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Effects of 'Queen' and 'Smooth cayenne' pineapple fruit core extracts on browning inhibition of fresh-cut wax apple fruit during storage

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Abstract

The purpose was to investigate the browning inhibitory effect of 'Queen' and 'Smooth cayenne' pineapple fruit core extracts (PE) on fresh-cut wax apple fruit cv. 'Taaptipjan' during storage. Bromelain yield, pH and total phenols content of both pineapple fruits core and pulp extracts and superficial colour and overall acceptability score of the fresh-cut fruit were determined. 'Queen' pineapple fruit had bromelain yield, pH and total phenols content higher than 'Smooth cayenne' pineapple fruit. Both 'Queen' and 'Smooth cayenne' PE contained higher bromelain yield and pH and lower total phenols content than the both fruit pulp extracts. The 50% (v/v) of 'Queen' PE dip maintained lightness *(L^*)* value and whiteness index (WI), lowered colour difference, browning index (BI) and browning score (BC) when compared to the 50% (v/v) of 'Smooth cayenne' PE dip and control, respectively. The overall acceptability score of the fresh-cut fruit dipped in 'Queen" PE was also higher than that of fruit dipped in 'Smooth cayenne' PE and control, respectively. In conclusion, both 'Queen' and 'Smooth cayenne' PE could prevent browning of fresh-cut wax apple fruit during storage which the browning inhibition effect might due to the bromelain yield content. 'Queen' PE had higher bromelain yield content and browning inhibitory property than 'Smooth cayenne' PE.

Introduction

Wax apple (*Syzygium samarangenese* [Blume] Merrill & L.M. Perry) is an economically important fruit in Southeast Asia (Vara-Ubol *et al*., 2006; Shü *et al*., 2008). As having the combination of apple-like crispness, watery sweet and rose-like aroma, wax apple fruit has become a famous exotic fruit which not only intact fruit but also its fresh-cut form. 'Taaptipjan' wax apple is the most popular cultivar compared to other cultivars as its attractive ruby-like skin colour and seedless. The demand of fresh-cut 'Taaptipjan' wax apple has been continuously increased in fresh-cut fruit market; however its shelf-life is limited because of cut-surface browning (Supapvanich *et al*., 2011). Enzymatic-browning is widely known as a main factor limiting visual quality and consumer's acceptability of fresh-cut products which due to the oxidation reaction of phenolic compounds to quinones by polyphenol oxidases (PPOs) in the presence of oxygen (Walker and Wilson, 1975; Friedman, 1996). The product from the oxidation can undergo further reactions resulting in complex browning polymers (McEvily *et al*., 1992). To control enzymatic browning in fresh cut fruit, food additives such as ascorbic acid, L-cysteine, citric acid and phosphoric acid have been industrially used (Arshad *et al*., 2014). Moreover, sulfur dioxide and sulphites are also commercially used for long-term antibrowning (McEvily *et al*., 1992). However, some of these food additives might affect human health. Hence, the replacement of such compounds by using natural agents has become an important issue for fresh-cut product industry. Wessels *et al.* (2014) had investigated 36 plant extracts to inhibit enzymatic browning in fresh-cut apple which found that the browning inhibitory potential of plant extracts might be attributable to secondary metabolites. Soysal (2009) suggested that green tea extract could inhibit browning and PPO activity in 'Golden Delicious' apple fruit. Moreover, the use of pineapple juice preventing enzymatic browning had been reported for fresh and dried apple rings (Lozano-De-Gonzalez *et al*., 1993) and banana (Chaisakdanugull *et al*., 2007). From our previous work, antibrowning property of 'Smooth cayenne' pineapple fruit extract on fresh-cut wax apple fruit was reported and the fruit core extract had more potential inhibiting browning than the pulp extract (Supapvanich *et al*., 2012). Certain previous work also reported that bromelain extracted from pineapple fruit contributes enzymatic browning inhibitory property (Chaisakdanugull *et al.*, 2007; Srinath *et al*., 2012; Arshad *et al*., 2014). Thus, in this work we were interested in investigating effect of

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pineapple fruit core extract (PE) from 2 commercial cultivars, 'Queen' and 'Smooth cayenne' fruit, on browning inhibition of fresh-cut 'Taaptipjaan' wax apple during storage.

