Nutritional constituents and antioxidant properties of indigenous kembayau (Dacryodes rostrata (Blume) H. J. Lam) fruits

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1. Introduction

The year 2010 is recognised as the International Year of Biodiversity by the United Nations for biodiversity conservation and development to alleviate poverty in rural areas (Secretariat of the Convention on Biological Diversity, 2009). Biodiversity has a vital role as a source of food and income for rural people and communities that enormously depend on it for their livelihoods. In Malaysia, indigenous fruits are important sources for a better nutritional status and food security for rural communities. These fruits are easily grown in the local ecology and have less pest and disease problems as compared to exotic fruits. Dacryodes rostrata is an important source for a better nutritional status and food security for the people after blanching with hot water (Latiff & Zakri, 2000). Fresh fruits also serve as a snack food in black soya sauce and consumed as an appetiser with rice or porridge (Tinggal, 1992). The fruit is a drupe and is ovoid to oblong (1.3–2.6 cm by 0.7–1 cm) in shape with a single seed in the centre.

Kembayau fruits are usually preserved by local people in salt or by the United Nations for biodiversity conservation and development to alleviate poverty in rural areas (Secretariat of the Convention on Biological Diversity, 2009). Biodiversity has a vital role as a source of food and income for rural people and communities that enormously depend on it for their livelihoods. In Malaysia, indigenous fruits are important sources for a better nutritional status and food security for rural communities. These fruits are easily grown in the local ecology and have less pest and disease problems as compared to exotic fruits. Dacryodes rostrata is an important source for a better nutritional status and food security for the people after blanching with hot water (Latiff & Zakri, 2000). Fresh fruits also serve as a snack food in black soya sauce and consumed as an appetiser with rice or porridge (Tinggal, 1992). The fruit is a drupe and is ovoid to oblong (1.3–2.6 cm by 0.7–1 cm) in shape with a single seed in the centre.

Kembayau fruits are usually preserved by local people in salt or black soya sauce and consumed as an appetiser with rice or porridge (Tinggal, 1992). Fresh fruits also serve as a snack food for the people after Blanching with hot water (Latiff & Zakri, 2000). However, there is little information on the nutritional and antioxidant values of these fruits. Underutilised species, such as Barbados cherry (Malpighia glabra), Himalayan chenopod grains (Chenopodium species) and bambara groundnut (Vigna subterranea), have been documented for their potential as superior food for human health due to their high nutritional values (IPGRI, 2002). Thus, this study aimed at exploiting the nutritional and antioxidant values of kembayau fruit. Information provided by this study may facilitate nutritionists in improving the nutritional status of local communities. Additionally, a better understanding of the...
nutraceutical and functional potential of this fruit will further contribute to conservation and enhancement of species and to sustain the household income of rural communities.

2. Materials and methods

2.1. Reagents and chemicals

HPLC grade ethanol, analytical grade petroleum ether, sodium hydroxide (NaOH), sodium carbonate (Na₂CO₃) and sulphuric acid (H₂SO₄) (Fisher Scientific, Leicestershire, UK) were used. Analytical grade hydrochloric acid (HCl), boric acid and the standard solutions for minerals, such as calcium, magnesium, potassium, sodium, iron, copper and zinc, were purchased from Merck KGaA (Darmstadt, Germany). Potassium peroxosulphate, aluminium chloride (AlCl₃), anthrone reagent, sodium acetate, Folin-Ciocalteau reagent, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (trolox), 2,4,6-tripyridyl-s-triazine (TPTZ), gallic acid and rutin were purchased from Sigma Chemical Co. (St. Louis, USA). The following components were used: 2,2′-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) ammonium salt (ABTS), iron (III) chloride (Merck Schuchardt OHG, Hohenbrunn, Germany); perchloric acid (R & M Chemicals, Essex, UK); potassium chloride and iron sulphate (FeSO₄) (Himbö Chemicals, Hamburg, Germany); and sodium nitrite (NaNO₂) (VWR International Ltd., Poole, England).

