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Antioxidant study of pulps and peels of dragon fruits: a comparative study

[1]Nurliyana, R., [2]Syed Zahir, I., [3]Mustapha Suleiman, K., [3]'Aisyah, M.R. and [1,4]Kamarul Rahim, K.

[1]*Functional Food and Neutraceutical Research Cluster, Department of Biotechnology, Kulliyyah of Science, International Islamic University Malaysia (IIUM), Jalan Istana, Bandar Indera Mahkota, 25200 Kuantan, Pahang Darul Makmur, Malaysia*
[2]*Centre for Foundation Studies (Petaling Jaya Campus), International Islamic University Malaysia (IIUM), Jalan Universiti, Seksyen 17, Petaling Jaya, 46350 Selangor Darul Ehsan, Malaysia*
[3]*Basic and Applied Biomedical Research Cluster, Department of Biomedical Science, Kulliyyah of Science, International Islamic University Malaysia (IIUM), Jalan Istana, Bandar Indera Mahkota, 25200 Kuantan, Pahang Darul Makmur, Malaysia*
[4]*School of Biological Sciences (SBS), The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*

Abstract: The aim of this study is to compare antioxidant level and activities (i.e. primary and secondary) in pulps and peels of two species of dragon fruits, *Hylocereus undatus* (white dragon fruit) and *Hylocereus polyrhizus* (red dragon fruit). Total phenolic content (TPC) assay demonstrated that peels of both *Hylocereus* species contained higher phenolic content than the pulps. The phenolic content in peels of *H. undatus* was higher than *H. polyrhizus*, but the phenolic content in pulps of *H. undatus* was much lower than *H. polyrhizus*. 2, 2, diphenyl-1-picrylhydrazyl (DPPH) assay showed that radical scavenging activities of peels for both species were higher than the pulps. For ferrous ion chelating (FIC) assay, peels and pulps of both *Hylocereus* species showed moderate metal ion chelating effect as compared to EDTA. Overall, the results suggested that the TPC showed good relationship with the primary antioxidant activities for general comparison between the peels and the pulps.

Keywords: Antioxidant level, antioxidant activities, *Hylocereus undatus*, *Hylocereus polyrhizus*, peels, pulps

Introduction

Dragon fruit or pitaya is one of the tropical fruits under the cactus family, *Cactaceae*. In general, there are two species of dragon fruits commonly found in Malaysian market i.e. red dragon fruit (*Hylocereus polyrhizus*) and white dragon fruit (*Hylocereus undatus*). Their differences lie on the size and shape of the fruit, as well as the colour of their pulps i.e. red (*H. polyrhizus*) or white (*H. undatus*). The average weight of a dragon fruit is around 350 g. The best climate condition for dragon fruit plantation is dry, tropical or subtropical with annual rainfall ranges from 20-50" per year. As for the fruit production, one plant can produce up to four to six cycles of fruits per year and fruits are harvested when they are fully expanded and the skins become 85% red in colour.

Antioxidant studies on various types of fruits have been carried out for years. Previous studies have determined the antioxidant levels and activities in tropical fruits such as mangosteen, guava, papaya and star fruit, covering various parts of fruits. However, investigations on the antioxidant activities for fruit peels and seeds are lacking due to their low popularity and commercial application (Soong and Barlow, 2004). According to Caro and Piga (2007), seeds and peels of Italian fresh fig fruits cultivars showed higher antioxidant capacity and phenolic content than the edible portions. Dragon fruits, like many other tropical fruits and vegetables, are believed to be rich in antioxidants but information specifically on antioxidant levels and properties in its pulps and peels are still lacking. Until recently, many claims are being made on antioxidant properties and effectiveness of dragon fruits that promote them as one of the sources of natural food additives and ingredients. Nonetheless, from our reviews, very few antioxidant studies on *Hylocereus* species have been conducted (Lim *et al*., 2006; Mahattanatawee *et al*., 2006; Lim *et al*., 2007).

