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ORIGINAL ARTICLE

# Antioxidant compounds and antioxidant activities in unripe and ripe kundang fruits (*Bouea macrophylla* Griffith)

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**Abstract – Introduction.** Kundang fruit (*Bouea macrophylla* Griffith) is very popular in Malaysia and other ASEAN countries. The fruit is traditionally believed to impart potential health benefits, but no scientific information is available on the antioxidant compounds or the antioxidant activities in unripe and ripe kundang fruits. **Materials and methods.** Unripe and ripe kundang fruits were freeze-dried and subjected to three different types of solvent extraction (methanol, ethanol and distilled water). Freeze-dried samples were individually evaluated for antioxidant compounds (total phenolics, tannins, flavonoids and flavonols) and antioxidant activities (ferric reducing antioxidant power assay/FRAP assay, $ABTS^{-+}$ assay and $DPPH^{\cdot}$ free radical-scavenging activity assay). **Results and discussion.** High contents of phenolics, tannins and ascorbic acid were found in unripe fruits (extracted with methanol), whereas flavonoids and flavonols were high in ethanolic extracts. Anthocyanins were the highest in ethanolic extracts of ripe fruits. In addition, methanolic extracts of unripe fruits showed the highest antioxidant capacity [16,290.91 μM Fe (II) 100 $g^{-1}$], with 77.69% DPPH inhibition and 99.76% $ABTS^{\cdot+}$ radical scavenging activities. **Conclusion.** This study clearly indicated that solvents tend to influence the extractability of antioxidant compounds. Overall, the results of this study can be of practical use in providing sufficient information on the presence of various antioxidant compounds in kundang unripe and ripe fruits, which could be commercially exploited for developing various healthy food formulations.

**Keywords:** Malaysia / kundang / plum mango / *Bouea macrophylla* / antioxidant activity / phenolics / flavonoids / flavonols

**Résumé – Composés antioxydants et activités antioxydantes des fruits du kundang (*Bouea macrophylla* Griffith) selon leur maturité. Introduction.** Les fruits du kundang, mangue-prune en anglais (*Bouea macrophylla* Griffith) sont très populaires en Malaisie et autres pays de l'ASEAN. Traditionnellement, ce fruit est considéré conférer des bénéfices potentiels pour la santé ; toutefois, aucune information scientifique n'est disponible sur les effets santé des composés antioxydants ou sur les activités antioxydantes des fruits verts ou arrivés à maturité. **Matériels et méthodes.** Les fruits encore verts ou mûrs du kundang ont été lyophilisés et soumis à l'extraction par trois types de solvant : le méthanol, l'éthanol, et l'eau distillée. Les échantillons lyophilisés ont été analysés individuellement pour les composés antioxydants (composés phénoliques totaux, tanins, flavonoïdes et flavonols) et pour les activités antioxydantes (dosage d'activité anti-oxydante ferrique (FRAP), dosage de l'activité de décoloration cationique (2,2-azinobis 3-éthyl-6-benxothiazoline acide sulfonique ou ABTS), et dosage par piégeage des radicaux (2,2-diphényl-1-picrylhydrazyl ou DPPH). **Résultats et discussion.** Des teneurs élevées en composés phénoliques, en tanins et en acide ascorbique ont été trouvées dans les fruits immatures (extraits au méthanol), alors que les teneurs en flavonoïdes et flavonols étaient plus élevées dans des extraits éthanoliques. Les anthocyanes ont les teneurs les plus élevées dans les extraits éthanoliques des fruits mûrs. En outre, les extraits méthanoliques de fruits encore verts ont exprimé la capacité anti-oxydante la plus élevée [16 290.91 pM Fe (II) 100 $g^{-1}$] avec un piégeage de radicaux DPPH de 77,69 % et 99,76 % d'inhibition des radicaux $ABTS^{+}$. **Conclusion.** Cette étude a clairement indiqué que le type de solvant influence l'extractibilité des composés antioxydants du kundang. Globalement, les résultats générés dans cette étude présentent une utilité pratique en fournissant des informations sur la présence et la teneur de différents composés antioxydants dans les fruits verts ou mûrs du kundang. Ces informations pourraient être exploitées commercialement à travers le développement de diverses formulations d'alicaments.

