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Protection of antioxidants in pitaya (*Hylocereus undatus*) peel: effects of blanching conditions on polyphenoloxidase, peroxidase and antioxidant activities

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Abstract

Pitaya peel is a by-product of the fruit processing, rich in phytochemicals and has great potential for application in food industry. In this study, blanching was applied to the pitaya peel treatment for inactivation of the polyphenoloxidase (PPO) and peroxidase (POD) which caused the antioxidant loss in the material during the processing and preservation. The effects of blanching temperature and time on the PPO and POD activities as well as the stability of betacyanins and phenolics of pitaya peel were investigated. At the blanching temperature of 98 ± 2 °C, the inactivation rate constants and half-life values of PPO and POD were $6.6 \times 10^{-3}.s^{-1}$ and 105 s and $16.6 \times 10^{-3}.s^{-1}$ and 42 s, respectively. During the blanching, betacyanins and phenolics were partially destroyed, their degradation rate constants and half-life values were $9.3 \times 10^{-4}.s^{-1}$ and 744 s and $3 \times 10^{-4}.s^{-1}$ and 2310 s, respectively. During the storage of dried pitaya peel powder (PPP), the degradation rate constants of betacyanins and phenolics of the blanched PPP were 1.4 and 1.8 times, respectively lower than those of the unblanched PPP. In addition, reduction in DPPH radical scavenging and ferric reducing antioxidant power of the blanched PPP was significantly lower than that of the unblanched PPP.

Keywords: antioxidant activity; betacyanins; redox enzyme; phenolics; pitaya peel.

Practical Application: Pitaya fruit peel is rich in phytochemicals with high antioxidant activity and can be exploited as a potential ingredient for food processing. The determination of kinetic parameters of redox enzyme inactivation and kinetic parameters of phytochemical degradation of the peel during hot water blanching as well as the evaluation of phytochemical stability and antioxidant activity of the dried pitaya peel powder during its storage provide the scientific basis for choosing appropriate blanching conditions when setting up the production of pitaya peel powder.

1 Introduction

Pitaya peel is considered a by-product of pitaya fruit processing (Jalgaonkar et al., 2020). Pitaya peel contains a large amount of phytochemicals such as betacyanins, phenolics, terpenoids and alkaloids with different bioactivities including antioxidant activity, antimicrobial activity, anti-obesogenic/lipid-lowering effect, anti-cancer activity, anxiolytic effect, anti-diabetic activity, and photoprotective/anti-aging/whitening effect (Jiang et al., 2021). Among the bioactive compounds of pitaya peel, phenolics and betacyanins have attracted great attention due to their predominant content (Lourith & Kanlayavattanakul, 2013; Qin et al., 2020). It is reported that different phenolic acids (gallic acid, protocatechuic acid, caffeic acid, coumaric acid, ferulic acid) and flavonoids (flavonols, anthocyanins, flavones, isoflavonoids) are identified in pitaya peel and these compounds exhibit high antioxidant activity (Tang et al., 2021). Pitaya peel betacyanins include betanin, isobetanin, phyllocatin, isophyllocactin and hylocerenin, the antioxidant activity of which has widely been documented (Belhadj Slimen et al., 2017; Suh et al., 2014). In addition, betacyanins have purple color which can be considered as a good source of natural colorants. Therefore, fresh pitaya peel has been used as a potential material for extraction of phytochemicals in different studies (Chen et al., 2021; Jiang et al., 2021; Leong et al., 2019; Tang et al., 2021).

Besides phytochemicals, pitaya peel also contains a large amount of dietary fiber (Zhuang et al., 2012) with a balanced ratio of insoluble dietary fiber to soluble dietary fiber (Mello et al., 2014). Especially, the dietary fiber of pitaya peel is rich in pectin which exhibits great adsorption capacity towards cholesterol and improves blood lipid profile in human diet (Zaid et al., 2019). In food processing, it is preferable to utilize the whole pitaya peel with phytochemicals and fibers for the formulation of food products since these valuable compounds of the by-product can be exploited for human nutrition (Pop et al., 2021; Subiria-Cueto et al., 2021). In this case, fresh pitaya peel needs to be blanched, dried and crushed into pitaya peel powder (Sengkhamparn et al., 2013) which is subsequently preserved and used in food recipe. Pitaya peel powder has recently been added to the formulation of different food products such as Chinese steamed bread (Hsu et al., 2019), noodle (Shiau et al., 2020), strawberry ice-cream (Utpott et al. (2020) or chicken nugget (Madane et al., 2020) for enhancement of betacyanin, phenolic and fiber content as well as antioxidant activity of the products.