There is a wide variety of antioxidant compounds in fruits. All antioxidant compounds can act as substances that delay or prevent the oxidation of cellular oxidisable substrates caused by reactive

*Corresponding author.
Email: *physique481@yahoo.co.uk*
Tel: +609-5716748; Fax: +609-5716794

oxygen species (Ajila *et al*., 2007). The main principle of antioxidant activity is the availability of electrons to neutralise any free radicals. Free radicals which are produced during the oxidation process are extremely reactive and have the potential to damage transient chemical species. Among the most abundant antioxidant compounds in tropical fruits are carotenoids, phenolics and betalains. According to Park *et al*. (2008), polyphenols, as one of phenolic compounds, play the main role in contributing to the overall antioxidant activity. Polyphenols such as flavonoids can be found mostly in the pulps, peels and seeds of the fruits. However, Esquivel *et al*. (2007) found out that betalains containing both phenolic and non-phenolic structures were responsible for the major antioxidant capacity of purple *Hylocereus* juices evaluated, while non-betalainic phenolic compounds contributed only to a minor extent. It was once thought that betalains were related to anthocyanins (i.e. a flavonoid derivative), the reddish pigments found in most plants. However, betalains are structurally and chemically unlike anthocyanins because they contain nitrogen whereas anthocyanins do not.

Dragon fruits are usually consumed by people directly or being processed into juice. Therefore, the major byproduct of dragon fruits is the peel. Betalains in pulps of purple *Hylocereus* species were responsible for the major antioxidant capacity (Esquivel *et al*., 2007), and we hypothesised that the peels also contain more or less antioxidant properties due to their colour. Thus, both the peels and the pulps could be beneficial especially in food and pharmaceutical industry. Since Malaysia is abundant with *Hylocereus* species in the local market, further studies focusing on *Hylocereus* species are necessary. Besides, the fruits of *Hylocereus* species have recently drawn much attention of the world for their betalaine antioxidant activities. Therefore, the aim of this study is to compare antioxidant level and activities (i.e. at primary and secondary level) in pulps and peels of two species of dragon fruits, *Hylocereus undatus* (white dragon fruit) and *Hylocereus polyrhizus* (red dragon fruit). TPC assay was carried out to determine the level of antioxidant compounds in each of the fruit parts using the Folin-Ciocalteu method. Both the primary and secondary antioxidant activities were assessed using DPPH assay and FIC activity assay, respectively.

Materials and Methods

Sample collection

Two species of dragon fruits used as model system in present study are red dragon fruit (*Hylocereus polyrhizus*) and white dragon fruit (*Hylocereus undatus*). Dragon fruits were purchased from local markets and supermarkets in Kuantan, Pahang Darul Makmur, Malaysia.

Sample preparation and extraction

Dragon fruits were washed and peeled in order to separate the peels from the pulps for further tests. For pulps preparation, 10 to 30 g of the edible portion was crushed using blender to a paste-like state for 1 min. The homogenised sample was firstly freeze-dried in order to reduce moisture content of the sample for a more efficient extraction process. Based on the modified method by Lim *et al*. (2007), the homogenised sample was then poured into 250 mL volumetric flask and 70% ethanol was added to the volume of 250 mL. The mixture was then shaken using the mechanical shaker for 2 days before filtered using Whatman No.4 filter paper. After that, the filtrate was rotary evaporated for 4 hours at 40°C to remove the solvent and followed by lyophillisation to remove the water remaining inside the extracts.

On the other hand, peels of dragon fruits were dried in the oven with temperature 70°C until all moisture were gone. Dried peels were ground into fine powder and extracted with 70% ethanol using Soxhlet for 12 hours (Okonogi *et al*., 2007). The flask containing the extracted compounds and solvents was evaporated using rotary evaporator at 40°C for 4 hours. Next, the flask containing extracted compounds was lyophilised until all waters were removed. The lyophilised samples were stored at 4°C and protected from lights until further tests.

