Violet-red discolouration of canned Palmyra palm during processing

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Abstract The objectives of the research were to investigate the causes of the violet-red discolouration during processing of canned Palmyra palm and to identify preventive methods without the use of chemical additives. Palmyra palm flesh with (13–21 %) /without some peel left on was tested for the source of violet-red discolouration during blanching. It was found that blanching in distilled water had no effect on discolouration when blanching conditions were at 75, 85, and 95 °C for 7 min but the violet-red discolouration occurred only when tap water was used for blanching at 95 °C for 7 min. Moreover, the addition of bicarbonate (NaHCO_3) in distilled water to imitate higher alkalinity of tap water during blanching could contribute to the violet-red discolouration. Thus the observed cut off alkalinity of the blanching water wherein not to expect any discolouration was found to be about 100 ppm. After sterilization, there was no violet-red discolouration from Palmyra palm flesh without any peel left on even though it had a preceding treatment of blanching in highly alkaline tap water.

Research highlights • Palmyra palm peel left on created violet-red discolouration during blanching in tap water.

- Palmyra palm flesh without the peel showed no violet-red discolouration while blanching.
- Anthocyanin found in the Palmyra palm peel was the cause of violet-red discolouration.
- Blanching any samples in distilled water did not result in violet-red discolouration.
- The cut off alkalinity of water wherein not to expect any discolouration was about 100 ppm.

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Keywords Palmyra palm · Anthocyanin · Discolouration · Blanching · Sterilization

Introduction

Thailand is recognized internationally as one of enriched resources of fruits in the tropical zone (Chomchalow et al. 2008). Various famous varieties of tropical fruits have been grown and exported such as durian, Logan, mango, mango-steen, papaya, lychee, rambutan, sugar apple, tamarind, coconut etc. Some of these fruits each has a unique taste and flavor which enchant more people around the world to consume those (Chomchalow et al. 2008). Palmyra palm (*Borassus flabellifer* - Asian Palmyra palm) which is one of the sugar palm group is a native plant in Thailand and mostly grows in the middle part of the country. This fruit is not only useful as food, but many parts of the Palmyra palm can be employed for innumerable medicinal uses (Morton 1988; Heinonen et al. 1998). The Jelly like seeds of the young Palmyra palm after the peel of which were removed was edible, locally called Palmyra palm flesh and popularly prepared, especially in some kinds of sweets eaten after the main dishes.

Generally Palmyra palm flesh has a white colour or is translucent and it is thought to possess a little change of colour after exposure to heat treatment during sterilizing, such as browning. The peel of the Palmyra palm, which is intended to be taken away before feeding is about 2 mm thick and has a slightly bitter taste. It was found to have 20.28–22.57 % of tannin when extracted with water and about 26.23–26.64 % when extracted with 50 % ethanol (Pintaput 1997). Figure 1 shows Palmyra palm with the peel and after removing the peel. Therefore, in raw material preparation, the Palmyra palm peel should be removed as much as possible leaving only the flesh part. However, after sterilization, Palmyra palm flesh

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Fig. 1 Palmyra palm (a) with the peel and (b) without peel

may turn a little bit brownish due to browning which is still acceptable in terms of consumer perception. One of the problems mostly found in the canned Palmyra palm is the violet-red discolouration. It looks peculiar, but is still edible. Food manufacturers have reported that this problem occurs from time to time, but it is not regular which makes it hard to control. Moreover, it creates inconsistency in product quality. Thus, the objectives of the current research were to investigate the causes of the violet-red discolouration during the processing of canned Palmyra palm in syrup and to determine a preventive method without the use of chemical additives.

Anthocyanins are the source of the pigment mostly found in fruits (Tian et al. 2001; Lee 2002; Moyer et al. 2002; Kuskoski et al. 2003; Longo et al. 2005) and flowers, predominantly in the outer cell layers (Anonymous 2013). The colour of an anthocyanin depends on its structure, but also on the acidity of the fruit (Brouillard 1982). For example, many anthocyanins are red under acidic conditions and can turn blue or green under less acidic conditions (Jolly 2009; Boulton 2001).