Materials and Methods

Plant materials and minimal processing

Wax apple fruit (*Syzygium samarangenese* [Blume] Merrill and L.M. Perry) cv. 'Taaptimjan', a red skin wax apple fruit, was obtained from a fresh produce detail market named Talad Thai. The fruit were screened based on uniform red skin color, size and without physical damage and decay. The fruit were cleaned with tap water and then immersed in 50 µL/L sodium hypochlorite solution for 10 min. The fruit were cut into half with a sharp knife and each half was then cut at the exposed end into four equal pieces. The endocarp tissue and calyx end of the fruit were eliminated.

Experiment

Six pineapple fruit *(Ananas comosus)* cv. 'Queen' and 'Smooth cayenne' were obtained from Talad Thai. The fruit at commercial maturity were screened without any physical damages and decay. Crown leaves were removed. The fruit were cleaned by spraying with tapped water and then dipped in 100 µL/L sodium hypochlorite solution for 30 min. The outer skin of the fruit was removed and the fruit pulp and core were separated using a sharp knife. The fruit pulp or core were minced by using a food processor and then squeezed and filtered using cloth sheet. Bromelain yield, pH and total phenols content of both pulp and core extract were measured. The core extract was diluted with sterile distilled water to get 50% (v/v) pineapple core extracts (PE) for 2 min. After treatments, four pieces of the fresh-cut fruit were placed into a PET food container (81×145×29 mm size) and stored at 4±1°C for 6 days. The changes in lightness (L^*) value, whiteness index (WI), colour difference (ΔE^*) value, browning index (BI), browning score (BC) and overall acceptability score of the treated fresh-cut fruits were compared with the untreated fresh-cut fruit (control).

Bromelain yield assay

A ten gram of pineapple core or pulp was homogenized using a homogenizer and then centrifuged at 4°C at a speed of 10,000 rpm for 30 min. The supernatant was collected and again filtered at 4°C using Whatman No. 1 filter paper. The filtrate was collected. Bromelain yield was measured using the casein method which described by Arumugam and Ponnusami (2013). One mL of enzyme sample was mixed with 5 mL of casein and then incubated at room temperature (33±1°C) for 30 min. Five mL of 0.11 M tricarboxylic acid (TCA) was then added in the mixture and again allowed to stand at room temperature for 30 min. The sample was filtered using Whatman No.1 paper filter. Two mL of filtered sample was mixed with 1 mL of Folin-Ciocalteau reagent and then 5 mL of saturated sodium carbonate solution was added. The reaction was allowed to stand for 30 min. Absorbance at 660 nm was recorded. Enzyme yield (unit) was calculated comparing tyrosine standard curve. The data were expressed as unit per mg protein.

Total phenolic content analysis

One mL of the filtrate was diluted with 9 mL of distilled water. The solution was used to assay total phenols content in pineapple extract. The total phenolic content was assayed following the method described by Slinkard and Singleton (1977). The reaction began when 1 mL of the sample was added into a solution of 1 mL 50% (v/v) Folin-Ciocalteu reagent solution and 2 mL saturated Na_2CO_3 solution. The mixture was left at room temperature for 30 min. The absorbance at 750 nm was recorded. The total phenolic content was expressed in term of µg gallic acid/mL (µg GA/ mL).

pH measurement

The pH of the both pineapple fruit core and pulp extracts was measure using a pH meter, Mettler Toledo AG 8603 (Schwerzenbach, Switzerland).

