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Research Article

Total Phenolic, Total Flavonoid and Antioxidant Activities of *Durio graveolens* Becc. from Sabah, Malaysia

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ABSTRACT

Sabah is home to diverse wild durian species, including the orange-fleshed durian (*Durio graveolens* Becc.), locally known as "dalit." Despite its prevalence, scientific data on this wild durian remains limited. This study aimed to characterise the phytochemical composition and antioxidant potential of *D. graveolens* fruit parts (flesh, seed, mesocarp, and exocarp). Freeze-dried samples were extracted using 80% methanol and 60% acetone, followed by qualitative phytochemical screening. Total phenolic and total flavonoid contents were quantified via the Folin-Ciocalteu and aluminium chloride colourimetric methods, respectively. Antioxidant activity was assessed using 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical scavenging assays, and ferric reducing antioxidant power (FRAP) assay. The 60% acetone extracts demonstrated superior phytochemical content and antioxidant activity compared to methanolic extracts. The mesocarp exhibited the highest total phenolic (76.64 ± 1.21 mg GAE/g, $p < 0.01$) and flavonoid (69.30 ± 0.69 mg CE/g, $p < 0.01$) contents, along with the strongest antioxidant activity (DPPH IC_{50} = 70 µg/ml, $p < 0.01$; ABTS IC_{50} = 50 µg/ml, $p < 0.01$; FRAP = 71.15 mg TE/g, $p < 0.01$). These findings highlight the mesocarp's potential as a natural antioxidant source with promising pharmaceutical applications.

Keywords: Antioxidant properties; phytochemical content; dalit; orange-fleshed durian.

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INTRODUCTION

Borneo is recognised as a biodiversity hotspot for the genus *Durio*. The most famous durian species is *Durio zibethinus* Murr., known for commercially cultivated and widely consumed fruits in Southeast Asia (Maninang et al., 2011). Due to its popularity, researchers are interested in exploring the properties of this species and its potential applications. For example, the volatile composition of several varieties of *D. zibethinus*' pulp was reported to contain compounds of esters, alcohols, a few aldehydes and sulphurs (Chawengkijwanich et al. 2008; Chin et al. 2007a; Chin et al. 2008b; Voon et al. 2007). Other researches include the antioxidant studies (Ashraf et al. 2010; Chingsuwanrote et al. 2016; Evary & Nur, 2018), anti-inflammatory (Chingsuwanrote et al., 2016), and several applications of *D. zibethinus* such as the potential of its seed as stabiliser in juice production (Herlina et al. 2016) and durian peels as new insulating particleboards in building insulation (Hirunlabh et al., 2003).

In Sabah, approximately 14 species out of 27 have been reported, including those that are popular edible types and lesser-known wild durian which are endemic to the region (Soegeng-Reksodihardjo, 1962; Nyffeler & Baum, 2001; Mursyidin et al. 2024). The most notable wild durian is *Durio graveolens* Becc., known locally in Sabah as 'Durian dalit' and commonly found in the local markets. It grows wild in Borneo, the Malay Peninsula, and Sumatra. Morphologically, it is smaller than the common *D. zibethinus*, with a thin to thick, vividly coloured pulp ranging from red to orange, and the fruit naturally opens when ripe (Soegeng-Reksodihardjo, 1962). This durian has a unique cheese-like texture with a sweet flavour (Sunaryo et al., 2016). Despite its ecological and economic value, scientific information on *D. graveolens* remains scarce (Nasaruddin et al. 2013; Sunaryo et al. 2016; Gaber et al. 2025). Existing studies have reported on fruit performance and its nutritional properties (Sunaryo et al., 2016), phylogenetic relationships in several *Durio* species (Kanzaki et al., 1998), proximate and fatty acid content (Nasaruddin, 2013), and antimicrobial properties against gram-negative bacteria (Gaber et al. 2025).

The consumption of fruits and vegetables has numerous health benefits due to the source of phytochemicals associated with a reduced risk of oxidative stress-related diseases (Kubola et al. 2011 & Chingsuwanrote et al. 2016). Antioxidants in fruits are generally linked to phenolic and flavonoid content, associated with its ability to scavenge radicals. Gorinstein et al. (2011) reported that some exotic Thai fruits exhibited high antioxidant properties in DPPH assay, strongly correlated with the high total polyphenolic content in the fruits. Similarly, several underutilised Malaysian fruits were also reported to possess remarkable radical scavenging activity due to high phenolic constituents (Ikram et al., 2009).