TPC assay

Antioxidant level for each sample was measured by TPC assay using Folin-Ciocalteu's method based on modified method by Lim *et al*. (2006). A volume of 0.3 mL of each extract was mixed with 1.5 mL of Folin-Ciocalteu's reagent (which was diluted 10x with distilled water) and 1.2 mL of sodium carbonate (7.5% w/v) in a test tube. The tube was then vortexed and covered by parafilm. The tube was incubated in dark for 30 min at room temperature. After that, absorbance readings were taken by measuring the sample using Perkin Elmer Lambda 25 UV/Vis spectrophotometer at absorbance of 765 nm. Gallic acid with concentrations of 0.05 mg/ml, 0.10 mg/ml, 0.15 mg/ml, 0.20 mg/ml and 0.25 mg/ml used as standards were prepared by dissolving in 70% ethanol. Both samples and gallic acid were measured against 70% ethanol which was used as blank. All samples and readings were measured in triplicate.

DPPH assay

The radical scavenging activity of each sample was measured using a modified method described by Khamsah *et al.* (2006). Each sample was prepared in a series of dilution (0.2 mg/mL, 0.4 mg/mL, 0.6 mg/mL, 0.8 mg/mL and 1.0 mg/mL) with final volume of 10 mL. A volume of 1 mL of each solution was then mixed with 2 mL of 0.1 mM DPPH reagent and mixed thoroughly. After the tubes were incubated at room temperature in the dark for 30 min, absorbance of the mixture was measured spectrophotometrically at 517 nm against 70% ethanol which was used as blank. The negative control contained only 2 mL of 0.1 mM DPPH and 1 mL of 70% ethanol without any extract. Butylated hydroxyanisole (BHA) acted as positive control to be compared with all the samples. Each sample was measured in triplicate and expressed in mean average. The radical scavenging activity was calculated accordingly:-

$$\% \text{ inhibition} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100$$

$A_{control}$ = Absorbance reading of control
A_{sample} = Absorbance reading of the sample

IC_{50}, the amount of sample extracted into 1 mL solution necessary to decrease by 50% the initial DPPH concentration, was derived from the % inhibition versus concentration plot (Figure 2).

FIC assay

FIC assay was carried out according to the modified method of Wang *et al*. (2008) to determine secondary antioxidant activity of the samples. A 10 mL series of dilutions was prepared for each sample at five different concentrations (0.02 mg/mL, 0.04 mg/mL, 0.06 mg/mL, 0.08 mg/mL and 0.1 mg/mL). The reaction mixture (2.15 mL) contained 500 µL samples (at different concentrations), 50 µL of 2 mM $FeCl_2$ (dissolved in distilled water) and 1.6 mL of 70% ethanol. The mixtures were then mixed thoroughly and incubated for 5 min. After that, 100 µL of 5 mM ferrozine (dissolved in 70% ethanol) was added, mixed and left in the dark at room temperature for another 5 min. Absorbance of the Fe^{2+}-ferrozine complex was measured at 562 nm against 70% ethanol as blank. Both ethylenediaminetetraacetic acid (EDTA) and BHA were used as positive control. As for the negative control, the reaction mixture contained only $FeCl_2$, 70% ethanol and ferrozine.

The chelating effect of each sample was calculated using the following equation:-

$$\text{Chelating effect \%} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100$$

$A_{control}$ = Absorbance reading of control
A_{sample} = Absorbance reading of the sample

Statistical analysis

All experiments were performed in triplicate. The results were presented in mean ± standard deviation. As for the data and graphs, they were subjected to analyses using Microsoft® Office Excel 2003.

Results

TPC assay

Results of TPC assay were expressed as gallic acid equivalent (i.e. x mg of gallic acid per 1 g of the extract). TPC of each sample was calculated from calibration curve of gallic acid (not shown) where the calibration equation was determined to be $y = 7.2455x + 0.0777$ ($R^2 = 0.9945$), whereby y = absorbance at 765nm and x = concentration of total phenolic compounds in mg per 1 ml of the extract. It was observed that reaction mixture with both peel extracts of *Hylocereus* species and pulp extracts of *H. polyrhizus* were dark blue in colour that visually indicated high phenolic content. On the other hand, reaction mixture with pulp extracts of *H. undatus* was light blue in colour indicating low phenolic content. In general, TPC results for both *Hylocereus* species showed that the peels contained higher phenolic content than the pulps (Figure 1). Peels of *H. undatus* contained more phenolic content than *H. polyrhizus*. As for the pulps, TPC for *H. undatus* was lower than *H. polyrhizus.*

DPPH assay

In reaction mixture, BHA that acted as positive control gave the fastest colour change from purple to yellow. As for the samples, peels of both *Hylocereus* species and pulps of *H. polyrhizus* showed bleaching of purple colour during eye observation. However, pulps of *H. undatus* showed no obvious purple bleaching effect, even though there were decreases in the absorbance readings.