Superficial colour measurement

Superficial colour was measured using a Minolta (CR-300; Minolta Camera Co., Japan). L^*, $a^*$and b^* values were recorded. Whiteness index (WI) and total colour difference *((ΔE^*)* were calculated according; formula (1) and (2), respectively.

$$WI = 100 - \sqrt{(100 - L*)^2 + a*^2 + b*^2} \quad (1)$$

$$\Delta E* = \sqrt{\Delta L*^2 + \Delta a*^2 + \Delta b*^2} \quad (2)$$

Sensory score

Twenty semi-trained judges scored the fresh-cut wax apple for browning score (BC) and overall acceptability. The panellists were asked to rate the browning and liking in visual appearance by using 5 points scale. The fresh-cut fruit were evaluated using BC of 0 = no brown, 1 = slight brown, 3 = moderate brown and 5 = extreme brown. The overall acceptability was determined using the following

Table 1. Bromelain yield, pH and total phenols content of core and pulp ‘Pattavia’ and ‘Queen’ pineapple fruit extracts

Pineapple cultivars	Bromelain Yield (Unit/mg protein)		pH		Total phenols content (µg GA/ mL)	
	Core	Pulp	Core	Pulp	Core	Pulp
‘Queen’	0.67 ± 0.04^{a}	0.57 ± 0.02^{b}	4.02 ± 0.02^{a}	3.92 ± 0.04^{ab}	0.59 ± 0.05^{b}	738.3 ± 0.2^{a}
‘Pattavia’	0.51 ± 0.04^{c}	0.41 ± 0.02^{d}	3.86 ± 0.02^{b}	3.68 ± 0.01^{c}	370.4 ± 4.8^{d}	557.3 ± 4.6^{c}

Data are means ± SD of four4 replications. Difference letters in each parameter represents significant difference at $P < 0.05$.

scales: 5 = like extremely, 2.5 = neither like nor dislike, the limit of acceptance, and 1 = dislike extremely.

Statistical analysis

A complete randomized design (CRD) was used in this work. Statistic analysis was carried out using ANOVA and the means compared by using a Post Hoc least significant difference (LSD) test at a significance level of $p < 0.05$ using SPSS software (version 15.0, IBM Crops; White Plains, NY, USA). Data were expressed as the mean ± SD of four replications.

Results and Discussion

Bromelain yield, pH and total phenols content in pineapple fruit extracts

Regarding many works reported about browning inhibitory effect of pineapple juice relating to bromelain activity (Lozano-De-Gonzalez *et al*., 1993; Chaisakdanugull *et al*., 2007; Arshad *et al*., 2014), organic acids content (Chaisakdanugull *et al.,* 2007) and phenolic compounds content (Wen, 2001), we thus were interested in investigating bromelain yield, pH and total phenols content of both core and pulp of ‘Smooth cayenne’ and ‘Queen’ pineapple fruits. The result shows that bromelain yield of ‘Queen’ pineapple fruit was higher than that of ‘Smooth cayenne’ pineapple fruit (Table 1). Both pineapple fruit core extracts (PEs) had bromelain yield higher than both pineapple fruit pulp extracts. The pH and total phenols content of both core extract and pulp extract of ‘Queen’ pineapple fruit were significantly higher than those of ‘Smooth cayenne’ pineapple fruit. The pH of both ‘Queen’ and ‘Smooth cayenne’ core extract was higher than that of their pulp. Total phenols content of both pineapple pulp extracts was obviously higher than that of their core extracts. Phenolic compounds and protease extracted from pineapple juice was reported having browning inhibition property (Wen, 2001; Wrolstad and Wen, 2001). Srinath *et al.* (2012) reported that bromelain extracted from pineapple fruit could contribute enzymatic-browning inhibition effect. Wrolstad and Wen (2001) reported that sulfur containing amino acids and phenolic compounds, S-sinapyl-L-cysteine, N-L-γ-glutamyl-S-sinapyl-L-cysteine, and S-sinapylglutathione found in pineapple juice have antibrowning effect. Later, Zheng *et al*. (2010) suggested that (S)-2-amino-5-((R)-1-carboxy-2-((E)-3-(4-hydroxy-3-methoxyphenyl) allylthio) ethyl-amino)-5-oxopentanoic acid, N-L-γ-glutamyl-S-sinapyl-L-cysteine, S-sinapylglutathione and S-sinapyl-L-cysteine isolated from pineapple juice may contribute to antibrowning property. Furthermore, Chaisakdanugull *et al.* (2007) suggested that the malic and citric acids content in pineapple juice played a key role inhibiting PPO activity in banana fruit. Our previous work showed that 50% (v/v) of ‘Smooth cayenne’ PE was more effective to prevent browning of fresh-cut wax apple fruit than the pulp and peel extracts (Supapvanich *et al*., 2012). Thus, 50% (v/v) of both ‘Queen’ and ‘Smooth cayenne’ PEs were selected to investigate browning inhibition of fresh-cut ‘Taaptimjan’ wax apple fruit during storage.