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Fresh pitaya peel contains various oxidative enzymes (polyphenoloxidase (PPO), peroxidase (POD), lipoxygenase, β-glucosidase) which are responsible for phytochemical degradation and color loss during the drying of fresh pitaya peel and the preservation of dried pitaya peel powder (Batista Moreira Santos et al., 2019; Wu et al., 2020; Xiao et al., 2017). PPO and POD are the main redox enzymes causing the loss of phenolics and betacyanins in pitaya peel as well as in other fruits and vegetables (Martínez-Parra & Muñoz, 2001; Queiroz et al., 2008; Tinello & Lante, 2018). Blanching is therefore a key process for enzyme inactivation in the making of pitaya peel powder. In the study of Sengkhamparn et al. (2013), blanching of fresh pitaya peel was performed at 90 ± 2 °C during 1 min before it was dried and crushed to yield the powder. However, phenolics and betacyanins are thermolabile compounds and they can be lost during the blanching (Zhang et al., 2021). According to our knowledge, the effects of blanching conditions of fresh pitaya peel on the catalytic activity of the redox enzymes and the antioxidant content have not been reported in the literature.

In this study, fresh pitaya peel was blanched using hot water method. The aim of this study was to evaluate the effects of blanching temperature and time on the inactivation of PPO and POD of pitaya peel as well as the stability of its betacyanins and phenolic compounds during the hot water blanching. In addition, the stability of betacyanins and phenolic compounds and the antioxidant activity of the dried pitaya peel powder were also evaluated during its storage.

2 Materials and methods

2.1 Materials

Ripe pitaya fruits with white-flesh (*Hylocereus undatus*) which had uniform purple-red color all over the surface of the fruits were purchased from a pitaya fruit farm in CuEbuar commune, Buon Ma Thuot city, Dak Lak province, Vietnam. After cleaning the fruits with tap water, the fresh peels were manually removed from the fruits, and then cut into 2 cm in width and 5 cm in length.

All chemicals used in the study were supplied by Sigma-Aldrich (MO, USA) and they were of analytical grade.

2.2 Blanching of fresh pitaya peel

The blanching was performed in a heating water bath (Daihan, WCB-22, Seoul, Korea). About 250 g pitaya peel was directly immersed in the blanching water. The ratio of peel weight and water volume was fixed at 1/6 (w/v). The temperature of blanching water was various: 70, 80, 90 and 98 (±2) °C while the blanching time was kept constant at 180 s. During the blanching, sampling was taken every 30 s; the blanched samples were immediately cooled to room temperature using an ice bath and subsequently analysed for PPO and POD activity, betacyanin and phenolic content and antioxidant activity. The control sample was the unblanched pitaya peel.

2.3 Storage of dried pitaya peel powder

The pitaya peel pieces which were blanched at 98 (±2) °C for 3 min were immediately separated and cooled to room temperature, then dried at 60 °C to achieve approximately 9-10% moisture content using a forced air oven (Memmert, Model SF30, Schwabach, Germany). The dried peel pieces were ground by a high speed multi-functional crusher at 25,000 rpm for 2 min and sifted through a 70-mesh sieve. The obtained pitaya peel powder (PPP) samples were preserved in air-proof polyethylene bags at ambient temperature for 16 weeks. During the storage, sampling was performed every 2 weeks for evaluation of betacyanin and phenolic content and antioxidant activity. The control sample was the pitaya peel powder produced from unblanched fresh peel.

2.4 Chemical analysis

For betacyanin extraction, 4 g crushed fresh peel or 1 g PPP was added to a 50 mL beaker with 20 mL distilled water; the ultrasound-assisted extraction was performed at 150 W for 15 min using an ultrasonic probe (Sonics, VC750, CT, USA). During extraction, the beaker was put in a cooling water bath (Daihan, WCB-22, Seoul, Korea) to remain the slurry temperature at about 30 °C. The mixture was then centrifuged (Hettich, Rotofix 32A, Tuttlingen, Germany) at 3500×g and 25 °C for 5 min. The supernatant was collected and the process was repeated in triplicate. The obtained extracts were mixed together. Betacyanin content was analysed using a spectrophotometric method described by Jamilah et al. (2011).