Pink discolouration can be found in canned fruits and vegetables, including apple, lychee, peach, pear, banana, guava, gooseberry etc. (Hulme 1971; Ranganna and Parpia 1974). The occurrence of pink discolouration can vary with different fruit species, variation in the cultivation conditions (Luh et al. 1960), different growing locations or maturity (Chandler and Clegg 1970b), blanching conditions (Cheng et al. 1981), heating level during sterilization and cooling process after heating or the final pH of the product (Pannaviroj et al. 2006) and also, the level of applied nitrogenous fertilizer and the level of exposure to sunlight (Czerkaskyz 1970).

In addition, conditions of low pH in the product, the quantity of leucoanthocyanidin, and any oxygen and tin ion in the canned pears contribute to this pink discolouration (Chandler and Clegg 1970a). Macrae et al. (1993) supported that claim that leucoanthocyanidin would merge with tin or metal ion present from the can to form a thermally stable pink pigment of anthocyanin during heating.

Coconut juice also had a problem of pink discolouration when heating (Pannaviroj et al. 2006). This pink discolouration was presumably initiated by the heat

processing together with the reaction between dehydroascorbic acid and amino lysine in the juice itself. Pannaviroj et al. (2006) found that heating for a shorter period of 10 min at 95 °C and rapid cooling could diminish or avoid the discolouration in the juice.

Possible pink discolouration pathway of canned lychee was trying to be explained by Cheng and Hwang (1986). For canned pears, Chandler and Clegg (1970a) reported that the pathway of pink compound formation started from the decomposition of leucoanthocyanidin to quinone methane by enzymatic reaction or atmospheric oxidation. After being heated, anhydrobase was formed first and changed to cyanidin later. Then, the cyanidin could have reacted with tin ions to produce a tin-anthocyanin complex. If the tin ions reacted with the anhydrobase, the red colour of cyanidin would be constituted when the pH was less than 3, becoming a violet colour at pH 8.5 or blue at pH 11.

Many researchers have endeavored to prevent pink discolouration in canned fruits. Chakraborty et al. (1974) investigated the pink discolouration in canned lychee and reported it was retarded by adding 0.1–0.15 % citric acid in a 30 °Brix sugar solution (final pH of 4.4–4.5) together with the use of 300 ppm of SO₂ and sterilizing for 10 min in boiling water. Finally, the products had an odor of sulfur. Nevertheless, Wu and Fang (1993) investigated the addition of citric acid mixed with 0.2 % polyphosphate in a sugar solution concentration of 30 °Brix to canned lychee and found that it could perk up instead of hinder the pink discolouration in the canned product. Shewfelt (1975); Cheng and Hwang (1986) and Somseang (2007) found that lychee flesh immersed in 0.2 % bisulfite solution successfully inhibited the activity of polyphenol oxidase and therefore prevented the pink discolouration in canned lychee. However an excess amount of sodium bisulfite caused the white, pale abnormal colour and taste in canned lychee. Moonroto (2002) reported that when canned broken lychee or lychee puree was treated with citric acid solution to a final pH not lower than 3.95, there was no pink discolouration.

For other kinds of fruit products such as canned guava, banana puree, pear puree and canned pear, Ranganna et al.

(1966); Guyer and Erickson (1954); Moonroote (2002); and Furia (1968) reported that chemical additives could effectively prevent pink discolouration. Nevertheless, these techniques involved the role of additives as preventive measures which may not be willingly accepted by consumers.

Materials and methods

Statistical analysis

The following experiments in this section were all triplicated. Statistical analysis was performed using SAS (SAS Inc., Cary, NC, USA). A completely randomized design (CRD) was used for the testing factors. Differences between means were tested for significance by using a GLM (general linear model) procedure with Duncan's test, using a level of significance of $P \leq 0.05$.