Likewise, Figure 2 shows that for both *Hylocereus* species, the peels contained higher radical scavenging activity as compared to the pulps. At the highest concentration of 1.0 mg/mL, peels of *H. undatus* showed the highest percentage

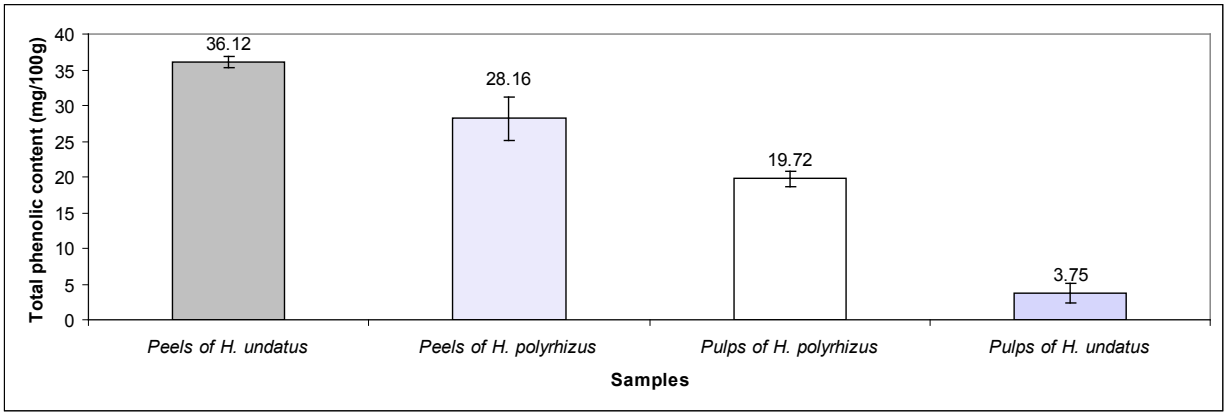

Figure 1. Level of total phenolic content in each sample

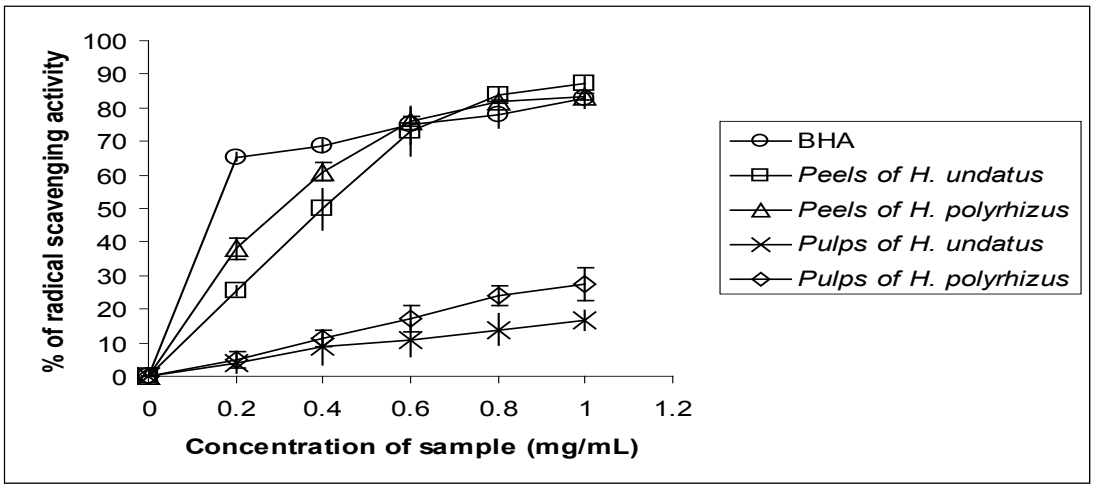

Figure 2. Comparison of radical scavenging activity between the positive control, BHA and samples. IC_{50} value (in mg/mL) for each sample was derived from the graph at 50% radical scavenging activity