The present study aimed to evaluate phytochemical content by quantifying the total phenolic and flavonoid contents of 80% methanol and 60% acetone extracts of different parts of durian fruit. Antioxidant potential of orange-fleshed *D. graveolens* were evaluated through three assays: 2,2-diphenyl-1-picrylhydrazyl radical assay (DPPH), 2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) radical cation assay (ABTS) and ferric reducing antioxidant power assay (FRAP). This research contributes new insights into antioxidant potential of *D. graveolens* as valuable natural sources of bioactive compounds with their antioxidant capabilities. Furthermore, this research enhances the scientific understanding of this wild durian species and lays the foundation for its sustainable use, conservation, and potential application in future nutraceutical or propagation efforts.

METHODOLOGY

Sample collection and preparation

The orange-fleshed *D. graveolens* was bought from the local market at Tamparuli, Sabah (6°8'3"N, 116°16'4"E). The sample selection was based on the colour of the fruit, size consistency, shape and flesh colour with preference given to fruits exhibiting minimal natural opening upon ripening (Fig. 1). The sample was verified by Mr Joel bin Dawat from the Systematic Botanic Section, Sepilok Forest Research Centre, Sabah (5° 52' 26.3" N, 117° 56' 59.1" E). The herbarium specimen (BORH 3011) was deposited in the BORNEENSIS, Herbarium, Universiti Malaysia Sabah. The samples were cleaned and separated into flesh, seed, mesocarp and exocarp. The sample parts were stored at −80 °C before being freeze-dried for five days. The freeze-dried samples were ground into a fine powder using a Waring blender (Waring, Japan) and stored at −80 °C until further use.

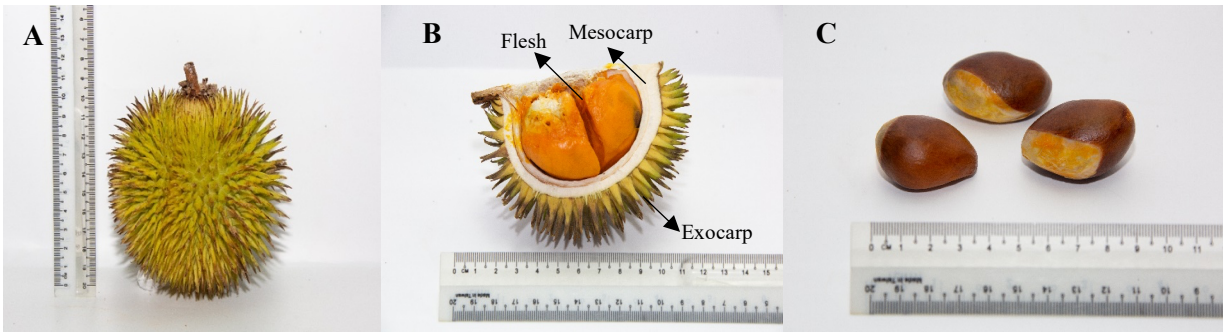

Figure 1: *Durio graveolens*. **A.** Irregular round-shaped with green to yellowish spine, 9–12 cm long. **B.** Durian slice with 10–15 cm wide covering the orange-coloured pulp with labelled flesh, mesocarp and exocarp. **C.** Glossy, dark brown seeds with 3–5 cm length.

Sample extraction

The flesh, seed, mesocarp and exocarp were extracted using 80% methanol and 60% acetone in the ratio of 1:20 (w/v). The vials were agitated for two hours at 200 rpm using an orbital shaker. The solution was filtered through Whatman No. 5 filter paper, and the supernatant was collected in a 20 ml vial wrapped in aluminium and stored at −80°C. Phytochemical contents and antioxidant activity assays were determined in the extracts.

Total phenolic content (TPC)

The Folin-Ciocalteu method from Muhtadi and Ningrum (2019) was used to measure total phenolics, with some modifications in the sample-to-reagent ratio. The sample extracts (10 µl, 50 mg/mL) were added into a 96-well plate containing 75 µl Folin-Ciocalteu reagent (10%) and incubated in a microplate reader (Thermo Scientific, USA) for 5 minutes before the addition of 75 µl of sodium carbonate solution (Na_2CO_3, 6%) into the well plate. The well plate was incubated in the dark for 90 minutes and the absorbance of TPC was measured at 725 nm using a microplate reader (Thermo Scientific, USA). Gallic acid, in the concentration range from 0.05 to 0.25 mg/ml was used as a reference standard. The TPC was expressed as milligrams of gallic acid equivalent (mg GAE) per gram of dry sample, as indicated in equation (1).

$$\text{Gallic acid equivalent (mg/g)} = C1 \times V/m \quad (1)$$

Where C1 represents concentration from gallic acid standard curve (mg/ml), V is the extract volume used in this assay (ml), and m is the dry weight of extract (g).