**Mots clés :** Malaisie / kundang / *Bouea macrophylla* / activité anti-oxydante / composés phénoliques / flavonoïdes / flavonols

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## 1 Introduction

Antioxidants are those compounds which are capable of functioning as free radical scavengers, and decrease the side effects of free radical activities in human cells. A vast wealth of literature from epidemiological studies available on the Internet indicates that the consumption of fruit rich in antioxidant compounds (*e.g.* phenolics, tannins, flavonoids, flavonols, vitamin C, anthocyanins, etc.) is capable of minimising the damage induced by free radicals (such as cardiovascular diseases, ageing, diabetes, etc.) in humans. According to available reports [1,2], tropical fruits are rich in bioactive antioxidant compounds and can stimulate health benefits.

*Bouea macrophylla* Griffith, popular as kundang fruit, plum mango or mini mango, is traditionally believed to impart health benefits among the local communities in Malaysia and other parts of the ASEAN region. Ripe and unripe fruits are both edible, but highly seasonal. Ripe fruits (sweet to sour in taste) have multiple uses in preparing refreshing beverages, dried snacks and jellies, as well as in direct consumption, while unripe fruits (sour taste) are used as a vegetable or in the preparation of "sambal belacan", a sweet-sour-tasting sauce. In many parts of Malaysia and Indonesia, the young leaves of the kundang plant are traditionally used in the preparation of salads or consumed as a raw vegetable ("ulam"), while the purple colour and bitter-tasting endosperm of the seeds is considered to be edible [3–5]. Results on the composition have indicated unripe kundang fruit to possess high levels of ash, crude lipid, fibre and protein compared with the ripe fruits [5]. As kundang fruit plants are mainly grown as an ornamental or shade tree (and not as a cash crop), it is very difficult to obtain or estimate the average statistical data on the production rate or provide information on the family revenue that can be generated in Malaysia or other ASEAN regions.

To our knowledge, no scientific reports are available on the antioxidant composition or activities exhibited by the unripe and ripe fruits of kundang. Hence, based on this, the objective of the present work was to identify the levels of various antioxidant compounds and evaluate the antioxidant activities of unripe and ripe kundang fruits. Our hypothesis in this study was that the unripe kundang fruits might possess higher levels of antioxidant compounds (total phenols, tannins, flavonoids, flavonols and ascorbic acid) and exhibit better antioxidant activities than the ripe fruits, which might be a practical indication for future commercial exploitation.

## 2 Materials and methods

### 2.1 Sample collection

Unripe and ripe fruits of *B. macrophylla* were collected from a local farm in the Perak region (coordinates: 4°45′ N 101°0′ E) of Malaysia during the fruiting season (October to December). In 2011 and 2012 the temperature during the collection period was between 26 and 27 °C. The collected fruits were sorted for uniform size, maturity, and without any apparent physical damage. The freshly harvested fruits were brought to the laboratory, thoroughly washed with potable water and wiped dry. Further, fruits devoid of seeds were cut and freeze-dried at a temperature of −46 °C, at a vacuum pressure of 0.030 mBar (freeze dryer model: 7754511, Labconco Corporation, Kansas City, USA). The freeze-dried fruit powder obtained was ground in a kitchen mixer (Panasonic, Malaysia) and sieved with a 250-μm sieve.

### 2.2 Solvent extraction for assays

The method of sample preparation for antioxidant assays was based on previous reports [6, 7]. Briefly, three different solvents were used for extraction, which included: methanol, ethanol and distilled water. Concisely, a known amount of freeze-dried kundang fruit powder (from unripe and ripe fruits) was extracted twice with respective solvents (200 mL), and pooled. This was further centrifuged (wrapped with aluminium foil to avoid exposure to light), followed by agitation using an orbital shaker (200 rpm, 50 °C for 2 h). After this, the mixture obtained was stored in the dark for 12 h (except for the distilled water sample, which was prepared fresh before analysis), followed by recentrifugation (3000 rpm, 10 min at a room temperature of 25 ± 1 °C), and the supernatants were collected in clean glass vials (wrapped with aluminium foil).