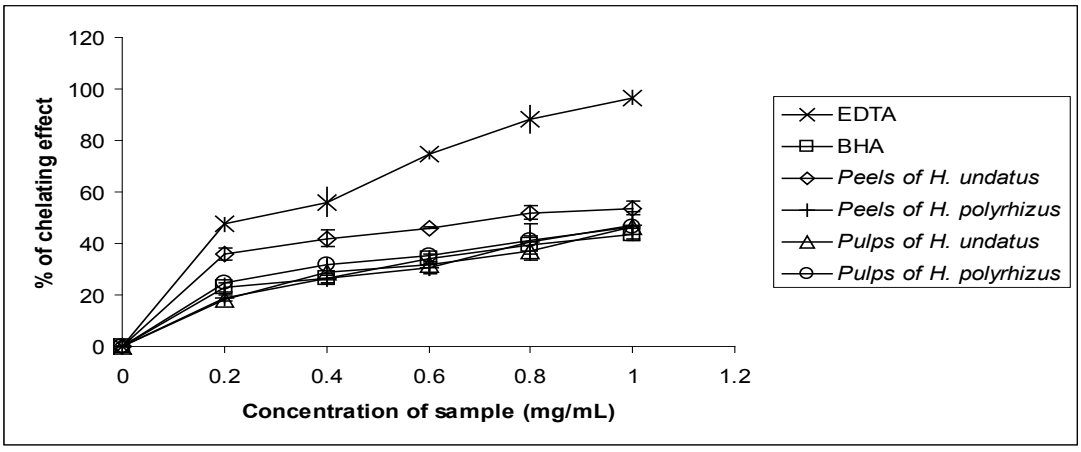

Figure 3. Comparison of ferrous ion chelating effects between EDTA, BHA and sample

of scavenging activity (i.e. 87.02 ±2.24%). At the same concentration, radical scavenging activity of peels of *H. polyrhizus* was slightly lower than *H. undatus* (i.e. 83.48 ±1.02%). Furthermore, radical scavenging activity of pulps of *H. polyrhizus* was higher than pulps of *H. undatus* over increasing concentrations. The radical scavenging activity for pulps of *H. polyrhizus* reached up to 27.45 ±5.03% at concentration of 1.0 mg/mL, whereas for pulps of *H. undatus* was only at 16.56 ±2.96%. Figure 2 also clearly illustrates that the radical scavenging activity for peels of both species were higher than BHA at approximate concentration of 0.8 to 1.0 mg/mL.

In terms of IC_{50}, the lowest value was shown by the positive control, BHA (0.15 ±0.01 mg/mL) followed by peels of *H. polyrhizus* (0.30 ±0.01 mg/mL) and peels of *H. undatus* (0.40 ±0.01 mg/mL). However, IC_{50} for pulps of both species could not be directly determined from the graph due to their low percentage of radical scavenging activities over the measured extract concentrations, but Figure 2 clearly suggests that their IC_{50} could be more than 1.0 mg/mL.

FIC assay

For this assay, it was demonstrated that only reaction mixture with EDTA showed colour changes from purple to yellow as the concentration increased. BHA and all samples did not show any obvious colour changes, although there were decreases in absorbance readings.

According to Figure 3, there was no large difference between ferrous ion chelating effects of the peels and the pulps. The highest chelating effect among all the samples was shown by peels of *H. undatus*. Even at the lowest concentration of 0.2 mg/mL, chelating effect of peels of *H. undatus* reached 36.09 ±2.35%, while the other three samples were in the range of 18.00 to 25.00 %. At concentration of 1.0 mg/mL, chelating effect of peels of *H. polyrhizus* (i.e. 47.1 ±5.45%) was lower than peels of *H. undatus* (i.e. 53.71 ±2.56%).