For phenolic extraction, 4 g crush fresh peel or 1 g PPP was added to a 100 mL beaker with 40 mL 60% (v/v) methanol solution; the ultrasound-assisted extraction was conducted at 150 W for 15 min. The extraction temperature was kept at about 30 °C using a cooling water bath as described above. The slurry was then centrifuged (Hettich, Rotofix 32A, Tuttlingen, Germany) at 3,500×g and 25 °C for 10 min and the residue was re-extracted under the same conditions. The supernatants were combined and used for determination of total phenolic content. Total phenolic content was measured by spectrophotometric method with Folin-Ciocalteau reagent (Singleton & Rossi, 1965).

2.5 Evaluation of antioxidant activity

The betacyanin extract and phenolic extract were mixed and used for evaluation of antioxidant activity. Antioxidant activity was measured by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity (Brand-Williams et al., 1995) and ferric reducing antioxidant power (FRAP) assays (Benzie & Strain, 1996); the results were expressed as μmol Trolox equivalent/100 g dry weight (d.w.) of sample.

2.6 Color measurement

Instrumental color was evaluated using a colorimeter (Minolta, CR-400, Tokyo, Japan) and CIE L* a* b* system. The total color difference between the blanched and the unblanched fresh pitaya samples was calculated by the formula previously described elsewhere (Sengkhamparn et al., 2013).

2.7 Polyphenol oxidase and peroxidase assay

Enzyme extraction was carried out according to the procedure described by Z. Zhang et al. (2018) with some modifications. For each sample, 10 g fresh pitaya peel was added to 20 mL of

0.1 M potassium phosphate buffer (pH 6.5) which was preliminary cooled to 4 °C. The sample was homogenized for 2 min using a crusher (Ika, Model A11, Staufen im Breisgau, Germany). The suspension was then centrifuged (Hettich, Mikro 220R, Tuttlingen, Germany) at 14,000 × g and 4 °C for 30 min and the obtained supernatant was used to assay enzyme activity.

PPO activity was determined by the increase in absorbance at 420 nm with 175 mM catechol solution as substrate. One unit (U) of enzyme activity is defined as the amount of enzyme that causes an increase in absorbance of 0.001 per min per gram of sample under the assay conditions (Zhang et al., 2015).

POD activity was determined by the increase in absorbance at 470 nm due to the formation of tetraguaiacol from guaiacol in the presence of H_2O_2. One unit of enzyme activity (U) is defined as the amount of enzyme that produces a change in absorbance of 0.01 per min per gram of sample under the assay conditions (Zhang et al., 2015).

The retention of activity was calculated following Equation 1:

$$R(\%)=(A_t / A_0)x100\% \quad (1)$$

Where A_t is the enzyme activity after a given blanching time t and A_0 is the initial enzyme activity of the unblanched sample.

2.8 Determination of kinetic parameters of enzyme inactivation and kinetic parameters of betacyanin and phenolic degradation

The kinetic data of PPO and POD inactivation and those of betacyanin, phenolic degradation were analysed with first-order kinetics (Gonçalves et al., 2010; Kayın et al., 2019) using Equation 2:

$$C_t / C_0 = exp(-k.t) \quad (2)$$

where C_t and C_0 are the PPO/POD activity or betacyanin/phenolic content at time t and zero, respectively; k is the first-order rate constant; and t is the blanching time (s) or storage time (week).

The half-life ($t_{1/2}$) was calculated according to Equation 3:

$$t_{1/2} = ln(2) / k \quad (3)$$

where $t_{1/2}$ is the half-life and k is the first order inactivation/degradation rate constant.

The effects of temperature on the inactivation/degradation rate constants were expressed by the linearized Arrhenius equation by plotting lnk against 1/T in which the temperature dependence of k was quantified by the activation energy (E_a) according to Equation 4:

$$lnk = lnC - E_a / RT \quad (4)$$

where E_a is the activation energy of the reaction (kcal.mol^{-1}); R is the gas constant (8.314.10^{-3} kJ.K^{-1}.mol^{-1}); T is the absolute temperature (K); and C is the pre-exponential constant.

The E_a value was calculated from the slope of the straight lines given by Equation 4.

2.9 Statistical analysis

All experiments were performed in triplicate and the obtained results were presented as means±standard deviation (n=3). Mean values were considered significantly different when the probability was less than 0.05 using multiple range test. One-way analysis of variance was conducted by using software Statgraphics Centurion XV.I (Manugistics Inc., Rockville, USA).

3 Results and discussion

3.1 Effects of blanching temperature and time on polyphenoloxidase and peroxidase activity

Figure 1 shows the catalytic activity of PPO and POD, respectively during the blanching.