### 2.3 Evaluation of antioxidant compounds

#### 2.3.1 Total phenolic, tannin, flavonoid and flavonol contents

The total phenolic contents (Folin-Ciocalteu's assay method), tannins (Vanillin-HCl method), flavonoids (colorimetric method) and flavonols (spectrophotometric method) in unripe and ripe kundang fruit extracts were determined based on standard methods [8–11].

The total phenolic content (TPC) of the fruit extracts was determined by the method of Singleton and Rossi [8] using the Folin-Ciocalteu (FC) assay. In brief, 400 μL of the fruit extract were mixed with 2.0 mL of FC reagent (pre-diluted 10 times). After leaving it untouched for 5 min at room temperature, sodium carbonate solution was added (1.6 mL of 7.5% w/v) and the solution mixture was again thoroughly mixed. Following this, after about 1 h incubation (at room temperature), the absorbance was measured at 765 nm using a UV-visible spectrophotometer (Shimadzu UV-160A, Kyoto, Japan). The results are expressed as mg Gallic Acid Equivalent (GAE) 100 $g^{-1}$ sample.

The vanillin-HCl method was adopted to determine tannins in the fruit extracts according to the method by Burns [9]. One mL of fruit extract was treated with 5 mL reagent mixture (4% vanillin in methanol and 8% concentrated HCl in methanol, 1:1). Then the mixture was mixed thoroughly and kept in the dark (for 20 min). The absorbance was read at 500 nm using a UV-visible spectrophotometer with catechin used as a standard. Tannin content is expressed as mg catechin equivalent (CE) 100 $g^{-1}$ sample.

The total flavonoid content (TFC) in the fruit extracts was determined by the colorimetric method, as demonstrated

by Sakanaka *et al.* [10]. For this, initially, 250 μL of the fruit extract were mixed with distilled water (1.25 mL) in a test tube. Subsequently, 5% sodium nitrite solution (75 μL) was added, which was followed by the addition of 10% aluminium chloride (150 μL) solution after 6 min. This mixture was allowed to stand for 5 min at room temperature, and finally, 0.5 mL of 1 M sodium hydroxide was added. The mixture was made up to 2.5 mL with distilled water and mixed well. The absorbance was measured immediately using a UV-visible spectrophotometer at 510 nm, and the results are expressed as mg catechin equivalent (CE) 100 $g^{-1}$ sample.

The method illustrated by Miliauskas *et al.* [11] (with slight modifications) was employed to evaluate the total flavonol content in the fruit extracts. The quercetin calibration curve was prepared by mixing 1 mL of 0.15–0.05 mg $mL^{-1}$ quercetin methanol solution with 1 mL of 2% aluminium trichloride and 3 mL of 5% sodium acetate. After 2.5 h at 20 °C, the absorbance was measured at 440 nm using a UV-visible spectrophotometer (Shimadzu UV-160A, Kyoto, Japan). The same procedure was carried out with 1 mL of the extract instead of using quercetin solution. Total flavonol content is expressed as mg quercetin equivalent (QE) 100 $g^{-1}$ sample.

#### 2.3.2 Total anthocyanin content

The standard spectrophotometric method as detailed by Abdel-Aal and Hucl [12] was adapted to determine the total anthocyanin content in the fruit extracts. Briefly, acidified methanol (methanol and 1 M HCl, 85:15 v/v) with a solvent to sample extract ratio of 10:1 was used to extract anthocyanins in kundang fruit extracts. After centrifugation, the absorbance was measured at 525 nm against a reagent blank. Cyanidin-3-glucoside was used to prepare the standard calibration curve and the total anthocyanin content is expressed as mg cyanidin-3-glucoside equivalents (c-3-gE) 100 $g^{-1}$ sample.