2.2. Sampling and sample preparation

Fresh kembayau fruits at their maturity stage were sampled (1 kg each) from the Lachau town (longitude of 111°19'E; latitude of 1°08'N) in Sarawak, Malaysia. The collected kembayau fruits were identified and harvested from three different cultivars sites as follows: Lachau 1, Lachau 2 and Lachau 3. Voucher specimens of these fruits (Voucher no DRL1, DRL2 and DRL3) were deposited at the Universiti Putra Malaysia, Malaysia. The fruits were transported by airmail and stored in −20 °C at our laboratory until further use.

The physical parameters of the fruits were precisely measured. The seeds, pulp and peels of kembayau fruits (500 g each) were separated and homogenised for proximate and mineral analysis. An additional 500 g of the kembayau fruit seeds, pulp and peels were separated for lyophilisation. The lyophilised samples were ground into powder and sieved through a 0.25 mm mesh. The samples were subsequently stored at −20 °C until further analysis.

2.3. Proximate and mineral analysis

Proximate and mineral analyses were done in the Laboratory of Nutrition at Universiti Putra Malaysia. Moisture content was determined according to methods described by Tee, Rajam, Young, Khor, and Zakiyah (1996) through a direct drying method using an air oven (Memmert Universal, Schwabach). Lipid content was determined by a Soxhlet method as described by Tee et al. (1996). The protein content of samples was determined according to the Kjeldahl method (AOAC, 2000) facilitated by the Kjeltec instrument (Kjeltec 2200, Foss, Höganas, Sweden), and the conversion factor used was 6.25. The total available carbohydrate content of samples was determined using the Clegg-anthrone method (Peris-Tortajada, 2004). A dry ashing method was used to determine the ash content by incinerating the sample in a furnace (Furnace 62700, Barnstead/THERMOLyne, IA, USA) set at 550 °C (Tee et al., 1996). The remaining inorganic material was cooled and weighed. The results for proximate analysis were expressed as g/100 g fresh sample (FS).

The resulting ash was further used for determination of mineral contents. An ash solution was prepared by dissolving the ash in 100 ml of 1 M HCl. The contents of calcium, magnesium, potassium, sodium, iron, copper and zinc were then measured using an atomic absorption spectroscopy method (AA400, Analytik Jena AG, Jena, Germany) (Tee et al., 1996). The results for mineral content were expressed as mg/100 g FS.

2.4. Extraction of sample for antioxidant assessment

The extraction method was modified from Liu, Qiu, Ding, and Yao (2008). Lyophilised sample (1 g) was extracted with 20 ml of 70% ethanol containing 1.2 M HCl. The extraction was conducted using an orbital shaker (Heidolph Unimix 1010, Schwabach, Germany) at 200 rpm at 60 °C for 2 h. The sample extract was subsequently filtered through Whatman paper No. 4, and the filtrate was subjected to assays measuring antioxidant properties.

2.5. Determination of total phenolic content

Total phenolic content (TPC) was estimated according to a method previously described by Singleton and Rossi (1965) with some modifications. A properly diluted sample (2 ml) was mixed with 1 ml of 1 N Folin-Ciocalteau reagent. The mixture was incubated for 5 min. Subsequently, 4 ml of a saturated Na₂CO₃ solution (60 g/L) was added to the mixture, and the mixture was brought to a final volume of 10 ml using distilled water. After a 2 h reaction time, the absorbance was read at 760 nm (UV-1601, Shimadzu Corporation, Victoria, Australia) against distilled water used as a blank. A standard calibration curve of gallic acid (0.02–0.05 mg/ml) was plotted to calculate the results. Results were expressed as mg gallic acid equivalent (GAE)/100 g freeze-dried sample (FDS).