Total flavonoid content (TFC)

The TFC was determined based on the colourimetric method with a slight modification in the sample-to-reagent ratio (Muhtadi & Ningrum, 2019). In this assay, 100 µl of the sample extract (50 mg/ml) was mixed with 400 µl distilled water in a 2 ml centrifuge tube. Subsequently, 60 µl of 5% sodium nitrite ($NaNO_2$), 30 µl of 10% aluminium chloride ($AlCl_3$), and 200 µl of 1 M sodium hydroxide (NaOH) were added sequentially and the tube was shaken for 5 minutes after adding each reagent. The tube was incubated in the dark for 30 minutes to allow colour development. A total of 200 µl was added into 96-well plate and the absorbance of TFC was measured at 420 nm using a microplate reader (Thermo Scientific, USA). Catechin was used as the reference standard with a calibration curve prepared using a concentration range of 0.05–0.4 mg/ml. The results were expressed as mg catechin equivalent per gram of dry sample, based on equation (1).

2,2-diphenyl-1-picrylhydrazyl radical assay (DPPH)

The method outlined by Wang and Li (2014) was used to test the extracts' scavenging ability against the DPPH radical. The extract was serially diluted to concentrations of 7.8, 15.6, 31.25, 62.5, 125, 250, 500 and 1000 µg/ml. A total of 100 µl of each sample extract was mixed with 100 µl of 0.1 mM DPPH working solution in a 96-well plate and incubated in the dark for 30 minutes. The absorbance was measured at 519 nm using a microplate reader (Thermo Scientific, USA). The DPPH scavenging percentage was calculated according to equation (2), and results were expressed in IC_{50} value (concentration of sample able to scavenge 50% of the DPPH free radical). Trolox was used as positive control in this assay.

$$DPPH\ scavenging\ activity\ (\%) = 1 - \left(\frac{Sample\ reading - Empty\ sample\ reading}{DPPH\ reading - Blank\ reading}\right) X\ 100 \qquad (2)$$

2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) radical cation assay

ABTS assay was carried out using the method outlined by Wang and Li (2014). The ABTS reagent was prepared by reacting 15 ml of ABTS solution (7.4 mM) with 264 µl potassium persulphate ($K_2S_2O_8$, 2.6 mM). The solution was kept at room temperature for 24 hours in the dark. The working solution was diluted, and absorbance was measured to obtain a value of 0.70 ± 0.02. The ABTS working solution (100 µl) was added to each well containing serially diluted sample extracts (7.8–1000 µg/ml) and incubated in the dark for 30 minutes. A microplate reader (Thermo Scientific, US) was used to measure the absorbance at 734 nm. The results were expressed in IC_{50} (concentration of the extracts capable of scavenging 50% of the ABTS radical). Trolox was used as positive controls in this assay.

Ferric reducing antioxidant power assay (FRAP)

This procedure was performed according to Abu Bakar et al. (2009). The FRAP reagent was freshly prepared by mixing acetate buffer (300 mM, pH 3.6), 2,4,6-tris(2-pyridyl)-1,3,5-triazine solution (TPTZ, 10 mM), and ferric chloride hexahydrate ($FeCl_3.6H_2O$, 20 mM). The sample extracts (50 mg/ml, 20 µl) were added into the 96-well plate containing 180 µl FRAP reagent and incubated for 30 minutes in the dark. The absorbance was measured at 593 nm, and the results were expressed as milligrams of Trolox equivalent per gram of dried sample (mg TE/g), based on equation (3).

FRAP values (C) = C1 x v/ M (3)

Where C = total FRAP content in mg TE/g, C1 = concentration of trolox obtained from the calibration curve in mg/ml, V= volume of extract in ml, and m = the weight of the sample in g.

