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Physico-chemical characteristics of red pitaya (*Hylocereus polyrhizus*) peel

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Abstract: Pitaya peel (*Hylocereus polyrhizus*), which consists approximately 22% of the whole fruit weight, is discarded during processing. Physico-chemical properties of the discarded pitaya peel were determined in order to evaluate its potential for recovery of any value-added materials. The moisture content of the peel was approximately 92.7% and it was low in total soluble solids, protein, ash and fat content. Betacyanin pigment (150.46 ± 2.19 mg/100 g) and pectin (10.8%) were high in the peel. Glucose, maltose and fructose were detected in the peel but not sucrose and galactose. The peel also had very high insoluble and soluble dietary fibre which had exhibited a good ratio of insoluble dietary fibre to soluble dietary fibre (3.8: 1.0).

Keywords: pitaya peel, composition, betacyanin, pectin, fibre

Introduction

Red pitaya (*Hylocereus polyrhizus*), a member of the family Cactaceae is locally known as dragon fruit or *pitaberry*. The ripened fruit has an attractive purple-red peel and flesh which is delicate and juicy with small black seeds well-dispersed. The fruit is cultivated on a large scale in Malaysia, Vietnam, Thailand, Taiwan and some parts of the world. Its popularity is increasing due to its health benefit claims such as reducing dyslipidemia (Mohd Adzim Khalili et al., 2009). Various pitaya based products such as beverages, jams, and candied fruits are commercially produced in Malaysia. Reports on pitaya flesh's pigment, antioxidant properties and their stabilities are numerous (Wybraniec et al., 2001; Stintzing et al., 2002; Wybraniec and Mizrahi, 2002; Stintzing et al., 2003; Herbach et al., 2004; Moßhammer et al., 2005; Wu et al., 2006; Mahattanatawee et al., 2006; Esquivel et al., 2006; Herbach et al., 2006; Esquivel et al., 2007a; Phebe et al., 2009, Mohd Adzim Khalili et al., 2009).

Esquivel et al. (2007b) investigated the contributions of phenolics to the antioxidant capacity of purple-red pitaya and concluded that betalains were responsible for the major antioxidant capacity of purple pitaya juices while non-betalainic phenolic compounds contributed the least. Other researchers had also confirmed the role of betacyanin in the antioxidant activities of pitaya fruit (Wybraniec and Mizrahi, 2002). Proximate analysis of purple-red pitaya had been reported by Ruzainah et al. (2009). Azis et al. (2009) had reported on the extraction and determination of the essential fatty acid composition from the pitaya seed oil.

Both the red pitaya flesh and peel were rich in polyphenols and antioxidants with the peel exhibiting higher antioxidant activities (Wu et al., 2006). Stintzing et al. (2002) suggested that pitaya peel may posses the same set of betalain forming enzymes as the flesh had, since the betacyanin pattern was found to be similar. To date, literature search indicated that the work on the pitaya peel is still scanty. Pitaya peels are often discarded during processing, especially in the beverage production industries. Phebe et al. (2009) and Harivaindaram et al. (2008) had suggested their potentials as natural colorants and thickening agent or as a moisturizer in cosmetic products (Stintzing et al., 2002). Therefore, the present study was undertaken to determine more intensively the physico-chemical composition of the peel from pitaya fruit, so as to provide information on the possibilities of recovering value added ingredients from the pitaya peel for various commercial applications.

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Materials and Methods

Pitaya peel

Commercially matured red pitaya fruit with an average weight of 350-550 g each were purchased from a farm in Melaka, Malaysia for the study. They were purchased within a week of harvest. They were cleaned and peeled manually prior to grinding and freeze-drying. Exposure to light was consciously avoided to reduce possible loss of nutrient. Freeze-dried sample was blended and homogenized before storing at -20°C for future analysis. All analyses were carried out in triplicates.

Chemicals and reagents

Chemicals and solvents were purchased from Fisher Scientific (UK) and were of analytical or HPLC grade. MES hydrate, Trizma® base, m-hydroxydiphenyl solution, galaturonic acid standard, organic acid and sugar standards were obtained from Sigma Chemical Co. (St. Louis, USA), Megazyme TDF Assay kit (thermostable α-amylase, purified protease and amyloglucosidase enzyme) were purchased from Megazyme International Ireland Ltd. (Wicklow, Ireland). Deionised water produced in the laboratory was used throughout the study.