Source of discolouration

Palmyra palm flesh and Palmyra palm flesh with some peel (13–21 % of total peel weight left on)

The tested material was divided into two groups; one was only Palmyra palm flesh and the other was Palmyra palm flesh with 13–21 % of peel left on. These materials were cut into small pieces of the same size before being blanched in tap water at 95 °C for 7 min. After leaving in 0, 10, 20 and 30 min to cool, visible observation was carried out on the colour of the flesh of the Palmyra palm samples and the tap water. Afterwards, only the tap water was taken for colour measurement at room temperature in the CIE system. Peel and the flesh of the fresh Palmyra palm were sampled to analyze the anthocyanin and amino acid compositions which could contribute to discolouration.

Effect of exposure to the air and immersion in water before blanching

Samples of Palmyra palm flesh with some peel left on as above were divided into two groups; one was exposed to the air for 1, 2 and 3 h before blanching and the other was immersed in tap water for the same period of time. Then all samples were blanched in tap water at 95 °C for 7 min. After leaving to cool for 0, 10, 20 and 30 min, the samples were checked for any visible discolouration of the flesh of the Palmyra palm and the blanching water. Only the blanching water was assessed for colour in the CIE system.

Effect of temperature and quality of blanching water

Samples of the Palmyra palm with 13–21 % of peel left on were prepared for testing in two different types of blanching water quality (tap and distilled water) at 3 different levels of blanching temperature (75, 85 and 95 °C). All test samples were blanched for 7 min. After allowing to cool for about 30 min, the samples were checked for any visible discolouration of the flesh of the Palmyra palm with some peel left on and of the blanching water. Only the blanching water was assessed for colour in the CIE system as before.

Effect of addition of sodium bicarbonate (NaHCO_3) to blanching water

NaHCO_3 (Finechem Pty Ltd., Australia) solutions (62.5, 125 and 250 mg/L) in distilled water were prepared for use as blanching water. Samples of Palmyra palm flesh with 13–21 % of peel left on exposing to the air for 1 h were blanched in these solutions at 95 °C for 7 min. The control was this Palmyra palm flesh with some peel left on blanched in tap water under the same conditions. After cooling for 30 min, the solutions were assessed for colour as above.

Prevention of violet-red discolouration

Effect of immersion in citric acid before blanching

Samples of Palmyra palm flesh with some peel left on (13–21 %) were cut into small pieces and then divided into two groups: one was immersed in tap water with the addition of citric acid at concentrations of 1, 3 and 5 % (w/v) for 3 h and the other was immersed in tap water for 3 h instead for comparison. Then, these pieces of the Palmyra palm with some peel from each group were taken out and blanched in tap water at 95 °C for 7 min. After allowing cooling for 30 min, colour measurement and observation of the Palmyra palm flesh with some peel left on and of the blanching water were carried out as in the above section.

Effect of sterilization at 105 °C for 5 min on violet-red discolouration in canned Palmyra palm in syrup

The tested samples were divided into two groups: one consisted of Palmyra palm flesh and the other was Palmyra palm flesh with 13–21 % of peel left on. Both groups were blanched at 95 °C for 7 min in distilled water to which had been added 62.5 mg/L and 250 mg/L of NaHCO_3 , respectively, in order to simulate the level of alkalinity found in tap water. After immediate cooling, the pieces of the Palmyra palm were removed from the blanching water and put in cans. A sugar solution (26–28 °Brix) was used to fill the cans before seaming. Then, they were sterilized at 105 °C for 5 min and

stored at room temperature for 3 days before performing colour evaluation. The colour measurement and observations on any discolouration from these two groups of canned samples were carried out as before.