Visual appearance and superficial colour

Figure 2 shows visual appearance of the fresh-cut fruit after dip in 50% (v/v) of both ‘Queen’ and ‘Smooth cayenne’ PEs during storage for 6 days at 4±1 °C. Browning of the control was higher than that of the fresh-cut fruit dipped in ‘Queen’ and ‘Smooth cayenne’ PE over storage. On day 3 and 6, browning of the control fruit obviously occurred when compared to that of the fresh-cut fruit dipped in ‘Queen’ and ‘Smooth cayenne’ PE. On day 6, the fresh-cut fruit dipped in ‘Queen’ PE showed the best appearance when compared to the fresh-cut fruit dipped in ‘Smooth cayenne’ PE and control, respectively. These related to the results shown in Figure 3 which L^{*} value and WI of the fresh-cut fruit dipped in ‘Queen’ PE were higher than those of the fresh-cut fruit dipped in ‘Smooth cayenne’ PE and

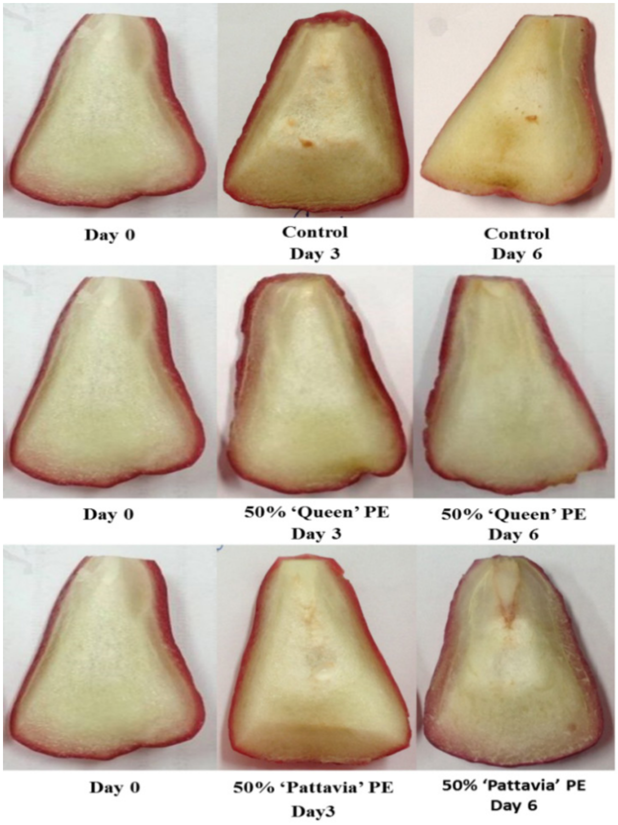

Figure 2. Visual appearance of fresh-cut wax apple fruit dipped in 'Queen' and 'Pattavia' pineapple fruit core extracts compared with the untreated fresh-cut fruit during storage at 4±1°C for 6 days