#### 2.3.3 Determination of ascorbic acid content

The ascorbic acid content in the fruit extracts was determined by employing the standard 2,6-dichlorophenol iodophenol (DCPIP) titrimetric method of the AOAC [13]. Initially, the colouring factor was acquired by titrating the standard solution of ascorbic acid with a solution of a standard dye until an end point indicator of a pink-coloured solution was obtained. Further, a known amount of the sample extract (10 mL) was diluted (to 100 mL with 3% metaphosphoric acid), followed by filtering (Whatman number 1 filter paper). Then, a known volume of an aliquot (5 mL) of the filtrate was titrated using a (DCPIP) indicator until the end point was attained. The results obtained were expressed as mg ascorbic acid 100 $g^{-1}$ sample.

### 2.4 Antioxidant activities

#### 2.4.1 Ferric reducing/antioxidant power (FRAP) and $ABTS^{\cdot+}$ assays

The antioxidant capacity of the fruit extracts was evaluated by employing the method described by Benzie and Strain [14]. Initially, prior to the experiment, FRAP reagent was freshly prepared [mixing 200 mL of 300 mM acetate buffer with pH 3.6 in 20 mL of 10 mM 2,4,6-tris(2-pyridyl)-5-triazine (TPTZ) solution with 20 mL of 20 mM $FeCl_3.6H_2O$ solution, and 24 mL distilled water]. This reagent was always maintained pre-warmed at 37 °C. Further, for the analysis, appropriately diluted fruit extracts (of 40-μL aliquots) were taken and mixed with 3 mL FRAP reagent. This reaction mixture was incubated (for 4 min. at 37 °C) in a water bath, followed by taking the absorbance reading at 593 nm (using a UV-visible spectrophotometer, Shimadzu UV-160A, Kyoto, Japan) against a blank prepared by substituting the amount of extracts with distilled water. Finally, a calibration curve was prepared (using an aqueous solution of ferrous sulphate, $FeSO_4.7H_2O$), and the FRAP activity is expressed as micromoles of ferrous equivalent Fe (II) 100 $g^{-1}$ sample.

With regard to measuring the total antioxidant activity in the fruit extracts by $ABTS^+$ radical scavenging activity assay, the method proposed by Re *et al.* [15] was adopted. Prior to performing the experiments, $ABTS^+$ was freshly prepared (5 mL of 4.9 mM potassium persulphate + 5 mL of a 14 mM $ABTS^+$ solution), and this mixture was kept in the dark for 16 h. This solution was further diluted using methanol to produce an absorbance of 0.70 (± 0.05) at 734 nm. This was consequently used for the antioxidant assay. The final reaction mixture (1 mL) of the standard and the extracts (950 μL ABTS solution and 50 μL fruit extract) was vortex-mixed for 10 s. Further, after 6 min, absorbance was read at 734 nm by UV-visible spectrophotometer (Shimadzu UV-160A, Kyoto, Japan) and compared with the control $ABTS^+$ solution.

#### 2.4.2 DPPH free radical-scavenging assay

The antioxidant capacity of the fruit extracts was determined based on percentage inhibition of the free radical scavenging activity of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical, as described by De Ancos *et al.* [16]. The fruit extracts (10 μL) were added to 90 μL distilled water and DPPH methanolic solution (3.9 mL of 25 mM), and the mixture obtained was meticulously vortexed for 1–2 min, and left to stand in the dark (for 30 min). After this incubation period, the absorbance was measured at 515 nm against a blank of methanol without DPPH.

The percentage of inhibition of the DPPH radical was calculated according to the following equation:

$$\%\ inhibition\ of\ DPPH = \frac{(Abs\ control - Abs\ sample)}{Abs\ control} \times 100$$

where Abs control is the absorbance of DPPH solution without fruit extracts.

### 2.5 Standards and reagents

The chemicals used in the present study were purchased from Sigma-Aldrich® (USA) and R&M Chemicals (Essex, UK).