Statistical analysis

All the experiments were carried out in triplicate. The mean data were displayed as means ± standard deviations and statistically assessed using multiple variance analysis (two-way ANOVA) using Tukey's test in SPSS version 20.0 to evaluate the effects of sample part and solvent system, as well as their interaction ($p < 0.01$). Pearson's correlation coefficients were used to analyse the associations between the antioxidant activities of the three independent tests (DPPH, ABTS, and FRAP) and phytochemical content (TPC and TFC).

RESULTS

Total phenolic content (TPC)

The TPC of the extracts exhibited significant variation, ranging from 0.96 to 43.10 mg GAE/g for 80% methanolic extracts and 1.33 to 76.64 mg GAE/g for 60% acetone extracts (Fig. 2). The non-edible parts of both solvent extractions displayed higher TPC than the flesh part. The 60% acetone extracts of seed, mesocarp and the exocarp exhibited higher TPC values compared to the 80% methanolic extracts ($p < 0.01$). The highest TPC value was demonstrated by the mesocarp extracted using 60% acetone ($p < 0.01$), followed by the 80% methanol extracts with 76.64 ± 1.21 and 43.10 ± 0.9 mg GAE/g dried sample, respectively. The two-way ANOVA revealed significant effects of the sample parts and the solvent extractions on total phenolic content.

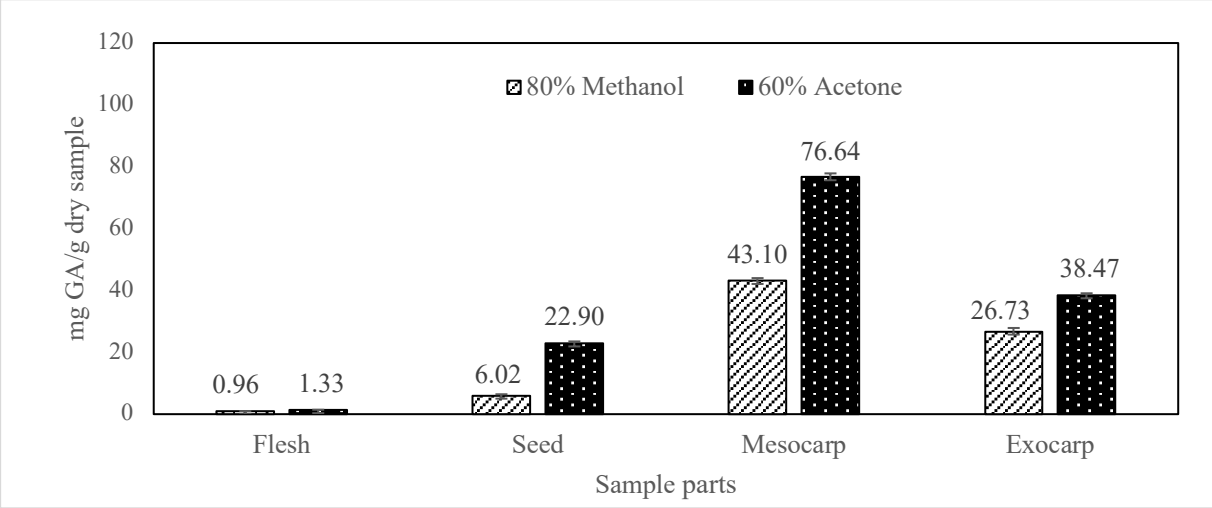

Figure 2: Total phenolic content in orange-fleshed *D. graveolens* (mg Gallic acid in 1 gram of dry sample). The data analysis involved using a two-way ANOVA with two factors: four sample parts and the different solvent extraction methods. (All significant at p <0.01 level).

Total flavonoid content (TFC)

The total flavonoid content (TFC) of *D. graveolens* extracts varied significantly among fruit parts, ranging from 0.06 to 42.90 mg CE/g for 80% methanol extracts and 0.56 to 69.30 mg CE/g for 60% acetone extracts (Fig. 3). Consistent with the total phenolic content results, the

mesocarp exhibited the highest flavonoid content (69.30 ± 0.69 mg CE/g in 60% acetone; 42.90 ± 1.93 mg CE/g in 80% methanol, $p < 0.01$), followed by exocarp > seed > flesh. A two-way ANOVA demonstrated significant main effects of fruit part and extraction solvent on the total flavonoid content ($p < 0.01$), with notable differences among the flesh, seed, mesocarp and exocarp, as well as between 80% methanol and 60% acetone extracts.

