Efficiency of coconut water immersion inhibiting browning incidence on cut-surface of fresh-cut ‘Gala’ apples during storage

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Abstract. The purpose of the work was to investigate the efficiency of coconut water preventing browning incidence of fresh-cut product using ‘Gala’ apple as the fruit model. The fresh-cut apples were dipped in coconut water at the concentration of 0, 50 and 100% for 2 min and then kept at 4 ± 1 °C for 7 days. Browning-related parameters such as browning index (BI), browning score (BS), lightness (L^*), whiteness index (WI), total colour difference (ΔE^*), total phenols (TP), and polyphenol oxidase (PPO) activity were determined. The result showed that visual appearance of the fresh-cut apple was maintained by coconut water dip. Coconut water dip apparently lowered BI, BS and ΔE^* increases and maintained L^* and WI throughout the storage. The increases in TP and PPO activity of the fresh-cut apples were inhibited by coconut water dips. No significant difference in browning prevention efficiency of the both 50 and 100% coconut water dips was found. Thus 50% coconut water dip is an effectively natural alternative preventing browning incidence of fresh-cut products.

1 Introduction

Browning on cut-surface is the main problem affecting the organoleptic properties including undesirable visual appearance of certain fresh-cut product. Regarding to the injury of tissue by minimal process, browning incidence is rapidly occurred on the cut-surfaces due to the reaction between PPO and phenolic compounds in the present of oxygen [1, 2]. To prevent browning incidence in fresh-cut products, sulphite has been industrially employed as antibrowning agent; however it has adverse effects on health aspects and is banned by government for fresh fruit and vegetables [3]. Recently, a range of natural chemicals including proteins, organic acids [4], carrageenan [5] and glutathione [6] were reported for browning prevention in fresh-cut fruits. Beside of these chemicals, the use of natural agents such as honey [7], pineapple juice [8] and Aloe vera gel [9, 10] preventing browning incidence have been considered. Browning inhibition property of natural agents is due to their antioxidant capacity [11]. Coconut water (CW) is recognised as a rich source of antioxidants especially free radical scavenging and superoxide radicals scavenging activities [12, 13]. In traditional Thai cuisine, CW dip could maintain visual appearance of craved fruit such as marian plum. Thus, this work was focused on the browning inhibitory effects of CW using fresh-cut ‘Gala’ apple as the fresh-cut fruit model.

2 Materials and Methods

2.1 Coconut water preparation and experiment

CW from young coconut at the maturity of 190-200 day after full bloom was diluted with distilled water in the ratio of 1:1 (50%) and 1:0 (100%).

‘Gala’ apple (*Malus domestica*) fruit were purchased from a detail fruit market. The fruit were cleaned using 200 μ L L-1 sodium hypochlorite. The fruit were vertically cut into 8 equal pieces and the core was removed using a knife. The cut apple pieces were dipped into prepared CW for 2 min. Six pieces of cut apple fruit were packed in a PE plastic box with lid and stored at 4 ± 1 °C for 7 days. Four boxes of each treatment were sampled during storage. Factors related to browning were determined by comparing with untreated fresh-cut apple fruits (control).

2.2 Browning score (BS) index (BI) measurements

Three grams of the fresh-cut apple fruit flesh were extracted with 30 mL of 60% (v/v) ethanol. The absorbance of the extracted solution at the wavelength of 420 nm was measured. The unit of BI was expressed as OD420 per g fresh weight (OD420/g FW). The BS was estimated using 5 points scoring test. The appraisal was performed by 30 semi-trained panels. The fresh-cut fruit were evaluated using browning scores of 0 = no brown, 3 = moderate brown and 5 = extreme brown.