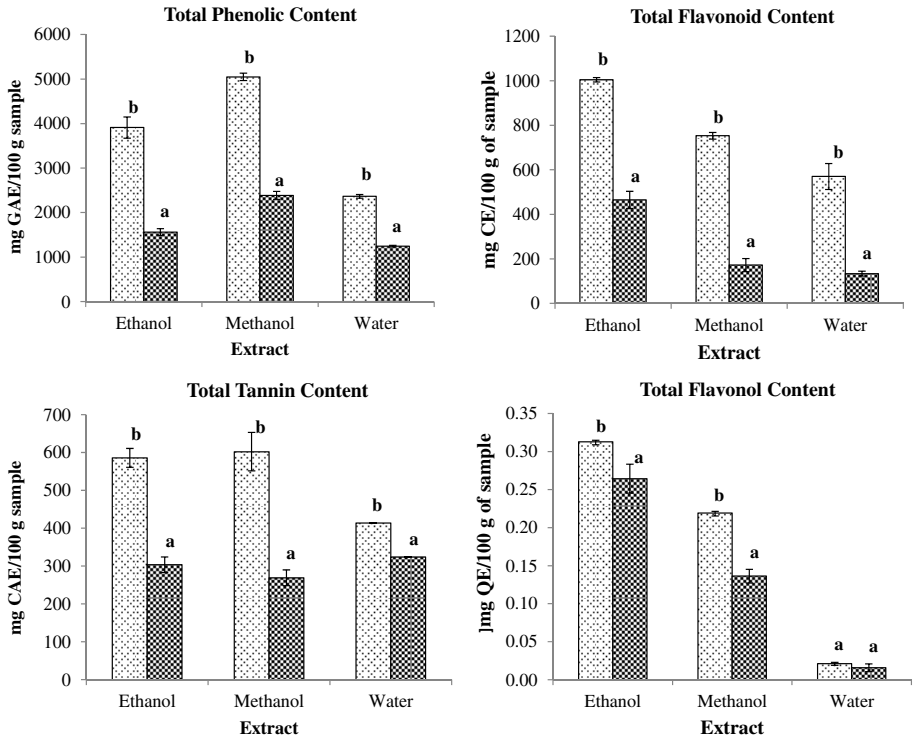


**Figure 1.** Antioxidant compounds in unripe and ripe kundang fruit extracted with various solvents (ethanol, methanol or water). Data values are means ± standard deviation ($n$ = 3). Different letters on the top of a column indicate significant differences between the treatments ($P < 0.05$).

### 2.6 Statistical analysis

All the analyses were performed in triplicate ($n$ = 3) and analysis of variance was applied to identify significant differences between the mean values (results represented as means ± standard deviation) and by using Duncan's new multiple range test (level of significance of $P < 0.05$; SPSS version 14.0 was used).

## 3 Results and discussion

### 3.1 Antioxidant compounds (phenolics, tannins, flavonoids, flavonols, anthocyanins and ascorbic acid)

Plant-based phenolic compounds which are abundant in fruits have been reported to exhibit rich antioxidant activities under *in vivo* and *in vitro* conditions. In fact, the antioxidant mechanism of these compounds is owed to the phenol moiety (hydroxyl group on an aromatic ring)/ reactivity and based on their abilities to scavenge free radicals via hydrogen or electron donation or breaking of the radical chain reaction and chelate metal ions [1, 17, 18].

In the present study, total phenolic contents (*figure 1*) varied significantly ($P < 0.05$) between the unripe and ripe fruit extracts, and were dependent on the solvents used for extraction. The total phenolics ranged from 2,366.27 to 5,050.60 mg GAE 100 $g^{-1}$ for the unripe fruits, and from 1,244.98 to 2,387.15 mg GAE 100 $g^{-1}$ in ripe fruits. This result shows that the phenolic contents in both unripe and ripe fruits are significantly higher ($P < 0.05$) than in whole and fresh-cut mango (*Mangifera indica* L.) cv. 'Ataulfo' (reported as 110.7 and 116.0 mg GAE 100 $g^{-1}$) [19]. Overall, methanol was found to be the most effective solvent to extract phenols, with the unripe fruits exhibiting the highest content. This result is also comparable with the results reported earlier [20, 21] in young ginger, buckwheat and oat bran, respectively, whereby phenolic compounds were found to be effectively extracted in methanol.