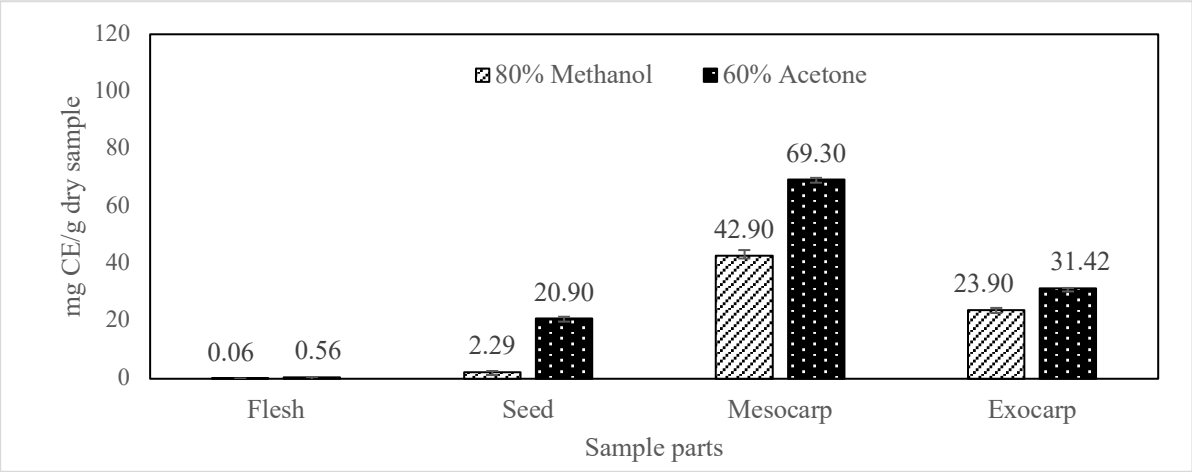

Figure 3: Total flavonoid content in orange-fleshed *D. graveolens* (mg Catechin in 1 gram of dry sample). The data analysis involved using a two-way ANOVA with two factors: four sample parts and the different solvent extraction methods. (All significant at p <0.01 level).

Antioxidant activity (DPPH and ABTS assay)

The antioxidant capacity of *D. graveolens* extracts was quantified through DPPH and ABTS radical scavenging assays, expressed as IC_{50} values (concentration required to inhibit 50% of radicals; Table 1). The IC_{50} values ranged from 70.4 to 2511.1 µg/ml for DPPH and 50.0 to 2228.4 µg/ml for ABTS assay across all sample extracts. The flesh part exhibited the highest IC_{50} compared to the non-edible parts, with mesocarp displayed the lowest values in both solvent extractions. The 60% acetone extract of the mesocarp demonstrated the strongest antioxidant capacity, with 70.4 ± 1.6 µg/ml and 50.0 ± 1.3 µg/ml in the DPPH and ABTS assays, respectively (p <0.01).

Table 1: IC_{50} values of 80% methanol and 60% acetone extracts from different fruit parts of *Durio graveolens* evaluated using DPPH and ABTS radical scavenging assays.

Solvent extraction	Fruit' part	IC_{50} DPPHc(µg/ml)	IC_{50} ABTS (µg/ml)
80% Methanol	Flesh	2511.1 ± 79.8	2228.4 ± 38.6
	Seed	662.2 ± 120.7	543.9 ± 80.4
	Mesocarp	116.8 ± 10.7	66.3 ± 1.2
	Exocarp	196.5 ± 12.4	133.2 ± 11.0
60% Acetone	Flesh	2034.8 ± 234.1	1753.2 ± 61.0
	Seed	218.8 ± 14.7	195.3 ± 23.2
	Mesocarp	70.4 ± 1.6	50.0 ± 1.3
	Exocarp	175.9 ± 6.8	106.5 ± 7.8
Trolox	Trolox	5.2 ± 0.6	5.5 ± 0.1

*Notes: Data represent mean ± standard deviation (n=3). Trolox was used as the positive control. The data analysis involved using a two-way ANOVA with two factors: four sample parts and the different solvent extraction methods. (All significant at p <0.01 level).