Proportion and proximate composition of pitaya peel

Skin thickness and average weight of total fruit, flesh and its peel were measured in ten pitaya fruits. Moisture, ash, lipid (soxhlet extraction method) and protein (micro-kjeldahl method with N x 6.25) were determined as the method outlined in AOAC (2000). Total carbohydrates were calculated by the difference.

Determination of pH, total soluble solids and titrable acidity of pitaya peel

Ten grams of the peel was first homogenized in 100 ml of deionised water. The pH of the fruit peel was then measured by a pH meter (Model 430, Corning, NY, USA). For the soluble solids concentration (°Brix) of the peel, refractometer (NAR-1T, Atago, Japan) was used. The titratable acidity determination was carried out by homogenizing 10 g of the pitaya peel in 100 ml deionised water, titrated with 0.1 N NaOH to pH 8.1 and expressed as g malic acid per L^{-1}.

Color measurement by Hunter Lab Colorimeter

The color of pitaya peel was measured using calibrated Hunter Lab UltraScan PRO colorimeter attached with EasyMatch QC software (Hunter Associate Laboratory Inc., Reston, USA) and expressed as *L* (lightness; 0 = black, 100 = white), *a* (−*a* = greenness, +*a* = redness), and *b* (−*b* = blueness, +*b* = yellowness) values.

Quantification of betacyanin content by spectrophotometer

Betacyanin content was quantified according to Stintzing et al. (2003). Freeze dried pitaya peel powder was weighed and diluted with McIlvaine buffer (pH 6.5) to reach an absorption value of 1.0 ± 0.1. McIlvaine buffer was prepared from 0.1 M citric acid (29.65 ml) and 0.2 M sodium phosphate dibasic (70.35 ml). Diluted sample was filtered before performing spectrophotometric measurement at 538 nm and corrected value at 600 nm using uv/vis spectrophotometer. Quantification of betacyanins was carried out by applying the following equation:

BC (mg/L)	= (A×DF×MW× 1000) / (ε×L), where
A	= absorption value at the absorption maximum (538 nm) corrected by the absorption at 600 nm
DF	= dilution factor
MW	= molecular weights of betanin (550 g/mol)
ε	= molar extinction coefficients of betanin (60,000 L mol^{-1} cm^{-1})
L	= path length of the cuvette

Determination of organic acid by HPLC

Organic acids of pitaya peel were quantified using Waters (Milford, MA) HPLC chromatographic system, equipped with an UV detector L-7400 and Waters 600 Controller. The column used was Bio-Rad Aminex HPX-87H (300 × 7.8 mm) of Switzerland. Malic, citric, oxalic, succinic and fumaric acids were used as chromatographic standards.

Organic acids were extracted from 20 g sample which was first blended with 80 ml of deionised water. The mixture was then filtered and washed through with additional 20 ml of water. The combined 100 ml filtrate was then centrifuged at 27200 x g for 10 min. The supernatant was them filtered through 0.45 µm disposable nylon membrane filter (47 mm diameter) (Whatman International, England) and Sep Pak C18 cartridge (Waters, Milford, MA). The acids were eluted isocratically at a flow rate of 1 ml/min using 0.01 N sulphuric acid in deionised water (v/v) as the mobile phase. Detection was carried out at 214 nm (Wills, Scriven and Greenfield, 1983).

Determination of pectin

Pectin assay was carried out as described by Blumenkrantz and Asboe-Hansen (1973) and all solutions used were freshly prepared. Total uronic

acids were quantified after subsequent reactions with sulfuric acid/sodium tetraborate solution and m-hydroxydiphenyl reagents. The absorbance was read at 520 nm. Pure galacturonic acid was used as the standard.

Determination of cellulose, lignin and starch

Cellulollse and lignin contents were determined gravimetrically by acid hydrolysis hydrolysis (Ng et al., 1998). Starch was determined using Radley method (1976). Reducing sugar of the sample was first determined using Somogyi-Nelson method. The amount of glucose released was multiplied by a factor of 0.9 to obtain the total starch content in the sample.