Among pulps of the two species, it was observed that *H. polyrhizus* had higher FIC effect than *H. undatus* at lower concentration. However, at the highest concentration of 1.0 mg/mL, pulps of both species had almost similar percentage of chelating effect. At that concentration, chelating effect of pulps of *H. polyrhizus* was 46.40 ±2.84%, whereas for *H. undatus* was 46.49 ±0.63%.

Discussion

Antioxidant level

Phenolic compounds are one of the most common compounds found in the plant kingdom. Phenolic compounds have been extensively exploited due to their multiple biological activities such as antimutagenicity, anticarcinogenicity, antiaging and also antioxidant (Kosem *et al*., 2007). Some typical phenolic compounds which are highly correlated with antioxidant activity are phenolic acid (e.g. gallic acid) and polyphenol (e.g. flavonoids). According to Bertoncelj *et al*. (2007), there were several studies showing that antioxidant activity was strongly correlated with the content of total phenolic compounds.

Folin-Ciocalteu assay depends on the basic mechanism of oxidation and reduction reaction (Verzelloni *et al*., 2007; Ajila *et al*., 2007). The mechanism refers to the redox properties of compounds present in the samples which are called antioxidants. These compounds react with Folin-Ciocalteu reagent, thus allowing the measurement of phenolic concentration. In present study, dark blue colour produced in the reaction mixture indicated that both peels of *Hylocereus* species and pulps of *H. polyrhizus* contained high phenolic compounds. Pulps of *H. undatus* producing light blue colour solution indicated that the plant portion contained low phenolic content.

Polyphenolic compounds were reported to be commonly found in both edible and inedible plants (Wojdylo *et al*., 2007). Usually, the non- flavonoid compounds can be found in the pulps, while the flavonoid compounds are located in the peels, seeds and stems (Paixão *et al*., 2007). In present study, it was shown that inedible peels of both species had higher TPC as compared to edible pulps of *Hylocereus* species. Even though some detrimental effects on the total phenolic compounds of the peels were expected due to the drying process in the oven at temperature 70°C, the TPCs of the peels were still higher than the pulps. It was shown by Caro and Piga (2007) that peels of Italian fresh fig fruits cultivars contained higher phenolic content as well as antioxidant activity than the pulps. Furthermore, Li *et al*. (2006) reported that TPC for peel extracts of pomegranate was nearly 10 times higher than the pulp extracts. There was also an antioxidant research conducted on Indian Laburnum that showed the highest concentration of total phenolics in stem bark, while the lowest was recorded in the pulp extracts (Siddhuraju *et al*., 2002). Besides, as mentioned by Lim *et al*. (2006), phenol content of non-peeled

guava was higher than peeled-guava suggesting that most of the phenolic compounds were present in the guava peel instead of the pulp itself. The presence of different kinds of antioxidant compounds can also be possible reasons why peels of *Hylocereus* species contained higher TPC than the pulps.

Higher level of phenol content in peels of *H. undatus* as compared to peels of *H. polyrhizus* may lie on the structure of the fruit itself. Beside the possible presence of different kinds of antioxidant compounds, it was postulated that the fruit size of *H. undatus* used in present study might be among the factors, as *H. undatus* was bigger than *H. polyrhizus* that was more rounded. In addition, Verzelloni *et al*. (2007) stated that not all vegetables, fruits and their derivatives from the same classes contain same phenolic composition. Such factors might have contributed to the different level of phenolic compounds in peels of the two *Hylocereus* species even though they are of the same genus.

As for edible portion of the *Hylocereus* species, pulps of *H. polyrhizus* showed higher phenolic content than *H. undatus*. Colour difference between pulps of the two *Hylocereus* species was suggested to be the explanation. The red colour of *H. polyrhizus* pulps may indicate the presence of higher phenolic compounds and betalains. Betalains, composed of red-violet betacyanin and yellow betaxanthins, are water-soluble pigments that provide colours in flowers and fruits (Wu *et al*., 2006). Esquivel *et al*. (2007) found out that betalains were responsible for the major antioxidant capacity of purple *Hylocereus* juices evaluated, while non-betalainic phenolic compounds contributed only to a minor extent. In contrast, for pulps of *H. undatus* that is white in colour, there might be less non-betalainic phenolic compounds, and no or less betalains explaining low phenolic content measured in its pulps. In order to gain better views on the antioxidant level of different phenolic compounds in *Hylocereus* species, further studies on purification, identification and quantification of each antioxidant compound are necessary in future.