2.6. Determination of total flavonoid content

Total flavonoid content (TFC) was determined by an aluminium chloride colorimetric assay as described by Liu et al. (2008). The appropriately diluted sample (2 ml) was mixed with 0.2 ml of 5% NaNO₂. After 5 min, 0.2 ml of 10% AlCl₃ was added to the sample and then mixed. After 6 min, 2 ml of 1 M NaOH was added, and the reaction mixture was diluted to a volume of 5 ml using 70% ethanol. The absorbance of the mixture was measured at 510 nm against 70% ethanol used as blank. A standard calibration curve of rutin (0.1–0.5 mg/ml) was plotted to calculate the results. Results were expressed as mg rutin equivalent (RE)/100 g FDS.

2.7. Determination of total monomeric anthocyanin content

The pH differential method using two buffer systems, namely 0.025 M potassium chloride buffer (pH 1.0) and 0.4 M sodium acetate buffer (pH 4.5), was applied to determine the total monomeric anthocyanin content (TMAC) as described by Giusti and Wrolstad (2001). The sample (0.2 ml) was diluted with 2.8 ml of a potassium chloride buffer (absorbance <1.2 at 510 nm). Subsequently, another sample was diluted with a sodium acetate buffer with the same dilution factor. All dilutions were allowed to incubate for 15 min at room temperature. The absorbance of each dilution was measured at 510 nm against distilled water used as blank followed by a measurement at 700 nm to subtract the absorbance of haze. The results were calculated and expressed as µg monomeric anthocyanin pigment (MAP)/100 g FDS. The calculation was done according to the following equations:

\[
A = (A_{510} - A_{700}) \text{ at pH } 1.0 - (A_{510} - A_{700}) \text{ at pH } 4.5
\]

(1)

\[
\text{TMAC (µg/100 g)} = (A \times MW \times DF \times 0.02) \times (\Sigma \times 1) \times 100
\]

(2)

Where A is the absorbance of the diluted sample; \(A_{510}\) is the absorbance at 510 nm; \(A_{700}\) is the absorbance at 700 nm; MW is the
molecular weight of cyanidin-3-glucoside, which was 449.2 because the predominant anthocyanin is unknown; DF is the dilution factor; and Σ is the molar absorptivity at 26,900. The path length of the cuvette was 1 cm.

2.8. Determination of trolox equivalent antioxidant capacity

The trolox equivalent antioxidant capacity (TEAC) was measured using a method previously described by Re et al. (1999) with some modifications. The stock solution of ABTS radical cations was prepared by mixing 10 ml of deionised water with 7 mM 2,2-′-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and 2.45 mM potassium peroxodisulphate followed by incubation at room temperature in the dark for 12–16 h. The working solution was freshly prepared by diluting the stock solution with deionised water to get an absorbance of 0.70 ± 0.05 at 734 nm. Properly diluted sample (0.1 ml) was then added to 10 ml of the working solution and mixed thoroughly. After 6 min, the absorbance was measured at 734 nm against deionised water used as blank. The percentage of antioxidant capacity was calculated based on the following equation:

Antioxidant capacity (%) = \left( \frac{A_{\text{ABTS}} - A_{\text{sample or standard}}}{A_{\text{ABTS}}} \right) \times 100 \tag{3}

Where \( A_{\text{ABTS}} \) is the absorbance of ABTS radical cations without sample or standard; and \( A_{\text{sample or standard}} \) is the absorbance of ABTS radical cations with sample or standard.

The results were then calculated based on the calibration curve plotted using trolox at different concentrations (0.2–1.0 mM). Results were expressed as mmol trolox equivalent (TE)/100 g FDS.

2.9. Determination of ferric reducing antioxidant power

The ferric reducing antioxidant power (FRAP) was determined using a method previously described by Poulid, Bravo, and Saura-Calixto (2000). Briefly, three reagents were prepared as follows: 300 mM acetate buffer (pH 3.6), 10 mM TPTZ in 40 mM HCl and 20 mM FeCl3. The FRAP reagent was then prepared by mixing acetate buffer, TPTZ solution, and FeCl3 solution at the ratio of 10:1:1 (v/v/v), respectively. To measure the ferric reducing capacity, a properly diluted sample extract (50 μl) was mixed with 3 ml of the FRAP reagent followed by an incubation at 37 °C. After 30 min, the absorbance was measured at 593 nm against distilled water used as blank. The results were then calculated based on the calibration curve plotted using FeSO4 at concentrations ranging from 0.2 to 1.0 mM. The results were expressed based on the following equation:

Where \( A_{\text{control}} \) is the absorbance of DPPH radicals without sample; and \( A_{\text{sample}} \) is the absorbance of DPPH radicals with sample.