Results and discussion

Source of discolouration

Palmyra palm flesh and Palmyra palm flesh with some peel (13–21 % of total peel weight left on)

The tested material was divided into two groups; one consisted only of Palmyra palm flesh and the other was Palmyra palm flesh with some peel left on. These samples were cut into small pieces of the same size before being blanched in tap water at 95 °C for 7 min. After leaving to cool for 0, 10, 20 and 30 min, violet-red discolouration occurred only in the samples of Palmyra palm flesh with some peel left on (Fig. 2). Moreover, leaving the samples to cool down naturally over a longer interval period produced more violet-red discolouration. At 0 min of cooling time, the values of L and a* from the blanching water of samples of the Palmyra palm flesh with some peel have been already significantly different from that of Palmyra palm flesh. The positive value of a* (indicating red colour) also increased with cooling time.

Therefore, the source of this discolouration might be coming from the peel of Palmyra palm.

Since the discolouration was violet-red, the peel and flesh samples of the Palmyra palm were subjected to analysis for anthocyanin as described by Watada and Abbott (1975), amino acid (by the acid digestion method) which could be the cause of this discolouration. It was found that the peel of the Palmyra palm contained anthocyanin (36.95×10^{-3} mg/100 g FW) which was much higher than in fresh flesh (7.44×10^{-3} mg/100 g FW) and blanched flesh (6.57×10^{-3} mg/100 g FW). This indicated that it was possible that the discolouration might have developed from the anthocyanin in the peel. When considering the chance of pink discolouration with reference to discolouration in coconut juice, lysine in the Palmyra palm peel was analyzed and found to be 108 mg/100 g FW which was higher than that in coconut juice (17 mg/100 g FW (Pannaviroj et al. 2006)). Hayashi et al. (1985) claimed that the pink discolouration in sterilized coconut juice was from the reaction between amino lysine and dehydro-ascorbic acid in the coconut juice liquid. However, the violet-red discolouration was found both in the tap blanching water and in Palmyra palm peel after blanching at 95 °C for 7 min. Since the amino lysine, which was found in the palm peel is a basic amino acid and probably dissolves in water, it could be the cause of the violet-red discolouration if ascorbic acid was present.

Fig. 2 Occurrence of violet-red discolouration of the Palmyra palm during cooling: **a** without peel and cooled for 0 min; **b** without peel and cooled for 30 min; **c** with some peel and cooled for 0 min; **d** with some peel and cooled for 30 min

Table 1 Average values (mean $\pm$ standard deviation) for a^* of blanching water for samples exposed to the air and immersed in water before blanching

	a^* average			
	Air	Water	Air	Water
Exposure time before blanching	0 min		10 min	
1 h	1.01 $\pm$ 0.86 ^{aA}	6.41 $\pm$ 2.45 ^{bA}	3.55 $\pm$ 2.46 ^{aB}	10.61 $\pm$ 4.51 ^{bB}
2 h	2.66 $\pm$ 2.92 ^{bA}	14.43 $\pm$ 3.52 ^{cdA}	9.64 $\pm$ 8.84 ^{bB}	23.53 $\pm$ 7.33 ^{cdB}
3 h	7.63 $\pm$ 2.98 ^{cA}	17.98 $\pm$ 5.10 ^{dA}	18.25 $\pm$ 3.85 ^{cB}	26.62 $\pm$ 6.16 ^{dB}
Exposure time before blanching	20 min		30 min	
1 h	4.94 $\pm$ 3.56 ^{aB}	12.21 $\pm$ 5.28 ^{bB}	6.19 $\pm$ 4.57 ^{aB}	12.91 $\pm$ 5.76 ^{bB}
2 h	12.53 $\pm$ 10.32 ^{bB}	25.09 $\pm$ 8.39 ^{cdB}	14.36 $\pm$ 11.29 ^{bB}	25.41 $\pm$ 8.52 ^{cdB}
3 h	22.30 $\pm$ 3.06 ^{cB}	28.01 $\pm$ 6.19 ^{dB}	25.70 $\pm$ 3.56 ^{cB}	27.96 $\pm$ 6.60 ^{dB}