Primary antioxidant activity

Antioxidant can be categorised into two main types called primary and secondary antioxidants where each type is responsible for different mechanisms (Lim *et al*., 2007). Primary antioxidant acts to scavenge free radicals in order to inhibit chain initiation and to break chain propagation by donating hydrogen atoms or electrons that convert them into a more stable product. Secondary antioxidant functions by suppressing formation of radicals and protect against oxidative damage. Besides, secondary antioxidant is also active in binding with metal ions and scavenging oxygen.

DPPH assay was carried out to measure the primary antioxidant activity of each sample in present study. The ability to remove or scavenge free radicals is classified as primary antioxidant (Wang *et al*., 2008). DPPH assay reaction depends on the ability of the samples to scavenge free radicals which is visually noticeable as the colour change from purple to yellow due to hydrogen donating ability (Ajila *et al*., 2007). The more rapid the absorbance decreases, the more potent the primary antioxidant activity (Siddhuraju *et al.*, 2002). In present study, all samples demonstrated purple bleaching reaction at increasing concentrations, showing the presence of compounds responsible as free radical scavengers which reduced the initial DPPH concentration. Very little absorbance changes occurred for pulps of *H. undatus* indicating the presence of very low radical scavenging compounds.

Both peels of *Hylocereus* species showed high radical scavenging activity as compared to BHA showing that they contained high amount of radical scavenging compounds (Figure 2). Plant phenolics constitute one of the major groups of compounds acting as primary antioxidant free radical terminators (Samarth *et al*., 2008). In comparison to the pulps, the radical scavenging activity of this inedible portion was higher. This was in accordance with phenolic content of the samples by which the pulps showed lower phenolic content than the peels. Present results supported the previous findings whereby high primary antioxidant activity was found in guava peel instead of the pulp (Lim *et al*., 2007). Li *et al*. (2006) also found that pomegranate peel showed higher antioxidant activity than the pulp and seed fractions.

For peels of both *Hylocereus* species, the results showed that the radical scavenging activity of the peels reached the same level as the positive control, BHA after concentration of 0.6 mg/mL. The findings indicated that peels of the two species more likely exerted similar antioxidant effect as the BHA. Interestingly, their radical scavenging activities were higher than BHA at approximate concentrations of 0.8 to 1.0 mg/mL. For IC_{50}, peels of both species had approximately two times less value than BHA; and the value for peels of *H. polyrhizus* was lower than *H. undatus* clearly showing that peels of *H. polyrhizus* had more capability to scavenge the free radicals. The small difference of radical scavenging activity between peels of the two species might be due to the difference in chemical constituents in each extract which may display significant variation in antioxidant activity (Samarth *et al*., 2008). Among

pulps of the two *Hylocereus* species, *H. undatus* had relatively lower radical scavenging activity. As mentioned earlier, natural red colour of pulps of *H. polyrhizus* might denote the presence of higher phenolic compounds and betalains.

Secondary antioxidant activity

FIC assay measures how effective the chemical compounds in an extract can compete with ferrozine for ferrous ion. In present study, evaluation of secondary antioxidant activity was made by measuring the iron-ferrozine complex using spectrophotometer at 562 nm, where large absorbance decrease indicates strong chelating power (Lim *et al*., 2006). EDTA which is an excellent metal ion chelator showed immediate colour changes to reaction solution from purple to yellow. By forming a stable iron (II) chelate, an extract with high chelating power reduces the free ferrous ion concentration resulting in colour changes to the reaction solutions. In contrast to EDTA, BHA and samples did not produce any obvious colour changes. Bounatirou *et al*. (2007) reported that both BHA and BHT showed no metal chelating activity. This may indicate that all samples of pulps and peels of *Hylocereus* species acted as weak or moderate metal ion chelators (Zhao *et al*., 2006).