At all blanching temperatures, the pitaya peel PPO activity was gradually reduced during the treatment (Figure 1A). The increase in blanching temperature resulted in a greater decrease in PPO activity. After 3-min blanching, the residual activity of pitaya peel PPO was approximately 71.8%, 51.6%, 44.7% and 29.4% at 70 °C, 80 °C, 90 °C and 98 (±2) °C, respectively. Reduction in POD activity was also observed during the blanching (Figure 1B). The pitaya peel POD activity remained approximately 40.1%, 22.9%, 13.4% and 4.6% after 3-min blanching at 70 °C, 80 °C, 90 °C and 98 (±2) °C, respectively. It can be noted that the decrease in POD activity was greater than that in PPO activity at all temperatures. PPO was therefore required a longer heat treatment time compared to POD to reach the same enzyme inactivation level at the same blanching temperature.

The decrease in PPO and POD activities was well fitted by the first-order kinetic model of enzymatic reactions under the experimental conditions since the coefficient of determination R^2 was ranged from 0.93 to 0.99. The kinetic parameters of PPO and POD inactivation by hot water blanching are shown in Table 1. It can be seen that the higher the temperature, the higher the thermal inactivation rate constant and the lower the half-life value for both pitaya peel PPO and POD. Similar result was reported for mangosteen pericarp PPO and POD activity during the blanching (Deylami et al., 2014; Deylami et al., 2016). When the blanching temperature increased from 70 to 98 (±2) °C, the inactivation rate constant k of PPO and POD of pitaya peel increased by 3.7 times and 3.3 times, respectively while their half-life $t_{1/2}$ decreased by 3.7 times and 3.3 times, respectively. The half-life of PPO in pitaya peel was approximately 2.5-2.7 times higher than that of POD. It indicated that PPO in pitaya peel was more heat-resistant than POD. Thus, the activation energy of PPO was higher than that of POD. The higher thermal stability of PPO compared to that of POD was also reported for pomegranate peel (Magangana et al., 2021), pineapple puree (Chakraborty et al., 2015) and peach (Lopes et al., 2014). In contrast, some studies demonstrated that POD was more heat resistant than PPO for red bell pepper (Wang et al., 2016) and coconut water (Chutia et al., 2019). Difference in thermal stability of POD and PPO for different fruits and vegetables is

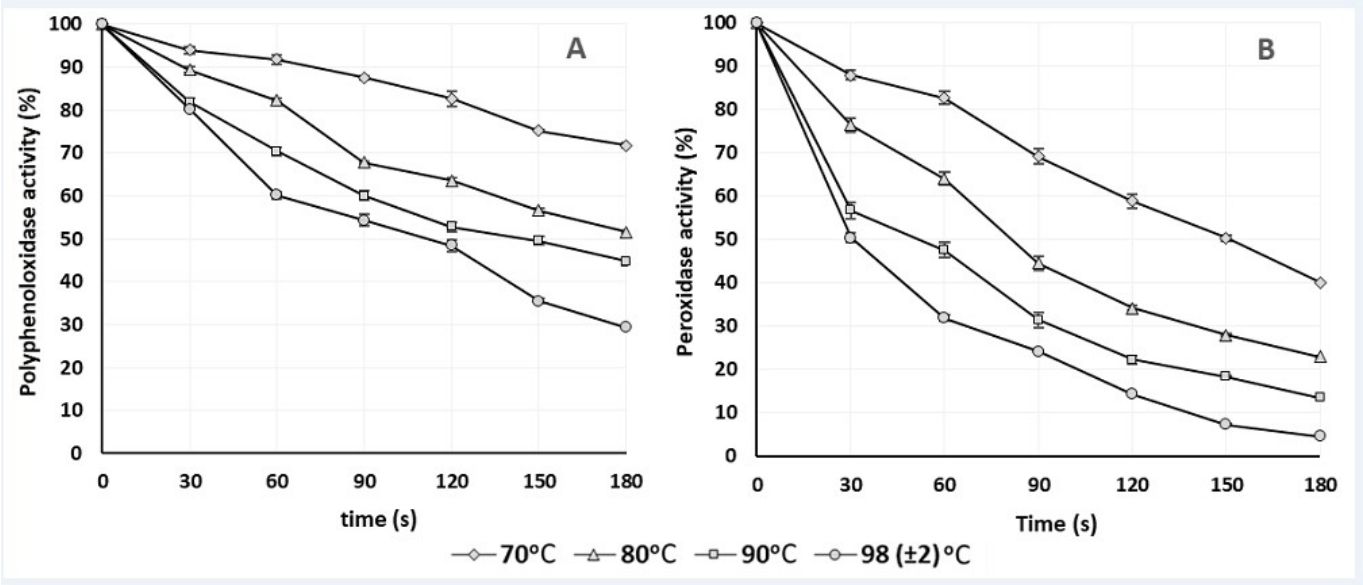

Figure 1. Catalytic activity of polyphenoloxidase (A) and peroxidase (B) of pitaya peel during the blanching. The enzyme activity measured at the initial moment was taken as 100%.