Condensed tannins, also known as proanthocyanidins (subdivided as condensed and hydrolysable compounds in vascular plants) are important secondary plant metabolites [22]. The highest tannin content was recovered with methanolic extracts of unripe fruits (648.28 mg CE 100 $g^{-1}$), followed by the ethanolic extracts (586.21 mg CE 100 $g^{-1}$). This was comparable with ripe methanolic and ethanolic extracts (413.79 and 324.14 mg CE 100 $g^{-1}$, respectively) (*figure 1*). The least recovery of tannins was from water extraction in both unripe (303.45 mg CE 100 $g^{-1}$) and ripe (268.97 mg CE 100 $g^{-1}$) fruits, without any significant differences ($P > 0.05$). This can be explained by the fact that in addition to the abundance of hydroxyl groups, tannins develop some hydrophobic character features owing to the presence of a benzene ring in the molecule [23]. As a result, methanol gave the highest extraction of tannins, followed by ethanolic extraction.

Flavonoids (also known as bioflavonoids) are antioxidant compounds produced naturally as secondary metabolites in plants. This group of compounds are widespread in plants and are extensively dispersed single groups of phenols. Furthermore, flavonoids have high potential in interacting and

scavenging free radicals and are known to produce complexes with metal ions, and thus restrain metal-initiated lipid oxidation [24]. As shown in *figure 1*, unripe fruits (ethanolic extract, 1,004.30 mg CE 100 $g^{-1}$) exhibited the highest flavonoid content, followed by methanolic extracts (752.69 mg CE 100 $g^{-1}$) and water extracts (569.89 mg CE 100 $g^{-1}$). With regard to ripe fruit extracts, the contents were significantly ($P < 0.05$) lower than unripe fruit extracts, and ranged between 133.33 and 464.62 mg CE 100 $g^{-1}$.

Flavonols, which are the most common sub-class of flavonoids in plants, were present in low amounts in the fruit extracts. The highest flavonol content was detected in ethanolic extract of unripe fruits (0.313 mg QE 100 $g^{-1}$), whereas aqueous (water) extracts of both unripe and ripe fruits exhibited the lowest flavonol content with non-significant differences ($P > 0.05$) (0.021 and 0.016 mg QE 100 $g^{-1}$, respectively).

Anthocyanin, which is one of the most important subclasses of the flavonoid group of compounds, has been reported to exhibit rich antioxidant, antidiabetic, anticancer, anti-inflammatory and anti-atherogenesis properties. In addition, being natural and owing to their attractive colours, they can be used as food colorants. Anthocyanins are water-soluble natural pigments abundantly found in fruits, vegetables and flowers, and their concentrations determine the colour and appearance of fresh produce [25, 26]. In the present study, the total anthocyanin content among all the ripe fruit extracts (*figure 2*) showed significantly ($P < 0.05$) higher values than that of unripe fruit extracts. In ripe fruits, ethanolic extracts exhibited the highest anthocyanin content of 2.24 mg c-3-gE 100 $g^{-1}$, followed by the methanolic extracts (1.58 mg c-3-gE 100 $g^{-1}$). Overall, ripe fruits contained a higher amount of anthocyanin content, which can be attributed to the bright yellow to orange-coloured peel and pulp.

The polarity and viscosity of the solvents used for the extraction process can significantly affect the extraction of polyphenolics or other antioxidant compounds. Generally, solvents with high polarity can exhibit higher antioxidant activities [23, 27]. Further, the level of recovery of antioxidant compounds is reported to be influenced by the solubility of these antioxidant compounds in a specific solvent which is used for extraction purposes [28, 29]. Previously, some of the solvents such as acetone, ethanol, methanol, propanol and others have been used for extracting antioxidant-rich polyphenolic compounds from fruits [1, 23, 30–32]. However, varied results were obtained for each of the solvent extracts in the particular type of fruit used. For example, in a study on selected tropical fruits as reported by Alothman *et al.* [1], the effects of solvent extraction (methanol, ethanol and acetone) gave varied results. Pineapple extracted with acetone (50%) or ethanol (70%) yielded the highest level of total phenols without any significant differences between them, while acetone (70%) was able to show the highest polyphenol content in banana extracts. With regard to guava, the total polyphenol content was high in both acetone (90%) and ethanol (90%).