2.11. Statistical analysis

All samples were analysed in triplicate. The data were expressed as means± standard deviations and were statistically analysed using the SPSS statistical software version 15 (SPSS Inc, Chicago, Illinois, USA). One-way analysis of variance (ANOVA) and Tukey HSD was used to compare means among groups. A Pearson correlation test was used to study the relationship between antioxidant components and antioxidant capacities. The level of significance was set at \( p<0.05 \).

3. Results and discussion

3.1. Physical properties

Fig. 1 shows three different cultivars of kembayau fruits (Fig. 1a, b and c), seeds (Fig. 1d), pulp (Fig. 1e) and peels (Fig. 1f). The pulp, also known as the mesocarp, of this fruit was quite similar to dabai (Canarium odonthophyllum) or Chinese black olives (Canarium pimela) ( Tinggal, 1992). Because limited information was found regarding the kembayau fruit physical properties, the weight, length, width, circumference, and pulp thickness as well as the percentage of mass from the seeds, pulp and peels were tabulated (Table 1). These data are important, especially for the food industry, to understand which parts of the fruit can be utilised for commercialisation.

The Lachau 3 cultivar had the largest fruit as compared to the Lachau 1 and Lachau 2 cultivars. The weight, length and width of these kembayau fruits (8.67–14.78 g, 3.65–5.50 cm and 2.30–2.50 cm, respectively) were comparable to C. odonthophyllum (12.73–18.28 g, 4.10–3.74 cm and 2.79–2.40 cm, respectively) (Azlan, Nasir, Amom, & Ismail, 2008). In contrast, the kembayau fruit was smaller when compared to the indigenous African pear (Dacyrones edulis) with the following dimensions: length of 3.98–8.08 cm, width of 2.39–3.41 cm and weight of 15.97–39.36 g (Onuegbu & Iheudohanna, 2008). Additionally, the greater part of the kembayau fruit weight was from the seeds (54.01–56.72%) followed by the pulp (23.73–29.74%) and peels (16.25–19.90%). In contrast, the C. odonthophyllum and D. edulis fruits have a higher proportion of mass from the pulp (53–59% and 56–81%, respectively) instead of from the seeds (35–40% and 20–64%, respectively) (Onuegbu & Iheudohanna, 2008; Azlan et al., 2009).

3.2. Proximal composition

The nutritional composition of the seeds, pulp and peels from the kembayau fruits are presented in Table 2. The total available carbohydrate, fat and ash contents obtained from the seeds, pulp and peels of three kembayau cultivars were similar. The moisture content was similar in the pulp (53.55–68.91 g/100 g FS) and peel (51.74–67.24 g/100 g FS). Seeds had a significant (p<0.05) higher total available carbohydrate (4.64–5.19 g/100 g FS) and protein (0.95–1.03 g/100 g FS) contents compared to pulp and peel. Besides, seeds (12.51–14.03 g/100 g FS) and pulp (11.50–21.29 g/100 g FS) represented as a good source of fat content. However, the peels had higher ash content (2.64–4.77 g/100 g FS) than the remainder. Our results of fat, moisture and ash content were in good agreement with previous studies by Hoe & Siong (1999) on kembayau fruits.