Table 1. Inactivation rate constants (k), half-lives ($t_{1/2}$) and activation energy of pitaya peel polyphenoloxidase and peroxidase at different blanching temperatures.

Blanching temperature (°C)	Polyphenoloxidase			Peroxidase		
	k ($\times 10^{-3}$ s^{-1})	$t_{1/2}$ (s)	Activation energy (E_a) (kJ/mol)	k ($\times 10^{-3}$ s^{-1})	$t_{1/2}$ (s)	Activation energy (E_a) (kJ/mol)
70	1.80 ± 0.06^{d}	378^{a}	43.63 ± 0.54	5.00 ± 0.06^{d}	138^{a}	39.75 ± 1.17
80	3.70 ± 0.06^{c}	186^{b}		8.40 ± 0.10^{c}	83^{b}	
90	4.40 ± 0.17^{b}	158^{c}		10.80 ± 0.06^{b}	64^{c}	
98	6.60 ± 0.10^{a}	105^{d}		16.60 ± 0.12^{a}	42^{d}	

Values with different subscripts in the same column are significantly different ($P < 0.05$).

due to their various origins, enzyme structures and blanching conditions (Fante & Noreña, 2012; Shivhare et al., 2009).

3.2 Effects of blanching temperature and time on betacyanin and total phenolic content of pitaya peel

The antioxidant content of pitaya peel during the blanching is presented in Figure 2A and 2B. The betacyanin and total phenolic content significantly decreased with increasing the blanching temperature and time. After 3-min treatment, the loss of betacyanins at the blanching temperature of 70 and 80 °C, was 2.5% and 5.7%, respectively. When the blanching temperature increased to 90 and 98 (±2) °C, the betacyanin loss after 3 min treatment reached about 8.6% and 15.6%, respectively. It can be noted that the loss of betacyanin content in the pitaya peel at the blanching temperature of 98 (±2) °C resulted in a decreased redness of the peel (data not shown). For phenolic compounds, their content was slightly lost from 1.3% to 6.0% after 3-min treatment when the blanching temperature increased from 70°C to 98 (±2) °C. The loss of betacyanins and phenolics was due to their partial diffusion from the pitaya peel into the blanching water. In addition, temperature strongly influences the betacyanin and phenolic stability. According to Chew et al. (2019), degradation of betacyanins is minor when these compounds are subjected to the heat treatment below 60 °C. Betacyanin degradation can be due to dehydrogenation and/or isomerization and/or decarboxylation (Kumorkiewicz & Wybraniec, 2017). The phenolic compounds might also be degraded due to hydrolysis and oxidation with the increase of processing temperature (Cao et al., 2021). The loss of betacyanin and total phenolic content during the blanching was previously reported for carrot peel (Chantaro et al., 2008), spinach, swamp cabbage, cabbage, kale (Ismail et al., 2004) and beetroot (Zhang et al., 2021).

During the blanching, the betacyanin and phenolic loss in pitaya peel was also fitted by the first-order kinetic model; the coefficient of determination R^2 ranged from 0.91 to 0.99. The corresponding kinetic parameters are presented in Table 2. When the blanching temperature augmented from 70 to 98 (±2) °C, the degradation rate constant k of pitaya peel betacyanins and phenolics increased by 4.67 and 4.48 times, respectively; on the contrary, the half-life $t_{1/2}$ of betacyanins and total phenolics decreased by 4.67 and 4.48 times, respectively. It should be noted that betacyanins of pitaya peel was less thermostable than its phenolic compounds. So, the energy activation of betacyanin