### 3.2 Ascorbic acid content

Ascorbic acid is one of the prominent antioxidants found abundantly in fruits and vegetables, associated with improved immunity and decreased risks of various chronic diseases. In this study (*figure 2*) a notably high content of vitamin C was extracted in methanolic extract of (99.27 mg AA 100 $g^{-1}$), followed by ethanolic (97.28 mg AA 100 $g^{-1}$) and water extracts (75.44 mg AA 100 $g^{-1}$) in unripe fruits. All the extracts of ripe fruits had comparatively lower vitamin C content, which ranged between 41.69 and 27.79 mg AA 100 $g^{-1}$. Hence, unripe fruits can be considered as a good source of vitamin C. These results are comparable with an earlier report [33] on Mangaba (*Hancornia speciosa*), an exotic fruit from North-Eastern Brazil, which had an ascorbic acid content of 96.3 mg AA 100 $g^{-1}$, as well as with a report on mature green mangos (*Mangifera indica*), which had vitamin C content of 93.5 mg AA 100 $g^{-1}$ [34].

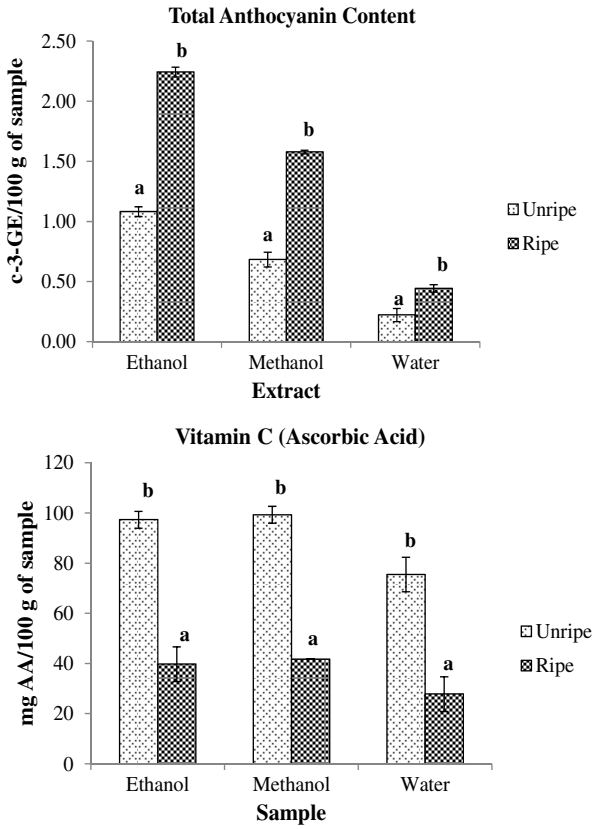


**Figure 2.** Total anthocyanin and vitamin C contents in unripe and ripe kundang fruits extracted with various solvents (ethanol, methanol or water). Data values are means ± standard deviations ($n = 3$). Different letters on the top of a column indicate significant differences between the treatments ($P < 0.05$).

### 3.3 Antioxidant activities (FRAP assay, ABTS radicals, percentage inhibition of DPPH)

Different researchers have employed different approaches to quantitatively determine the activity of antioxidants in different plant produce. In this study, we employed FRAP, $ABTS^{\cdot+}$ and DPPH free radical scavenging assays. In FRAP, the capability of the fruit extracts to reduce ferric iron ($Fe^{3+}$) to ferrous iron ($Fe^{2+}$) is measured, whereas the development