The fat content was considered high in the kembayau pulp (11.50–21.29 g/100 g FS) which is as good as the edible portion of dabai (26.2%), kembayau (16.1%) and sun-dried African pear seeds (27.3%) (Ajije, Okeke, Nnabuike, Ogunleye, & Elebo, 1997; Hoe & Siong, 1999). Our results are in agreement with those of Ajayi and Oderinde (2002), who reported that the oil from D. edulis fruit pulp had a higher fat yield than the oil from the seeds. Therefore, we suggest that fat is the most abundant macronutrient in kembayau fruits, which contributes to a higher calorie content. The consumption of these fruits, as snacks or side dishes, by rural people will not only help in preventing hunger but also reduce the prevalence of malnutrition.
A previous study reported that the Dacryodes species (African pear) with a high content of polyunsaturated fatty acid improves the quality of breast milk and benefits the development of breastfed infants (Rocquelin, Tapsoba, Mbemba, Gallon, & Picq, 1998).

Additionally, as kembayau seeds were also high in fat (12.51–14.03 g/100 g FS), similar to D. edulis seeds, the possibility of using it as raw material for making soap, paint, polish, wood varnish and skin cream, cannot be ruled out (Ajiwe et al., 1997). These efforts will further enhance the market value of kembayau fruits. Nonetheless, a previous study has reported that a different maturity stage may also affect the proximal composition. In D. edulis, longer ripening times increases the fat, protein and ash contents of the fruit pulp (Hez,

Results are expressed as means ± standard deviations ($n=6$). Values with different letters are significantly different at $p<0.05$ within the same column.
3.3. Mineral composition

The mineral elements of the kembayau seeds, pulp and peels are shown in Table 3. Along with the highest ash content, the peels exhibited a significantly high (p<0.05) content of most of the studied mineral elements, followed by seeds and pulp. All the results were comparable with the kembayau results reported by Hoe and Siong (1999), but they found a lower zinc content (more than one-fold less; 0.59 μg/100 g FS) than was reported in our study. The difference may have been due to the agronomic conditions in each study, such as salinity, water supply, temperature and light exposure, which may have affected the mineral composition of the plants (Martinez-Ballesta et al., 2010).

Potassium was the most prevalent mineral in the kembayau peels (380.72–1112.00 mg/100 g FS) followed by pulp (264.45–472.87 mg/100 g FS) and seeds (196.07–492.09 mg/100 g FS). The results were similar to the results reported by Hoe and Siong (1999). They reported that the potassium content was 399 mg/100 g FS in the edible portion of kembayau and 810 mg/100 g FS in dabai. Moreover, the kembayau peels and seeds were a good source for magnesium, which ranged from 52.02 to 62.39 mg/100 g FS and from 70.15 to 235.68 mg/100 g FS, respectively. The same trend was observed in African pears where potassium and magnesium are the main mineral elements (Obasi & Okolie, 1993).

3.4. Antioxidant properties

Indigenous fruits are always related to their high antioxidant content (Ikram et al., 2009; Prasad et al., 2011). Our study demonstrated that the highest antioxidant components in all the kembayau cultivars were flavonoids (1012.74–28,022.28 mg RE/100 g FDS) followed by total phenolic content (382.87–8629.92 mg GAE/100 g FDS) and total monomeric anthocyanin content (5.34–404.11 μg MAP/100 g FDS) (Table 4). On average, kembayau seeds exhibited a significantly (p<0.05) higher amount of total flavonoids and phenolics than pulp and peels. A previous study has reported that seeds from numerous underutilised fruits contain a high polyphenol content followed by peels and pulp (Pande & Akoh, 2010). However, an inverse condition was reported for dabai where the skin contained higher phenolic content than the seeds or pulp (Azrina et al., 2010).

Additionally, total monomeric anthocyanin content in the kembayau peels (122.10–404.11 μg MAP/100 g FDS) was more than 25-fold higher than in the seeds (5.34–10.40 μg MAP/100 g FDS) and pulp (8.35–15.13 μg MAP/100 g FDS). Missang, Guyot, and Renard (2003) indicated that D. edulis peels had higher total anthocyanin content when compared to the pulp. Although kembayau peels contained high anthocyanin content, the amount was low compared to the amount of flavonoids. Missang et al. (2003) also observed the same result in D. edulis skin with only 1–2% of the polyphenols being anthocyanins.