Remark Letters a, b, c and d as superscripts indicate a significant difference in column according to exposure time before blanching. A and B indicate a significant difference according to the exposure medium between air and water

Effect of exposure to the air and immersion in water before blanching

Samples of Palmyra palm flesh with some peel were divided into two groups; one was left exposed to the air for 1, 2 and 3 h before blanching and the other was immersed in tap water for the same period. It was found that different exposure times to the air or immersion in the water before blanching had some effects on the violet-red discolouration. The longer the exposure time, the greater the discolouration of the solution was, especially in the water as shown in Table 1. After heating or 0 min of cooling time, the a^* value of the blanching water of samples which were immersed in water for 1 h was found 6.41 $\pm$ 2.45. It was higher than that (2.66 $\pm$ 2.92) of the samples which were exposed to the air for 2 h or became more violet-redden when comparing to a 2 h air-exposure time. However, these values were not significantly different. Likewise, the a^* value of the solution from 2 h exposure in the water was also not significantly different from that of 3 h exposure time to air. After having them cool in a longer period of time, similar investigation was also observed in the other

cooling periods (10, 20 and 30 min). Thus, the effect of immersing the sample in water before blanching had a more prominent effect on violet-red discolouration than did exposing it to the air.

Effect of temperature and quality of blanching water

Samples of the Palmyra palm with some peel were tested in two different types of the blanching water (tap and distilled water) and at 3 different levels of blanching temperature (75, 85 and 95 °C for 7 min). It was found that the violet-red discolouration occurred only with samples that had been blanched in tap water at 95 °C, which indicates that blanching the samples in tap water at a lower temperature (75 and 85 °C) did not involve in the level of violet-red discolouration. However, blanching samples in distilled water in this temperature range (75–95 °C) did not demonstrate any discolouration. Table 2 indicates that when tap water was used for blanching at 95 °C, the a^* values (mean $\pm$ standard deviation) of the blanching water after cooling for 0, 10, 20 and 30 min were 2.82 $\pm$ 1.89, 6.55 $\pm$ 0.82, 9.61 $\pm$ 1.63 and 11.90 $\pm$

Table 2 Average values of a^* of blanching water in different water quality and temperatures as well as cooling periods

	a^* average			
	Distilled water	Tap water	Distilled water	Tap water
Blanching temperature (°C)	0 min		10 min	
95	−0.57 $\pm$ 0.36 ^b	2.82 $\pm$ 1.89 ^a	0.22 $\pm$ 0.43 ^b	6.55 $\pm$ 0.82 ^a
85	−0.05 $\pm$ 0.01 ^b	−0.49 $\pm$ 0.05 ^b	−0.04 $\pm$ 0.01 ^b	−0.58 $\pm$ 0.08 ^b
75	−0.26 $\pm$ 0.01 ^b	−0.28 $\pm$ 0.04 ^b	−0.26 $\pm$ 0.01 ^b	−0.27 $\pm$ 0.02 ^b
Blanching temperature (°C)	20 min		30 min	
95	0.38 $\pm$ 0.51 ^b	9.61 $\pm$ 1.63 ^a	0.44 $\pm$ 0.45 ^b	11.90 $\pm$ 2.33 ^a
85	−0.05 $\pm$ 0.02 ^b	−0.59 $\pm$ 0.09 ^b	−0.03 $\pm$ 0.02 ^b	−0.56 $\pm$ 0.06 ^b
75	−0.25 $\pm$ 0.01 ^b	−0.23 $\pm$ 0.01 ^b	−0.24 $\pm$ 0.01 ^b	−0.19 $\pm$ 0.02 ^b

Remark Letters a and b as superscripts indicate a significant difference
Values are mean $\pm$ standard deviation

Table 3 Alkalinity and pH of blanching water and the colourimetric parameters of water after blanching Palmyra palm flesh with 13–21 % of peel left on