Determination of sugars by HPLC

Sugars in pitaya peel were quantified individually by HPLC determination (Hunt et al., 1977). The HPLC system (Waters 600 Controller liquid chromatograph) was equipped with a Refractive Index detector (Model 410), injector (Waters 501) and pump (Waters 600 Controller). Sugar components in the peel were separated using Waters (Massachusetts, US) µBondapak C18 column (10µm, 300 x 3.9 mm) and the mobile phase used was a mixture of acetonitrile and deionised water (80:20; v/v). Glucose, fructose, maltose, galactose and sucrose were used as standards.

Determination of dietary fibre content

Dietary fibre composition was analyzed according to the enzymatic-gravimetric method (Prosky et al., 2008). Dried pitaya peel powder was first dispersed in MES-TRI buffer before being subjected to sequential enzymatic digestion by heat stable α-amilase, protease and amyloglucosidase.

Subsequently, insoluble dietary fibre (IDF) was filtered and the residue was washed with warm distilled water. Combined solution of filtrate and washings were precipitated with four volumes of 95% ethanol for soluble dietary fibre (SDF) determination. Collected residues were then dried in the oven and weighed. Protein and ash contents of both IDF and SDF residues were determined for corresponding corrections. Total dietary fibre (TDF) was calculated as the sum of IDF and SDF.

Statistical analysis

All analyses were carried out in triplicates. Means and standard deviations were determined using Minitab (Version 14) statistical package (Minitab Inc., PA, USA).

Results and Discussion

Proportion and proximate composition of pitaya peel

The proportion and the proximate composition of pitaya peel were as shown in Table 1. The flesh constituted about two-third (~ 65%) and the peel was approximately one-third (~ 22%) of the fruit. The moisture content of the peel in this study was approximately 93% (wet basis). This value was much higher than that reported by Norziah et al. (2008). Moisture content of the pitaya peel obtained was similar to the moisture content on other fruit peels such as carrot (91.05%), potato (81.83%), white grape (75.28%) and red apple (81.68%), which was reported by Chantaro et al. (2008) and Makris et al. (2007).

pH, total soluble solids and titrable acidity of pitaya peel

The physico-chemical properties of pitaya peel were as listed in Table 2. The pH of the peel was approximately 5 and it was low in both titrable acidity and total soluble solid.

Color and betacyanin content

Hunter lab colorimeter results (Table 2) showed that pitaya peel had low values of lightness (L = 16.65) and yellowness (b = 4.61), respectively, but a high redness value (a = 23.89). Low values of L indicated that pitaya peel had a dark color due to the development of reddish color in peel as pigmentation process occurred during maturation (Phebe et al., 2009). The hunter L, a and b values of six different cultivars of red apple peel were in the range of 32.10-48.46, 26.63-36.95 and 16.11-28.15, respectively (Vieira et al., 2009). Hence, pitaya peel has a deeper red color (lower L value) than the red apple peel.

Betacyanin content of pitaya peel was 150.46 ± 2.19 mg/100 g of the dry matter (DM). This value was similar to the commercial beet powder reported by Cai and Corke (2000). Since betalains could maintain their appearance over a wide pH range from 4 to 7 in contrast to anthocyanins; therefore, they could be an ideal coloring pigment for the low-acid foods such as dairy products (Stintzing et al., 2000).

Organic acids

Organic acid contents were crucial for the sugar/acid ratio of fruits which significantly influenced its sensory profile (Esquivel et al., 2007c). Pitaya peel was found to have low total organic acid content (1.62 %). The organic acids concentration in the peel was about five-fold lower than its sugar content (Table 2). In this study, oxalic acid and malic acid were the

Table 1. Proportion and proximate composition of the pitaya peel

Parameter	Value
(a) Proportion (means ± standard error, n = 10 fruits)	
i. Skin thickness (cm)	0.46 ± 0.07
ii. Flesh (g/100 g)	64.50 ± 1.68
iii. Peel (g/100 g)	21.98 ± 1.04
(b) Peel composition (means ± standard error (%), n = 3)	
i. Moisture	92.65 ± 0.10
ii. Protein	0.95 ± 0.15
iii. Fat	0.10 ± 0.04
iv. Ash	0.10 ± 0.01
v. Carbohydrate	6.20 ± 0.09

Table 2. Physico-chemical properties of pitaya peel

Properties	Values
a) pH	5.06 ± 0.01
b) °Brix (TSS)	6.00 ± 0.00
c) Titratable acidity (TA) (gL^{-1})	0.19 ± 0.04
d) Hunter Lab color	L = 16.65 ± 0.06
	a = 23.89 ± 0.23
	b = 4.61 ± 0.07
e) Betacyanin content (mg/100 g DM)	150.46 ± 2.19
f) Organic acids concentration (%)	
i. Oxalic	0.80 ± 0.01
ii. Citric	0.08 ± 0.00
iii. Malic	0.64 ± 0.00
iv. Succinic	0.19 ± 0.00
v. Fumaric	0.01 ± 0.00
Total acid	1.72

Values were means ± standard error (n = 3).