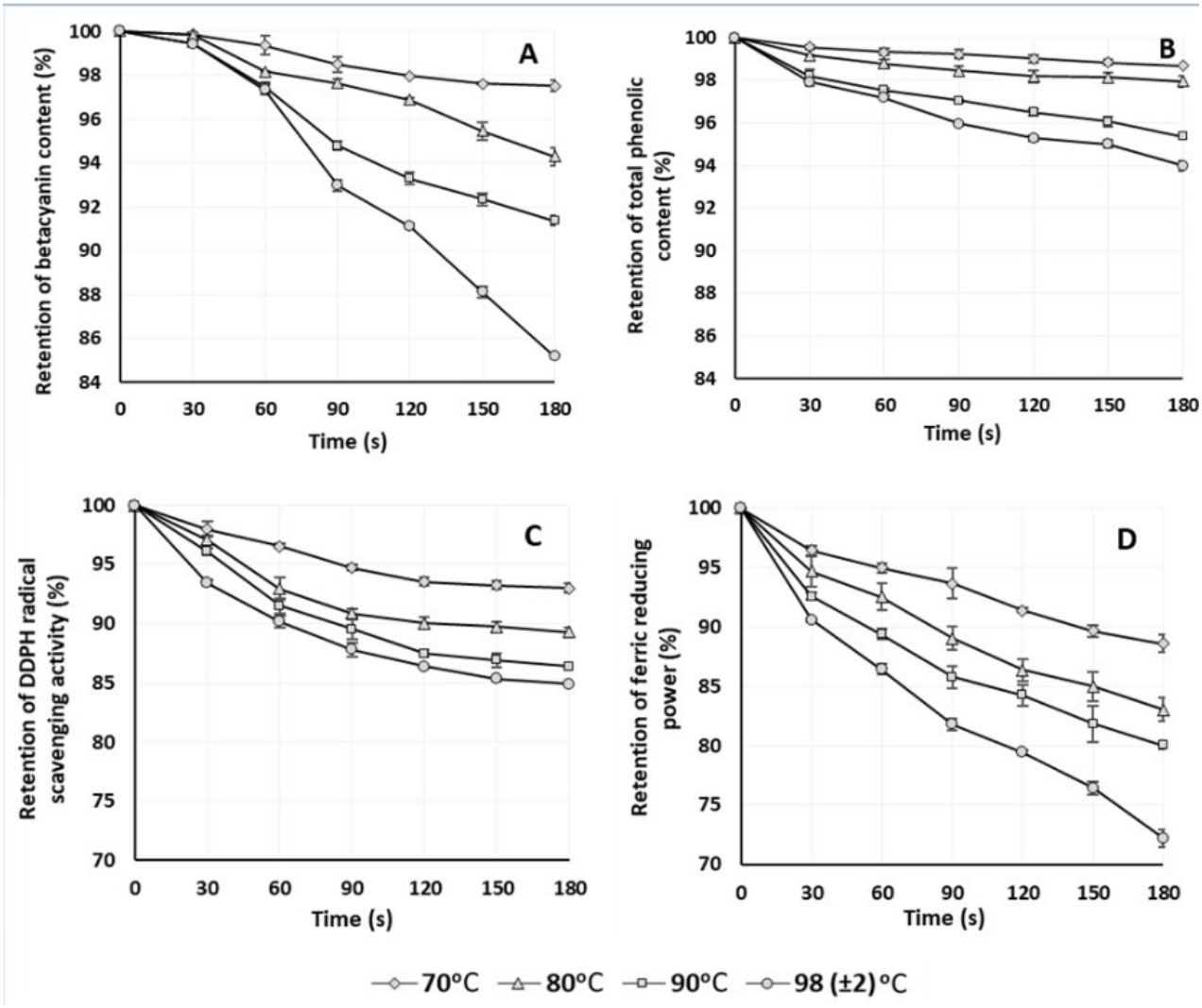

Figure 2. Retention of betacyanins (A), total phenolics (B), DPPH radical scavenging activity (C) and ferric reducing power (D) of pitaya peel during the blanching. The content of betacyanins, phenolics and the antioxidant activity at the initial moment were taken as 100%.

Table 2. Degradation rate constants (k), half-lives ($t_{1/2}$) and activation energy of the betacyanins and phenolics at different blanching temperatures.

Blanching temperature (°C)	Betacyanins			Phenolics		
	k ($\times 10^{-4}$ s^{-1})	$t_{1/2}$ (s)	Activation energy (E_a) (kJ/mol)	k ($\times 10^{-4}$ s^{-1})	$t_{1/2}$ (s)	Activation energy (E_a) (kJ/mol)
70	2.00 ± 0.00^a	3466^a	54.72 ± 0.44	0.67 ± 0.06^a	10452^a	59.70 ± 0.33
80	3.00 ± 0.00^b	2310^b		0.95 ± 0.05^b	7188^b	
90	5.50 ± 0.71^c	1271^c		2.00 ± 0.00^c	3466^c	
98	9.33 ± 0.35^d	744^d		3.00 ±0.00^d	2310^d	

Values with different subscripts in the same column are significantly different ($P < 0.05$).

was 1.1 times lower than that of phenolic compounds in pitaya peel. The E_a value of betacynins during blanching in this study was slightly higher than that of betacyanin extract (49.2 kJ/mol) in the report of Chew et al. (2019).