Sample	pH	Alkalinity level (ppm)		Color		
		CO ₃ ²⁻	HCO ₃ ⁻	L*	a*	b*
Distilled water	7.10	0	38			
Distilled water (for vehicle)	6.77	0	228			
Tap water	7.15	0	361			
Solution of NaHCO ₃ 62.5 mg/L	7.58	0	210			
Solution of NaHCO ₃ 125 mg/L	7.71	0	289			
Solution of NaHCO ₃ 250 mg/L	7.74	0	507			
Distilled water		0	35	32.43±0.95 ^a	-0.35±0.12 ^b	0.89±0.21 ^b
Distilled water + NaHCO ₃		0	61	32.13±0.64 ^a	-0.24±0.14 ^b	1.08±0.26 ^b
		0	100	31.41±1.54 ^a	1.21±2.22 ^{ab}	2.11±1.05 ^{ab}
		0	122	30.43±2.16 ^a	2.74±3.10 ^a	3.10±1.51 ^a
		0	146	30.38±1.92 ^a	2.78±2.56 ^a	3.10±1.21 ^a

Remark Different superscript letters in column indicate a significant difference

Six replicates were performed

2.33, respectively, and were significantly different from the rest of the treatments.

Effect of adding sodium bicarbonate (NaHCO₃) to blanching water

Different NaHCO₃ solutions (62.5, 125 and 250 mg/L in distilled water) were prepared to increase the alkalinity and to be used as blanching water. These concentrations were chosen to imitate the tap water quality, which was highly alkaline (Table 3). After blanching the sample of Palmyra palm flesh with some peel left on at 95 °C for 7 min, it was found that the violet-red discolouration occurred in all concentration and became more obvious as the concentration of NaHCO₃ increased. In particular, at 250 mg/L of NaHCO₃, it was about the same as the discolouration that occurred when using tap water for blanching (Fig. 3). From the statistical analysis, the

values of L, a* and b* in the treatments which used distilled water with the addition of either 62.5 or 125 mg/L NaHCO₃ as the blanching water were not significantly different from those when tap water was used. Therefore the concentration of NaHCO₃ in distilled water for blanching to imitate tap water quality is 62.5–125 mg/L

Note: In order to further on observing the cut off alkalinity of the blanching water wherein not to expect any discolouration, lessen the amount of NaHCO₃ also added in distilled water. Therefore, another four levels of lower alkalinity in blanching water were created as 61, 100, 122 and 146 ppm and similar experiments were carried out. It was found that when the alkalinity of water was as low as 100 ppm, after blanching the average value of L*, a* and b* of NaHCO₃ solutions were not significantly different from those obtaining from using only distilled water for blanching (Table 3).

Fig. 3 Comparison of violet-red discolouration after cooling for 30 min: **a** 250 mg/L of NaHCO₃ added to distilled water and used for blanching; **b** tap water used for blanching

Table 4 Colourimetric parameter comparison of blanching water with/without citric acid treatment before blanching

Colourimetric parameters	Blanching in tap water immediately	Immersing in tap water for 3 h	Immersing in 1–5 % citric acid solution for 3 h before blanching		
			1 %	3 %	5 %
L*	59.54±0.61 ^b	51.58±2.89 ^a	65.46±0.63 ^c	65.60±0.19 ^c	65.36±0.39 ^c
a*	1.65±1.26 ^d	17.98±5.10 ^e	0.002±0.12 ^d	−0.04±0.03 ^d	−0.26±0.08 ^d
b*	12.56±5.52 ^g	11.73±3.14 ^g	3.19±0.18 ^f	3.12±0.03 ^f	4.13±0.68 ^f