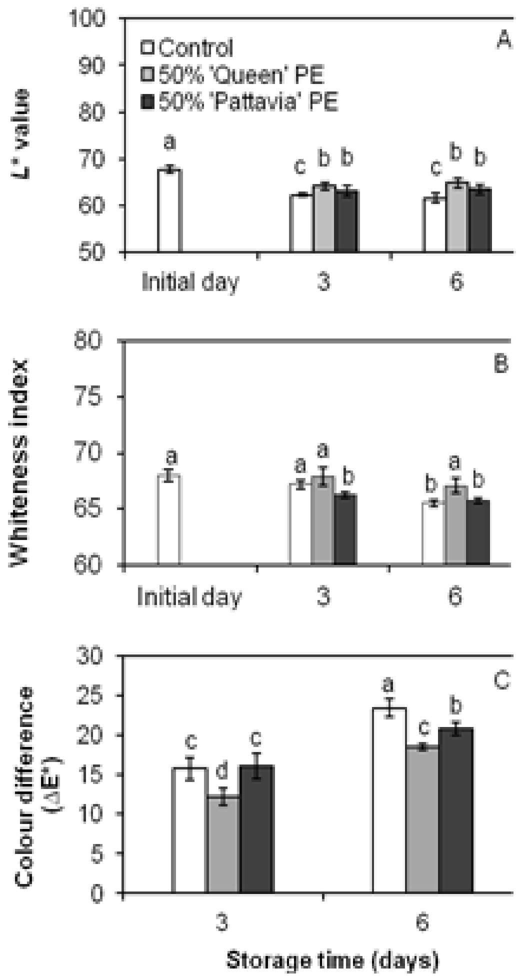

Figure 3. Lightness value *(L^*)* (A), whiteness index (WI) (B) and colour difference *(ΔE^*)* (C) of fresh-cut wax apple fruit dipped in 'Queen' and 'Pattavia' pineapple fruit core extracts compared with the untreated fresh-cut fruit during storage at 4±1°C for 6 days. Data are means ± SD of 4 replications

control, consequently, as well as the lowest ΔE^* value was also presented in the fresh-cut fruit dipped in 'Queen' PE. An apparent reduction of L^* value was found in the control throughout storage. The WI of both the 'Smooth cayenne' PE dipped and control fruit were significantly lower than that of the 'Queen' PE dipped fresh-cut fruit ($P \leq 0.05$). The ΔE^* value of the control and 'Smooth cayenne' PE dipped fresh-cut fruit were significantly higher than that of 'Queen' PE dipped fresh-cut fruit throughout storage ($P \leq 0.05$). These show that the appearance and superficial colour of the 'Queen' PE dipped fresh-cut fruit were close to those of the fresh-cut fruit at initial day.

Browning and overall acceptability

Figure 4 shows BI, BC and overall acceptability score of the fresh-cut fruit during storage. BI and BC of the fresh-cut fruits increased continuously during storage (Figure 4 A and B). Over the storage time, BI and BC of the control fruit were higher than those of both the 'Queen' PE and 'Smooth cayenne' PE dipped fresh-cut fruits. The lowest BI and BC were presented in the 'Queen' PE dipped fresh-cut fruit throughout storage. Especially on day 6, both BI and BC of the 'Queen' PE dipped fresh-cut fruit were significantly lower than those of others ($P \leq 0.05$). These results were confirmed by our previous work which the use of PE and PE incorporated with konjac glucomannan coating inhibited browning and maintained WI of fresh-cut wax apple fruit during storage (Supapvanich *et al*., 2012). Browning is widely recognized as a key problem limiting consumer's acceptability of most fresh-cut products, especially fresh-cut wax apple fruit (Supapvanich *et al*, 2011; Supapvanich *et al*., 2014). A five points hedonic scoring test was used to determined overall acceptability of the both PEs treated fresh-cut fruits comparing to the control fresh-cut fruit (Figure 4B). The overall acceptability score of the control was significantly reduced throughout storage which reached to score 1 on day 6. The highest overall acceptability score was presented in the 'Queen' PE dipped fresh-cut fruit which was 3.4 and 2.7 on day 3 and 6, respectively, which these were higher than acceptable level (2.5). Compared to 'Smooth cayenne' PE dipped fresh-cut fruit, overall