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2.3 Colour measurements

Colour attributes of the cut surface were measured using Minolta CR300 colorimeter (Minolta Co. Ltd. Japan). CIE L^* , and ΔE^* values of the cut surface of fresh-cut apple fruit were recorded. The whiteness index (WI) of the fresh-cut fruit was calculated using following equation (1).

$$WI = (100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2}).$$

2.4 Colour measurements

Five grams of fresh-cut apple fruit were homogenised with 60% (v/v) ethanol and then centrifuged at 6000 rpm for 20 min. The supernatant was used to determine total phenols content by using the method of SLINKARD and SINGLETON [12].

2.5 Total phenols assay

Five grams of fresh-cut apple fruit were homogenised with 60% (v/v) ethanol and then centrifuged at 6000 rpm for 20 min. The supernatant was used to determine total phenols content by using the method of SLINKARD and SINGLETON [12].

2.6 Polyphenol oxidase (PPO) activity assay

Two grams of the fresh-cut apple fruit were extracted with 0.1 M sodium phosphate. PPO activity was determined using the method described by GALEAZZI et al. [13].

2.7 Statistical Analysis

Statistical analysis was carried out using ANOVA and the means compared by the least significant difference test at a significance level of 0.05. The data are expressed as the mean of four replications and standard deviation (SD) bar.

3 Results

3.1 Coconut water preparation and experiment

The visual appearance and BI of fresh-cut apples during the storage are shown in Fig. 1 and 2, respectively. The visual appearance showed that browning incidence of the control was greater than the both CW dipped fresh-cut apples. The both 50% and 100% CW dips could inhibit cut-surface browning incidence of the fresh-cut apples. The visual browning incidence of the fresh-cut apples was concomitant with the BI value during the storage. The BI value of control was significantly higher than that of the both CW dipped fresh-cut apples throughout the storage ($P < 0.05$). The BI value of control was 1.76, 2.20 and 3.73 OD_{420nm} g⁻¹ during storage for 2, 5 and 7 d, consequently. The BI of both 50% and 100% CW were similar over the storage which it was approximately

0.47, 0.56 and 1.60 OD_{420nm} g⁻¹ during storage for 2, 5 and 7 d, consequently.

Fig. 1 Visual appearance of fresh-cut apple dipped in coconut water at various concentrations after storage for 7 d at 4±1°C.

Fig. 2 BI of fresh-cut apple dipped in coconut water at various concentrations during storage for 7 d at 4±1°C.

3.2 Coconut water preparation and experiment

Fig. 3 shows BS and superficial colour attributes such as L^* , WI and ΔE^* value of fresh-cut apples during the storage. BS of the control was markedly increased and significantly higher than those of both 50 % and 100 % CW dipped fresh-cut apples ($P < 0.05$) (Fig. 3A). The BS of both 50 % and 100 % CW dipped fresh-cut apples increased slightly during the storage and no significant difference between the both treatments was found throughout the storage. Both L^* value and WI of the control decreased obviously and were significantly lower than those of the both 50 % and 100 % CW dipped fresh-cut apples throughout the storage ($P < 0.05$) (Fig. 3A and 3B). L^* value of the both CW treatments and WI of 100 % CW dipped fresh-cut apples remained constant over the storage while WI of 50 % CW dipped fresh-cut apples was lower than that of 100 % CW dipped samples after storage for 5 and 7 days. The ΔE^* value of the control was significantly higher than that of the both CW treated fresh-cut apples ($P < 0.05$) and increased continuously throughout the storage (Fig. 3D). Whereas, ΔE^* value of the both CW treated fresh-cut apples seemed constant during storage. These indicate that CW immersion could maintain desirable appearance of fresh-cut apples due to inhibit browning incidence and maintain L^* and WI values.

Fig. 3 BS (A), L* (B), WI (C) and ΔE^* (D) values of fresh-cut apple dipped in coconut water at various concentrations during storage for 7 d at $4\pm 1^\circ\text{C}$.