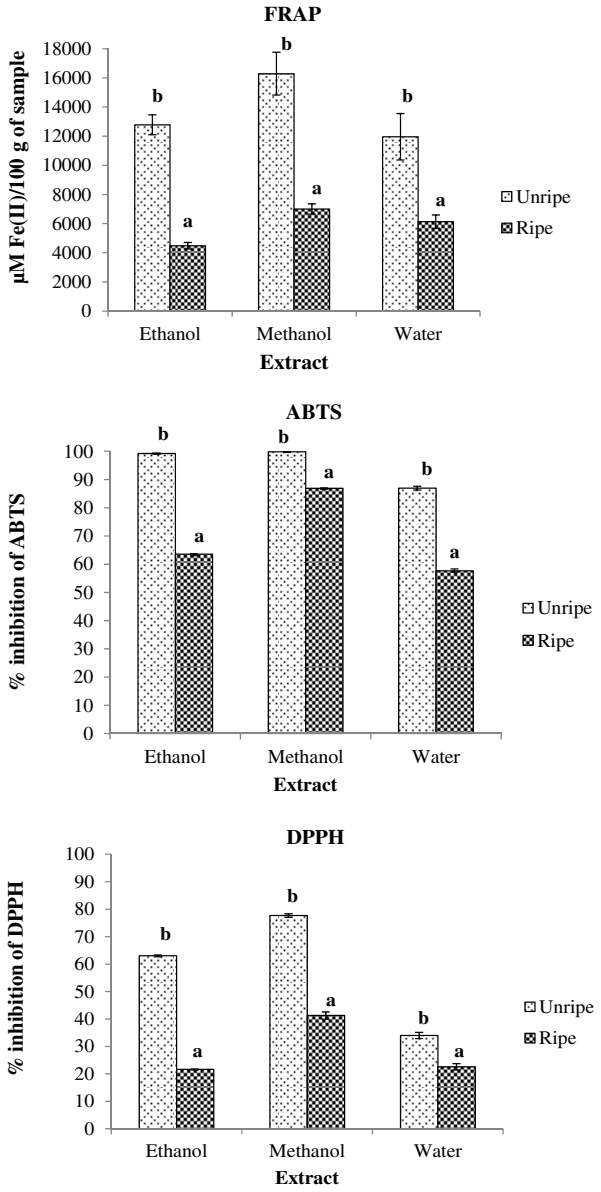


**Figure 3.** Ferric reducing/antioxidant power (FRAP), $ABTS^{+}$ and $DPPH^{\cdot}$ assay values for estimating the antioxidant activity in unripe and ripe kundang fruits extracted with various solvents (ethanol, methanol or water). Data values are means ± standard deviation ($n$ = 3). Different letters on the top of a column indicate significant differences between the treatments ($P < 0.05$).

of blue/green $ABTS^{\cdot+}$ chromophore (via a reaction between ABTS and potassium persulphate) is measured in the $ABTS^{\cdot+}$ assay, and reduction of the purple colour of the DPPH radical to a yellow colour is used as a determining factor in DPPH assays [1, 35].

The results obtained for antioxidant capacities in the fruit extracts are shown in *figure 3*. Among all three assays, methanolic extracts of unripe fruits contained the highest antioxidant capacity, with 16,290.91 µM Fe (II) 100 $g^{-1}$, 77.69% of DPPH inhibition and 99.76% of $ABTS^{\cdot+}$ radical inhibition. All 3 antioxidant capacities of unripe methanolic extracts were significantly higher ($P < 0.05$) than the ethanolic extract of unripe fruits, which had the following antioxidant capacity values: 12,781.82 µM Fe (II) 100 $g^{-1}$, 62.97% of DPPH inhibition and 99.17% of $ABTS^{\cdot+}$ inhibition. According to Peter *et al.* [36], vegetable juice obtained from Cowston press apple and beetroot showed a lower percentage of DPPH and $ABTS^{\cdot+}$ inhibition (64.4% of DPPH and 90.1% of $ABTS^{\cdot+}$ inhibition) than in the methanolic extracts of this unripe fruit. Furthermore, the FRAP values in this study were remarkably higher than those of other tropical fruit extracts [1].

## 4 Conclusion

The type of antioxidant compound being extracted from the kundang fruit varied depending on the type of solvent used. Methanol and ethanol were found to be the best solvents for extracting antioxidant compounds from *B. macrophylla* fruit. However, ethanol can be a better extraction solvent as it has acceptability for human consumption. Overall, and as anticipated, unripe fruits contained higher amounts of antioxidant compounds than the ripe fruits, except for the anthocyanin contents. The results of this study offer sufficient information on the presence of various antioxidant compounds in kundang unripe fruits to stimulate commercial application. Future studies on kundang fruit should evaluate the effects of various postharvest and food-processing techniques on the status of these antioxidants, in order to develop various healthy food formulations at a commercial level.

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