3.3 Effects of blanching temperature and time on antioxidant activity of pitaya peel

The antioxidant activity of pitaya peel during the blanching is shown in Figure 2C and 2D. The DPPH radical scavenging activity and ferric reducing antioxidant power of pitaya peel decreased with the increase in blanching temperature and time. This reduction was related to the loss of betacyanins and phenolic compounds by the thermal degradation and leaching into the blanching water. The higher the blanching temperature and the longer the treatment time, the lower the DPPH scavenging activity and ferric reducing antioxidant power of the pitaya peel. The maximum loss in DPPH scavenging activity (15.1%) and ferric reducing power (27.8%) was recorded at the blanching temperature of 98 (±2) °C after 3-min treatment. Chantaro et al.

(2008) also reported that the total antioxidant activity of carrot peel decreased after blanching in hot water at 90 ± 2 °C for 1 min. Besides, our results reveal that reduction in ferric reducing antioxidant power in pitaya peel was faster and greater than that in DPPH scavenging radical activity. It can be noted that betanin may be degraded by isomerisation, decarboxylation, cleavage or dehydrogenation during heat processing; dehydrogenation of betanin leads to neobetanin formation while cleavage of betanin and isobetanin can create betalamic acid and the colorless cyclo-Dopa-5-O-glycoside (Azeredo et al., 2007). These transformations can affect the antioxidant activity which depends on chemical structure of betalain molecules (Belhadj Slimen et al., 2017). Similarly, food processing conditions can lead to chemical and/or structural changes in phenolic molecules as well as their antioxidant activity (Rice-Evans et al., 1996). Similar reduction in DPPH scavenging radical activity and ferric reducing antioxidant power was also reported when beet, pinto and black beans were subjected to the heat treatment and that was due to the loss of betacyanins and/or phenolic compounds (Ramos et al., 2017; Xu & Chang, 2009).

3.4 Effects of blanching on the stability of betacyanin and phenolic compounds and antioxidant capacity of pitaya peel powder during the storage

The effects of blanching on the stability of betacyanins and phenolic compounds of pitaya peel powder during 16-week storage are presented in Figure 3A. Both betacyanin and phenolic content in the blanched and unblanched pitaya powder samples gradually decreased during the storage; however, the reduction of betacyanin and phenolic content in the blanched sample was significantly lower than that of the unblanched sample. Table 3 reveals that the degradation rate constant of betacyanins and phenolics in the blanched sample was approximately 29.8 and 45.3%, respectively lower than that in the unblanched sample while the half-life of betacyanins and phenolic compounds in the blanched sample was approximately 1.4 and 1.8 times greater than that in the unblanched sample. This proves that the blanching effectively reduced the loss of betacyanins and phenolic compounds in the PPP during the storage. Figure 3A also shows that the retention of phenolic compounds was lower than that of betacyanins in both unblanched and blanched samples. After 16-week storage, the loss of phenolics in the unblanched and blanched samples was 33.9% and 20.4%, respectively, while that of betacyanins in the unblanched and blanched samples was only 6.9% and 5.3%, respectively. It can be noted that the thermostability of betacyanins was higher than that of phenolic compounds during the storage of PPP while the opposite result was observed for fresh pitaya peel during the blanching (Table 2). Betacyanin and phenolic loss during the blanching was due to many reasons (pH, temperature, oxygen, light and leaching), among them leaching is one of the predominant factors (Mukherjee & Chattopadhyay, 2007; Zhang et al., 2021); nevertheless, leaching phenomenon was not observed during storage of PPP. Further research needs to be performed to clarify the interactive effects of different processing conditions on the loss of betacyanins and phenolic compounds during the blanching of fresh pitaya peel and the storage of PPP.

