and stored for 4 d at 15 °C. Lower temperature would be more appropriate for pitaya fruit storage, but pitaya is a chilling sensitive fruit which displays chilling injuries including water-soaking, wilting and pulp browning when storing at 6 °C (Nerd et al., 1999) and 8 °C was recommended as the appropriate storage temperature for fresh-cut pitaya fruit (Chien et al., 2007). Thus the high storage temperature (15 °C) used in this study is not recommended to keep the quality of fresh-cut pitaya fruit in industry, it was applied only to expedite the response to wounding stress (Reyes et al., 2007). Fruit samples were collected daily for analysis of quality parameters, total phenolics content, antioxidant activity and ROS production.

2.2. Quality parameters and total aerobic bacterial count assays

The Vitamin C content was analyzed by the procedure of Arakawa et al. (1981). Frozen tissue sample (2 g) was extracted in 5 mL of 5% trichloroacetic acid (TCA) solution. The homogenate extracts were centrifuged at 12,000 × *g* for 20 min at 4 °C. And the extract supernatants were used for VC analysis. VC content was expressed as $g\,kg^{-1}$ fresh weight, based on a standard curve. Total soluble solid (TSS) was measured by an Abbe refractometer (14081 S/N, USA). Titratable acidity (TA) was determined by the procedure of Jin et al. (2009). Flesh color was evaluated by measuring L*, a*, and b* values using a colorimeter (Konica Minolta, Japan). In our previous experiments neither L* nor a* value of fresh-cut pitaya fruit showed significant variations during 4 d of storage, while b* value (yellow degree) increased gradually during storage, corresponding to flesh browning. Thus, b* value was used to reflect flesh color in this study. Total aerobic bacterial count (TABC) was analysed according to a standard enumeration method by Tomas-Callejas et al. (2012). TABC was expressed as $\log_{10}$ colony-forming unit per kilogram based on fresh weight (log CFU kg^{-1}).

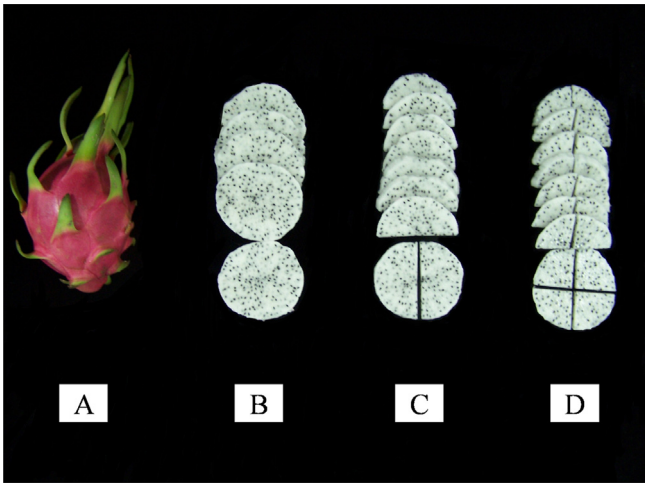

Fig. 1. Different cutting styles applied in pitaya fruit. Whole (A), slice (B), half-slice (C) and quarter-slice (D).

2.3. Total phenolics content measurement

The total phenolics (TP) content was analysed according to the Folin-Ciocalteu procedure of Swain and Hillis (1959) with slight changes. Frozen tissue samples (5 g) were extracted in methanol (25 mL). The obtained homogenates were preserved in covered centrifuge tubes for 12 h in darkness at 4 °C, and centrifuged at 12,000 × *g* for 20 min. The extract supernatants were used for TP analysis. TP content was expressed as $g\,kg^{-1}$ of GAE on a fresh weight basis.

2.4. Antioxidant activity (AOX) assay

The antioxidant activity was analyzed through the method of 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical-scavenging. The extraction method was the same as the extracts prepared for the TP assay and the determination was carried out by the procedure of Brand-williams et al. (1995). Results were calculated with the formula as follows:

$$\text{DPPH radical scavenging activity (\%)} = [(A_0 - A_1)/A_0] \times 100$$

With A_0 refers to absorbance of the control, A_1 refers to absorbance of the samples (Gorinstein et al., 2004).

2.5. Phenylalanine ammonia lyase (PAL) activity assay

The activity of PAL was measured according to the procedure of Ke and Saltveit (1986) with minor changes. Frozen tissue sample (1 g) was mixed and extracted in 5 mL of ice-cold borate buffer (50 mM, pH 8.5), which contained PVPP (40 $g\,L^{-1}$), β-mercaptoethanol (5 mM) and EDTA (2 mM). The homogenate extracts were centrifuged at 12,000 × *g* for 20 min at 4 °C. The extract supernatant was prepared for enzyme analysis. Fifty millimole of borate buffer (2.8 mL) was blended with 0.5 mL of 20 mM L-phenylalanine, incubating for 10 min at 37 °C, 0.7 mL of the enzyme extraction solution was mixed with the reaction system and the absorbance at 290 nm was determined promptly (OD_0). The absorbance of the mixture (OD_1) was measured again after another one hour incubation at 37 °C. A unit of PAL activity was equivalent to a variation of 0.1 at 290 nm per second and it was expressed as $U\,kg^{-1}$ based on protein content.

2.6. O_2^- and H_2O_2 measurements

The measurement of O_2^- production was based on the procedure of Elstner (1976) with slight modifications. Frozen sample (1 g) was extracted in 5 mL of phosphate buffer (100 mM, pH 7.8). The homogenate was centrifuged at 12,000 × *g* for 20 min at 4 °C. One milliliter of the supernatant was mixed with 1 mL of 1 mM hydroxylamine hydrochloride solution and incubated at 25 °C for 1 h. Then 1 mL of 7 mM α-naphthylamine and 1 mL of 17 mM 4-Aminobenzene sulfonic acid were added to the reaction system and the mixture were incubated at 25 °C for another 20 min, and the absorbance of the mixture after reaction was