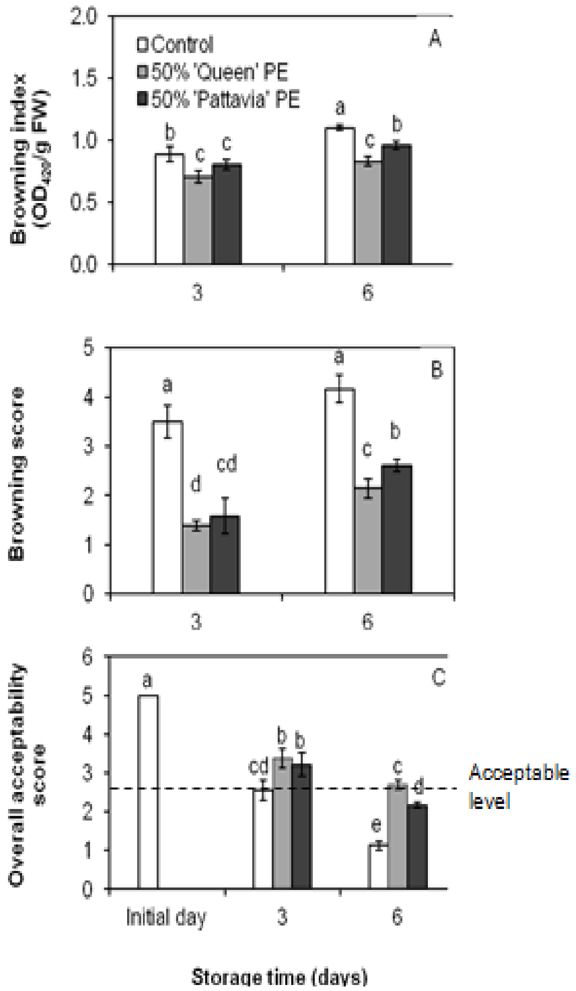

Figure 4. Browning index (BI) (A), browning score (BC) (B) and overall acceptability score (C) of fresh-cut wax apple fruit dipped in 'Queen' and 'Pattavia' pineapple fruit core extracts compared with the untreated fresh-cut fruit during storage at 4±1°C for 6 days. Data are means ± SD of 4 replications

acceptability of the 'Queen' PE dipped fresh-cut fruit was significantly higher as the result shown on day 6 of storage ($P \leq 0.05$). These results were apparently related to L^* value, WI and ΔE^* value as shown in Figure 3. A high L^* value and WI were concomitant with low BI and BC resulting the low ΔE^* value and high overall acceptability of the fresh-cut wax apple fruit which 'Queen' PE had more effect on browning inhibition than 'Smooth cayenne' PE. This might be associated with the high bromelain yield and total phenols content as shown in Table 1. Srinath *et al.* (2012) and Arshad *et al.* (2014) addressed that browning inhibition activity of fresh pineapple juice could be mainly contributed by protease. Lozano-De-Gonzalez *et al*. (1993) reported that the eluate from cation exchange of pineapple fruit juice had browning inhibition effects. Moreover, amino acid-conjugated sinapyl derivatives (Wrolstad and Wen, 2001) and sulfur-containing compounds (Zheng *et al*., 2010) from pineapple fruit extract contributed to enzymatic browning inhibition effect.

Conclusion

The study showed 'Queen' pineapple fruit had bromelain yield and total phenols content higher than 'Smooth cayenne' pineapple fruit. PE had bromelain yield higher than the fruit pulp extract. The pH of 'Smooth cayenne' pineapple fruit was higher than that of 'Queen' pineapple and the PE had pH lower than the fruit pulp extracts. 'Queen' PE dip effectively reduced L^* value and WI decreases and ΔE^*, BI and BC increases of the fresh-cut wax apple fruit during storage when compared to 'Smooth cayenne' PE dip. The overall acceptability of 'Queen' PE dipped fresh-cut wax apple fruit was significantly higher than that of the 'Smooth cayenne' PE dipped fresh-cut fruit. Moreover we also suggested that browning inhibition effects of pineapple fruit extract might be accompanied by bromelain yield and total phenols content in pineapple fruit.

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References

Arshad, Z. I. M., Amid, A., Yusof, F., Jaswir, I., Ahmad, K. and Loke, S. P. 2014. Bromelain: an overview of industrial application and purification strategies. Applied Microbiology and Biotechnology 98: 7283-7297.