Figure 3 shows that all extracts of pulps and peels of *Hylocereus* species had almost similar chelating effects at the highest concentration of 1.0 mg/mL. Besides, both peels and pulps of *Hylocereus* species can be considered as moderate metal chelators since their activities were approximately two times less than EDTA. Therefore, all extracts may be regarded as unable to strongly obstruct the generation of •OH radicals from Fenton reaction (Kosem *et al*., 2007). However, peels of *H. undatus* exhibited higher percentage of chelating effect as compared to the other samples of peels and pulps as the extract concentration increased. Even though peels of both species showed higher phenolic content than the pulps and great radical scavenging activity, the results for their secondary antioxidant capacities were rather low. Thus, it was suggested that peels of *Hylocereus* species acted as good radical scavengers but they were moderate metal ion chelators. Lim *et al*. (2006) showed that guava had a potent radical scavenging property, but its function as secondary antioxidant as measured by chelating power was rather low. This means that some fruit extracts may possess high primary antioxidant activities, but low secondary antioxidant activities.

Although pulps of both species exhibited lower phenolic contents than the peels, the present results showed that they had metal chelating ability at low chelating effect. Banana was reported to be a powerful secondary antioxidant, even though it had low phenolic content due to the presence of other active compounds that might bind to metal ions strongly (Lim *et al*., 2006). At the highest concentration of 1.0 mg/mL, pulps of both species showed almost similar FIC effect. However, pulps of *H. polyrhizus* showed better percentage of chelating effect than *H. undatus* at lower concentrations of extracts.

Relationship between results of TPC, DPPH and FIC assays

Generally, present results showed that only TPC and radical scavenging activity likely showed good relationship for general comparison between the pulps and the peels, as summarised in Table 1. Phenolic compounds are considered as one of the most important quality parameters since they are always associated with organoleptic characteristics such as colour, astringency and bitterness of fruits besides antioxidant properties (Pãixao *et al*., 2007). There were many studies reported that high polyphenols content contributes towards high radical scavenging activity (Céspedes *et al*., 2008; Garcia- Alonso *et al*., 2004; Lim *et al*., 2007; Park *et al*., 2008; Shui and Leong, 2006; Soong and Barlow, 2004). In addition, Samarth *et al*. (2007) also reported that there was a strong relationship between TPC and antioxidant activity in fruits, vegetables and grain products.

Furthermore, relationship between TPC and secondary antioxidant activity was negative for comparison between the peels and the pulps. Comparatively, higher phenolic content did not lead towards higher metal ion chelating effect, even though

Table 1. Summary of antioxidant properties for pulps and peels of *Hylocereus* species

Sample	Phenolic content	Radical scavenging activity	Metal ion chelating effect
Peels of *H. undatus*	Higher than pulps of both species	High	Moderate
Peels of *H. polyrhizus*	Higher than pulps of both species	High	Moderate
Pulps of *H. polyrhizus*	Moderate/Lower than peels of both species	Low	Moderate
Pulps of *H. undatus*	Lower than peels of both species	Low	Moderate

the peels showed high radical scavenging activity. Thus, this designates that the compounds present in the extracts are more important for the primary antioxidant rather than the secondary antioxidant activity (Kosem *et al*., 2007). Other compounds might actually affect the antioxidant activity measured, where different compound compositions have different activities (Garcia-Alonso *et al*., 2004).

Conclusions

In present study, it was found that the highest to TPC was in peels of *H. undatus* (peels of *H. undatus* > peels of *H. polyrhizus* > pulps of *H. polyrhizus* > pulps of *H. undatus*). Among the four samples, the highest radical scavenging activity as further supported by IC_{50} data was exhibited by peels of *H. polyrhizus* (peels of *H. polyrhizus* > peels of *H. undatus* > pulps of *H. polyrhizus* > pulps of *H. undatus*). In contrast, results from FIC assay indicated that ferrous ion chelator with the highest potential was peels of *H. undatus* (peels of *H. undatus* > pulps of *H. polyrhizus* > pulps of *H. undatus* > peels of *H. polyrhizus*). Nonetheless, in order to gain better views on the antioxidant level and activities in *Hylocereus* species, further studies on purification, identification and quantification of each phenolic compound and other non-phenolic compounds such as carotenoids and betalains are necessary in future.

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