Remark Different superscript letters indicate significant difference

Values are mean ± standard deviation

Prevention of violet-red discolouration

Effect of immersion in citric acid solution before blanching

After cutting into small pieces, the Palmyra palm flesh with some peel left on was immersed in tap water with the addition of citric acid at concentrations of 1, 3 and 5 % (w/v) for 3 h. As a result, the pH of the solution was found to be 2.94, 2.64 and 1.87, respectively. Then, the pieces of the Palmyra palm flesh with some peel were taken out and blanched in tap water at 95 °C for 7 min. After cooling down for 30 min, it was found that there was no discolouration in any samples at all concentrations of citric acid. The *a** (average values±standard deviation) of blanching tap water when pieces of Palmyra palm flesh with some peel were treated with citric acid concentrations of 1, 3 and 5 % before blanching were very low at 0.002±0.12, −0.04±0.03 and −0.26±0.08 respectively. Apparently they were significantly different from that of blanching tap water when Palmyra palm flesh with some peel were only immersed in tap water for 3 h but not different from the one sample of which was blanched immediately (Table 4). Therefore a citric acid solution at 1–5 % (w/v) can be used to inhibit the violet-red discolouration of Palmyra palm flesh with some peel, but the product may not be edible due to the sour taste developed from the exposure to the very low pH of the citric solution before blanching.

Effect of sterilization at 105 °C for 5 min of canned Palmyra palm flesh in syrup on violet-red discolouration

Samples of Palmyra palm flesh and Palmyra palm flesh with some peel left on were divided into two groups. Both were blanched at 95 °C for 7 min in distilled water with different concentrations of NaHCO₃ added at 62.5 and 250 mg/L. After immediate cooling, pieces of samples from each group were removed from blanching water and put into cans. A sugar solution of 26–28 °Brix was used to fill the cans as syrup before sealing and then sterilizing at 105 °C for 5 min and storing at room temperature for 3 days. Figure 4 shows that the violet-red discolouration was apparent in both syrup and the samples of Palmyra palm flesh with some peel, but the discolouration was not found in both the syrup and Palmyra palm flesh without the peel left on even these samples had been treated by blanching in distilled water with either 62.5 or 250 mg/L of NaHCO₃ added in.

From the statistical analysis (Table not shown), the values of *a** and *b** of the samples of Palmyra palm flesh without peel and of Palmyra palm flesh with some peel after sterilizing were significantly different in both treatments of 62.5 and 250 mg/L of NaHCO₃ added in the blanching water. Nevertheless, their sugar solutions did not have significantly different *L**, *a** and *b** values and the sugar solution did not have violet-red discolouration in any sample. This is probably caused by the dissolution of violet red pigment from some

Fig. 4 (Lower row) Violet-red discolouration in Palmyra palm flesh with some peel (upper row) but not in the Palmyra palm flesh without the peel at both concentrations of (a) 62.5 mg/L NaHCO₃ and (b) 250 mg/L NaHCO₃

peel which was almost over during blanching. When Palmyra palm flesh with some peel were removed out of blanching water and put in the can filled with syrup, there was too little pigment or, anthocyanin left to dissolve and turn violet-red discolouration in the sugar solution during sterilization. However, when the sample was Palmyra palm flesh without any peel and no matter water quality was, there was no source of pigments. Hence the product of canned Palmyra palm flesh without peel had no problem of violet-red discolouration at all.

Conclusions

Blanching in tap water of Palmyra palm flesh with 13–21 % of peel left on resulted in violet-red discolouration after cooling at room temperature, while Palmyra palm flesh without the peel showed no discolouration. Anthocyanin found in the Palmyra palm peel was the cause of violet-red discolouration occurring after blanching at 95 °C for 7 min in tap water. However blanching any samples in distilled water at 75–95 °C for 7 min did not result in any violet-red discolouration. The addition of sodium bicarbonate (NaHCO₃) at levels of 62.5–250 mg/L in distilled water used for blanching caused an increase in the alkalinity (total alkalinity of 210–507 ppm) so that it approximated that of tap water and subsequently resulted in violet-red discolouration. So the preventive measures for violet-red discolouration without using additives could be: (i) using only water which sustains a low level of bicarbonate (about 100 ppm as the cut off alkalinity) for any heat treatment that has direct contact with samples with 13–21 % of peel left on or (ii) using only Palmyra palm flesh without peel.

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