Arumugam, A. and Ponnusami, V. 2013. Pineapple fruit bromelain recovery using recyclable functionalized ordered mesoporous silica synthesized from sugarcane leaf ash. Brazilian Journal of Chemical Engineering 30(3): 477-486.

Chaisakdanugull, C., Theerakulkait, C. and Wrolstad, R. D. 2007. Pineapple juice and its fractions in enzymatic browning inhibition of banana [*Musa* (AAA group) Gros Michel]. Journal of Agriculture and Food Chemistry 55: 4252–4257.

Friedman, M. 1996. Food browning and its prevention: an overview. Journal of Agriculture and Food Chemistry 44: 631–653.

Lozano-De-Gonzalez, P. G., Barrett, D. M., Wrolstad, R. E. and Durst, R. W. 1993. Enzymatic browning inhibited in fresh and dried apple rings by pineapple juice. Journal of Food Science 58(2): 399-404.

McEvily, A. J., Iyengar, R. and Steven, W. S. 1992. Inhibition of enzymatic browning in foods and beverages. Critical Review Food Science and Nutrition 32: 253–273.

Shü, Z. H., Tirtawinata, R., Meon, Z. and Thanarut, C. 2008. Wax apple production in selected tropical Asian countries. Acta Horticulturae 773: 161–164.

Slinkard, K. and Singleton,V. L. 1977. Total phenol analysis: Automation and comparison with manual methods. American Journal Enology and Viticulture 28: 49–55.

Soysal, C. 2009. Effects of green tea extract on "Golden Delicious" apple polyphenoloxidase and its browning. Journal of Food Biochemistry 33: 134-148.

Srinath, R., Ramalingam, C. and Nasimun Islam, N. 2012. Isolation and characterization of bromelain from pineapple *(Ananas comosus)* and comparing its anti-browning activity on apple juice with commercial antibrowning agents. Elixir Food Science 45: 7822-7826.

Supapvanich, S., Pimsaga, J. and Srisujan, P. 2011. Physiochemical changes in fresh-cut wax apple (*Syzygium samarangenese* [Blume] Merrill and L. M. Perry) during storage. Food Chemistry 127:912–917.

Supapvanich, S., Prathaan, P. and Tepsorn, R. 2012. Browning inhibition in fresh-cut rose apple fruit cv. Taaptimjaan using konjac glucomannan coating incorporated with pineapple fruit extract. Postharvest Biology and Technology 73: 46-49.

Supapvanich, S., Samransuk, L., Somanusorn, T. and Mesa, N. 2014. Effect of glutathione on browning of fresh-cut wax apple fruit during refrigerated storage. Acta Horticulturae 1024: 339-346.

Vara-Ubol, S., Chambers, E., Kongpensook, V., Oupadissakoon, C., Yenket, R. and Retiveau, A. 2006. Determination of the sensory characteristics of rose apples cultivated in Thailand. Journal of Food Science 71: 547–552.

Walker, J. R. L. and Wilson, E. L. 1975. Studies on the enzymatic browning of apples. Inhibition of apple o-diphenol oxidase by phenolic acids. Journal Science Food and Agriculture 26: 1825–1831.

Wen, L. 2001. Pineapple juice: Phenolic composition and enzymatic browning inhibition. Oregon, USA: Oregon State University, PhD thesis.

Wessels, B., Damm, S., Kunz, B. and Schulze-Kaysers, N. 2014. Effect of selected plant extracts on the inhibition of enzymatic browning in fresh-cut apple. Journal of Applied Botany and Food Quality 87: 16-23.

Wrolstad, R. E. and Wen, L. 2001. Natural sinapyl compounds with antibrowning and antioxidant properties from pineapple. US Patent, 6224926.

Zheng, Z., Ma, J., Cheng, K., Chao, J., Zhu, Q., Chang, R. C., Zhao, M., Lin, Z. and Wang, M. 2010. Sulfur-containing constituents and one 1H-pyrrole-2-carboxylic acid derivative from pineapple [*Ananas comosus* (L.) Merr.] fruit. Phytochemistry 71: 2046-2051.