Overall, the antioxidant capacities in kembayau fruit were as follows: seeds (51.39–74.59 mmol TE/100 g FDS), pulp (0.82–4.04 mmol TE/100 g FDS) and peels (0.62–4.82 mmol TE/100 g FDS) as measured by the TEAC assay; seeds (530.05–556.98 mmol of Fe2+/100 g FDS), pulp (10.18–25.11 mmol of Fe2+/100 g FDS) and peels (65.73–97.72 mmol of Fe2+/100 g FDS) as measured by the FRAP assay; and seeds (92.18–92.19%), pulp (91.47–92.15%) and peels (70.39–86.51%) as measured by the DPPH assay. The trend was in agreement with the trend reported by Guo et al. (2003). They reported that the antioxidant capacities of various fruits were in the descending order of seeds, peels and pulp.

Nevertheless, a significant (p<0.05) and positive linear correlation was found between the following antioxidant capacities: TPC and FRAP (r = 0.974); TPC and TEAC (r = 0.994); TFC and TEAC (r = 0.941); and TFC and FRAP (r = 0.982). Our results are in agreement with previous studies that antioxidant activities have a high correlation with the TPC and TFC (Luximon-Ramma, Bahorun, & Crozier, 2003; Azrina et al., 2010).

4. Conclusion

The consumption of kembayau fruits by rural people may potentially help in preventing malnutrition due to their significant...
### Table 3
Mineral composition of kembayau fruits.

<table>
<thead>
<tr>
<th>Mineralsx Lachau 1 Lachau 2 Lachau 3 Kembayau y Dabaiy</th>
<th>Seed</th>
<th>Pulp</th>
<th>Peel</th>
<th>Seed</th>
<th>Pulp</th>
<th>Peel</th>
<th>Seed</th>
<th>Pulp</th>
<th>Peel</th>
<th>Edible portion</th>
<th>Edible portion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium</strong></td>
<td>492.09±7.02a</td>
<td>472.87±35.32a</td>
<td>1112.00±6.69b</td>
<td>217.88±1.02a</td>
<td>333.27±5.35b</td>
<td>380.72±5.29c</td>
<td>196.07±2.06a</td>
<td>264.45±3.72b</td>
<td>842.84±13.53c</td>
<td>399.00</td>
<td>810.00</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>0.40±0.01a</td>
<td>0.92±0.01b</td>
<td>1.23±0.02c</td>
<td>0.34±0.00a</td>
<td>0.49±0.00b</td>
<td>0.96±0.01c</td>
<td>0.29±0.01a</td>
<td>0.61±0.01b</td>
<td>0.91±0.03c</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>32.82±0.31a</td>
<td>24.25±0.34a</td>
<td>67.99±0.81c</td>
<td>31.87±0.30a</td>
<td>8.03±0.09b</td>
<td>32.42±0.64c</td>
<td>20.61±0.10a</td>
<td>57.30±0.30b</td>
<td>19.60±0.13c</td>
<td>83.00</td>
<td>200.00</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>2.14±0.04a</td>
<td>3.16±0.06b</td>
<td>12.92±0.36c</td>
<td>1.57±0.05a</td>
<td>2.52±0.07b</td>
<td>3.91±0.16c</td>
<td>2.11±0.02a</td>
<td>2.09±0.16b</td>
<td>5.95±0.05c</td>
<td>1.10</td>
<td>1.30</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
<td>0.49±0.00a</td>
<td>0.44±0.03b</td>
<td>2.36±0.01c</td>
<td>0.12±0.00a</td>
<td>0.27±0.00b</td>
<td>0.18±0.01c</td>
<td>0.39±0.00a</td>
<td>0.29±0.00b</td>
<td>0.83±0.03c</td>
<td>0.75</td>
<td>0.70</td>
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<tr>
<td><strong>Zinc</strong></td>
<td>0.99±0.00a</td>
<td>0.91±0.00b</td>
<td>2.46±0.01c</td>
<td>0.59±0.02a</td>
<td>1.04±0.01b</td>
<td>0.76±0.01c</td>
<td>0.89±0.00a</td>
<td>0.77±0.00b</td>
<td>2.71±0.01c</td>
<td>10.00</td>
<td>5.90</td>
</tr>
<tr>
<td><strong>Magnesium</strong></td>
<td>62.39±2.68a</td>
<td>18.01±0.89b</td>
<td>192.79±9.47c</td>
<td>36.50±0.57a</td>
<td>52.02±2.15b</td>
<td>70.15±0.68c</td>
<td>52.07±0.62a</td>
<td>43.07±0.86a</td>
<td>235.68±0.35b</td>
<td>83.00</td>
<td>106.00</td>
</tr>
</tbody>
</table>