3.2 Total phenols and PPO activity

TP content and PPO activity in the cut-surface tissues of the fresh-cut apples are shown in Fig. 4. The both TP content and PPO activity of control were significantly higher than those of the both CW treated fresh-cut apples over the storage ($P < 0.05$). The increase in TP content during storage was found in the control (Fig. 4A). The TP content of control stored for 7 days was reached to $0.93 \mu\text{g g}^{-1}$ which was significantly higher than that on day 0. The TP content of both CW treated fresh-cut apples was significantly decreased after stored for 2 days ($P < 0.05$) and then seemed constant over the storage. In the similar vein, the PPO activity of control increased during storage (Fig. 4B). The PPO activity of control on day 7 was significantly higher than that of the control on day 0 and the both CW treated fresh-cut apples ($P < 0.05$). Whereas, the PPO activity of both CW treated fresh-cut apples seemed constant did not significantly differ and seemed constant over the storage.

Fig. 4 TP content (A) and PPO activity (B) of fresh-cut apple dipped in coconut water at various concentrations during storage for 7 d at $4\pm 1^\circ\text{C}$.

4 Discussion

The visual appearance shown in Fig. 1 indicated that CW dips obviously inhibited browning incidence on the cut-

surface of the fresh-cut apples during the storage. The increases in both BI and BS of the CW treated fresh-cut apples were inhibited and apparently lower than those of the control. These were concomitant with the maintenance of L* and WI values. CW dips also lowered the increases in ΔE^* values of the fresh-cut apples throughout the storage (Fig. 3 and 4). The changes in browning incidence and colour attributes on the cut-surface of fresh-cut apples were accompanied with the levels of TP concentration and PPO yield which were obviously high in the control compared to the both CW dipped fresh-cut apples. These suggest that CW has ability controlling enzymatic browning reaction due to retard the increase in PPO activity as well as TP concentration. It is commonly acknowledged that the cut-surface of fresh-cut products are directly presented to oxygen in atmosphere activating the reaction of released PPO and phenolic compounds resulting in complex polymers providing brown pigments [14, 11]. Kwak and Lim [15], Soysal [16] and Wessels et al. [11] suggested that antibrowning capacity of natural antibrowning agents might be associated with their antioxidant capacity, TP content and pH. In this present study, the DPPH free radical scavenging activity, TP content and pH of CW were determined which were 9.2 %, 2 g gallic acid L-1 and 6, respectively. Soysal [16] reported that the optimal pH for PPO extracted from 'Golden Delicious' apple fruit was 5.5 and the enzyme activity is completely inhibited at pH below 3 [14]. Thus, the pH of CW might not affect PPO activity inhibition in the treated fresh-cut apples. The antioxidant activity and TP content of CW might play a role inhibiting enzymatic browning reaction. Wessels et al. [11] suggested that the reducing properties of polyphenols attributed antibrowning potential especially flavonoids and tannins which can inactivate PPO by complexing copper or reacting with proteins. Mantena et al. [17] had reported that CW had high antioxidant properties including DPPH scavenging, ABTS and superoxide scavenging as well as ascorbic acid concentration which is commercially used to inhibit browning in fresh-cut products [4]. Therefore, the antibrowning capacity of CW might be associated with the high level of antioxidant properties, the content of phenolic compounds and ascorbic acid concentration

incidence in fresh-cut 'Gala' apples during storage at 4 ± 1 °C for 7 days

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5 Conclusion

Results show that CW at the both concentrations apparently inhibited browning incidence and maintained desirable visual appearance of the fresh-cut apples compared to the control throughout the storage. CW dips lowered browning parameters such as BI and BS values and delayed the increase in ΔE^* value. The L* and WI were maintained by CW dips. CW dips also inhibited the increases in activity of PPO and TP content of cut-surface tissues of the fresh-cut apples. No significant difference in antibrowning capacity of the both 50% and 100% CW were found. We suggest that CW is an effective natural antibrowning alternative for fresh-cut fruits and 50% CW dip is sufficient to prevent browning