Table 3. Carbohydrate components of pitaya peel

Carbohydrate components	Percentage (%)
1) Pectin	10.79 ± 0.01
2) Starch	11.07 ± 0.03
3) Cellulose	9.25 ± 1.33
4) Lignin	37.18 ± 1.02
5) Sugars	
i. Glucose	4.15 ± 0.03
ii. Maltose	3.37 ± 0.01
iii. Fructose	0.86 ± 0.02
iv. Sucrose	ND
v. Galactose	ND
Total sugar	8.38
6) Total dietary fiber	69.30 ± 0.53
i. Insoluble	56.50 ± 0.20
ii. Soluble	14.82 ± 0.42
iii. Ratio of IDF : SDF	3.8: 1.0

Values were means ± standard error (n = 3), ND: Not detected.

major acids identified in the pitaya peel. Although the presence of oxalic acid was not reported earlier, however, the high concentration of oxalic acid in the peel could be due to the characteristic of the plantation soil where current pitaya fruit sample was obtained. Other three organic acids which were identified in the pitaya peel were succinic, citric and fumaric. The evaluation on the organic acids has not been reported on other fruit peels.

Sugars

Reports on the sugar profile of fruit peels have been negligible. The sugar content of the pitaya peel was approximately 8.4% (Table 3) and the sugars detected were glucose, fructose and maltose. The presence of maltose had not been reported in earlier studies. Glucose was the main sugar and it was followed by maltose. Sucrose and galactose were not detected in pitaya peel. This may due to the high invertase activity that was common in Cactaceae fruits as suggested by Wu and Chen (1997). Comparison with other fruit peels could not be made due to lack of literature.

Pectin, cellulose, lignin and starch

Carbohydrate compositions of the peel were as shown in Table 3. Pectin content of pitaya peel (10.8%) obtained was slightly lower than the pectin content reported by Nawirska and Kwasniewska (2005) in apple pomace (11.7%). Wang, Chuang and Hsu (2008) reported the total pectin content of eight varieties of citrus peels were in the ranged of 3.60 to 8.64%. Lignin content was the highest (approximately 37%) among the carbohydrates and this is higher than the lignin content in apple pomace (16.6%) reported by Nawirska and Kwasniewska (2005).

Dietary fibre content

Total dietary fibre content in the pitaya peel was very high (Table 3), which was approximately 69.3%. Insoluble dietary fibre (IDF) was the major fraction in the pitaya peel (56.50%). High content of the SDF (14.82 %) was also obtained. The dietary fibre of the pitaya peel was found to be higher than the by-product of pear (14.1% SDF, 22% IDF), orange (13.6% SDF, 24.2% IDF), peach (9.7% SDF, 26.1% IDF), artichoke (14.3% SDF, 44.5% IDF) and asparagus (10.4% SDF, 38.6% IDF) which was reported by Grigelmo-Miguel and Martin-Belloso (1999). According to Horn (1997), the recommended ratio of IDF to SDF in food was 3: 1. Pitaya peel had a good ratio of IDF to SDF, which is 3.8: 1.0. The presence of high IDF and SDF in the pitaya peel thus indicate that it is a dietary fibre with a very good physiological effect; better than some cereals like wheat bran (2.9% SDF, 41.1% IDF), and oat bran (3.6% SDF, 20.2% IDF) which have much lower SDF (Grigelmo-Miguel and Martin-Belloso, 1999).

Conclusion

Pitaya peel constitutes 22% of the whole pitaya

fruit, which is presently discarded. It contained considerable amount of pectin, betacyanin pigment and total dietary fibre. The peel had a good ratio of IDF to SDF (3.8: 1.0). Hence, pitaya peel could be utilized as a good source of fibre, pectin and natural colorant.

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