Figure 3B shows that the antioxidant activity of pitaya peel powder gradually decreased during 16-week storage. At the end of the storage, the retention of DPPH scavenging activity and ferric reducing power of the blanched sample was 85.9% and 87.9%, respectively while that of the unblanched sample was 73.9% and 78.8%, respectively. The low reduction in antioxidant activity of the pitaya peel powder from the blanched sample was recorded due to the high retention of betacyanin and phenolic compounds during the storage. The loss of betacyanins and phenolic compounds which led to the decrease of antioxidant

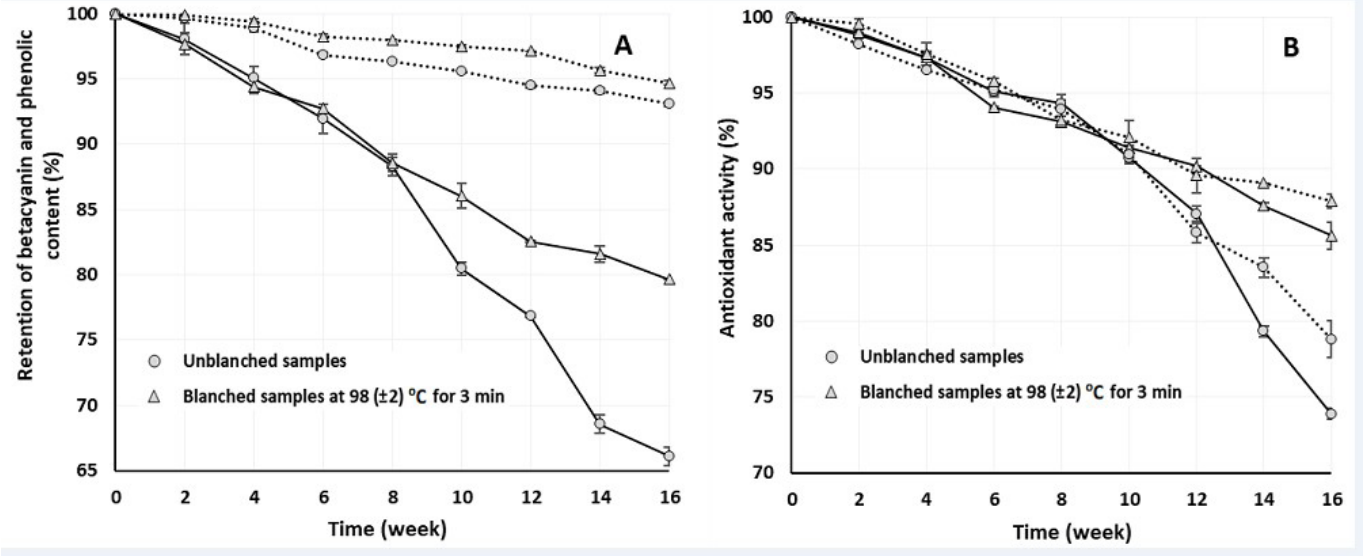

Figure 3. Retention of betacyanin and phenolic content (A), antioxidant capacity (B) of pitaya peel powder during the storage. The content of betacyanins, phenolics and the antioxidant activity at the initial moment were taken as 100%. Solid lines represent the retention of phenolics (A) and DPPH radical scavenging activity (B) of samples; dotted lines represent the retention of betacyanins (A) and ferric reducing antioxidant power (B) of samples.

Table 3. Effects of blanching on the degradation rate constants (k) and half-lives ($t_{1/2}$) of betacyanins and phenolics of the pitaya peel powder in the storage.

	Degradation rate constants (k) and half-lives ($t_{1/2}$) of betacyanins		Degradation rate constants (k) and half-lives ($t_{1/2}$) of phenolics	
	k ($\times 10^{-3}$ week^{-1})	$t_{1/2}$ (weeks)	k ($\times 10^{-3}$ week^{-1})	$t_{1/2}$ (weeks)
Unblanched sample	4.70 ± 0.28^{a}	148^{a}	27.40 ± 0.42^{a}	25^{a}
Blanched sample	3.30 ± 0.10^{b}	207^{b}	15.00 ± 0.20^{b}	46^{b}

Values with different subscripts in the same column are significantly different ($P < 0.05$).

activity during the storage in this study was in accordance with the findings of Bassama et al. (2021), Kim et al. (2018) and Pandey et al. (2018) for cactus pear juice, kiwifruit puree and beetroot powder, respectively.

4 Conclusions

Water blanching significantly reduced the PPO and POD activities of pitaya peel. The betacyanin and phenolic content as well as the antioxidant activities of pitaya peel gradually decreased during the blanching. Increased temperature and prolonged time of the blanching resulted in lowered PPO and POD activity and decreased antioxidant content. During the storage of pitaya peel powder, the loss of betacyanins and phenolic compounds as well as the reduction in antioxidant activities for the blanched samples was less than those of the unblanched samples.

Conflict of interest

The authors have declared no conflicts of interest for this article.

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