Results are expressed as means±standard deviations (n=3). Values with different letters are significantly different at p<0.05 within different parts of the fruit cultivar.

x mg/100 g fresh sample (FS).
y Hoe and Siong (1999).

### Table 4
Antioxidant properties of kembayau fruits.

<table>
<thead>
<tr>
<th>Study</th>
<th>Lachau 1</th>
<th>Lachau 2</th>
<th>Lachau 3</th>
<th>Kembayau</th>
<th>Dabaiy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seed</td>
<td>Pulp</td>
<td>Peel</td>
<td>Seed</td>
<td>Pulp</td>
</tr>
<tr>
<td><strong>Antioxidant components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPC</td>
<td>8629.92±134.04a</td>
<td>1120.65±399.51 b</td>
<td>1881.63±113.41 c</td>
<td>8524.39±42.66a</td>
<td>682.87±175.95 b</td>
</tr>
<tr>
<td>TFC</td>
<td>22,210.30±1774.62 a</td>
<td>1012.74±260.56 b</td>
<td>3122.23±202.95 b</td>
<td>28,022.28±2135.33a</td>
<td>1398.55±123.68 b</td>
</tr>
<tr>
<td>TMAC</td>
<td>6.76±2.65 a</td>
<td>10.15±3.74 a</td>
<td>404.11±27.75b</td>
<td>5.34±3.33a</td>
<td>15.13±5.68a</td>
</tr>
<tr>
<td><strong>Antioxidant capacities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEAC</td>
<td>74.59±3.19 a</td>
<td>4.04±1.71 b</td>
<td>4.28±3.49 b</td>
<td>51.39±3.33 a</td>
<td>2.08±1.10 b</td>
</tr>
<tr>
<td>FRAP</td>
<td>536.92±18.45 a</td>
<td>25.11±4.28 b</td>
<td>97.72±24.19 b</td>
<td>556.98±24.06 a</td>
<td>18.80±12.58 b</td>
</tr>
<tr>
<td>DPPH</td>
<td>92.18±0.19 a</td>
<td>91.47±0.21 b</td>
<td>70.39±8.83 b</td>
<td>92.19±0.19 a</td>
<td>91.98±0.36 a</td>
</tr>
</tbody>
</table>

Results are expressed as means±standard deviations (n=3). Values with different letters are significantly different at p<0.05 within different parts of the fruit cultivar. The following abbreviations were used: TPC, total phenolics content expressed as mg gallic acid equivalent (GAE)/100 g freeze-dried sample (FDS); TFC, total flavonoid content expressed as mg rutin equivalent (RE)/100 g FDS; TMAC, total monomeric anthocyanin content expressed as μg monomeric anthocyanin pigment (MAP)/100 g FDS; TEAC, trolox equivalent antioxidant capacity expressed as mmol trolox equivalent (TE)/100 g FDS; FRAP, ferric reducing antioxidant power expressed as mmol of Fe2+/100 g FDS; and DPPH expressed as percentage of inhibition (%).
nutritional content. Furthermore, these fruits are also rich in antioxidants, which may help to combat oxidative related diseases. The seeds have the highest amount of total flavonoids and phenolics compared to peels and pulps. This inedible portion may be used as raw material for extracting these antioxidants, especially flavonoids. However, future studies are needed to identify the bioactive compounds in kembayau fruits and the health benefits of these fruits.

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References