Ferric reducing antioxidant power assay (FRAP)

The reducing capacity of *D. graveolens* extracts, as determined by FRAP assay, demonstrated significant variation among fruit parts (Fig. 4). The 60% acetone extracts exhibited FRAP values ranging from 1.72 to 71.15 mg TE/g, while the 80% methanolic extracts showed values between 1.50 and 59.96 mg TE/g. The non-edible parts exhibited higher FRAP values as compared to the flesh parts in 80% methanol and 60% acetone extracts. The mesocarp displayed highest FRAP values, suggesting strongest antioxidant activity in 60% acetone (71.15 ± 0.41, $p < 0.01$) and 80% methanol extracts (59.96 ± 1.03 mg TE/g, $p < 0.01$), respectively.

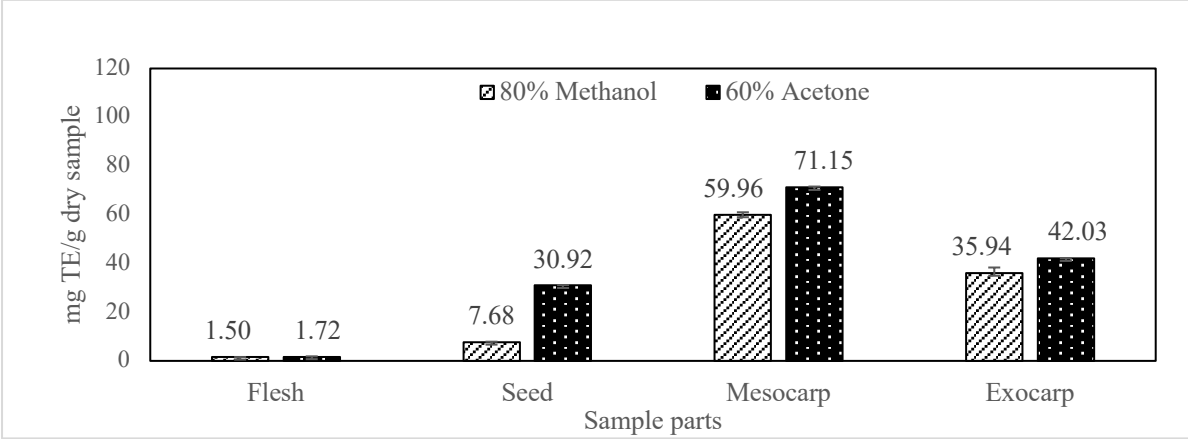

Figure 4: Ferric reducing antioxidant power assay in orange-fleshed *D. graveolens* (mg Trolox per 1 gram of dry sample). The data analysis involved using a two-way ANOVA with two factors: four sample parts and the different solvent extraction methods. (All significant at p <0.01 level).

Correlation between phytochemical content and antioxidant activities

Pearson correlation analysis revealed significant relationships between phytochemical composition and antioxidant capacity (Table 2). Total phenolic content (TPC) and total flavonoid content (TFC) both showed very strong correlations with FRAP (r = 0.987 and r = 0.983, respectively; $p < 0.01$). In contrast, significant inverse correlations were observed between TPC and TFC with IC_{50} values of DPPH and ABTS assays ($r < -0.90$, $p < 0.01$).

Table 2: Pearson's correlation coefficients of TPC and TFC versus DPPH, ABTS and FRAP assay.

Phytochemical content	DPPH [2]	ABTS	FRAP
TPC [1]	-0.990*	-0.992*	0.987*
TFC	-0.987*	-0.989*	0.983*

[1] TPC; Total phenolic content, TFC; total flavonoid content.
[2] DPPH; 2,2-diphenyl-1-picrylhydrazyl radical assay, ABTS; 2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) radical cation assay, FRAP; Ferric reducing antioxidant power assay.
*Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Phytochemical content of *D. graveolens* (TPC and TFC)

The 60% acetone extraction yielded significantly higher TPC values in the non-edible parts (seed, mesocarp, and exocarp) compared to 80% methanolic extracts. This finding aligns with

previous studies demonstrating the higher extraction efficiency of acetone/water mixtures for phenolic compounds in various plant materials, such as in *Macadamia tetraphylla* L.A.S. Johnson (Dailey & Vuong, 2015), *Lippia javanica* Spreng. (Bhebhe et al., 2016), *Eucalyptus* leaves (Nasr et al., 2019), and brewer's spent grains (Meneses et al., 2013). The higher extraction efficiency observed with acetone may result from its intermediate polarity, as it allows for more effective extraction of varied phenolic constituents than methanol.

The flesh extracts showed consistently low TPC values (2.1–3.8 mg GAE/g) between solvent extraction. Consistent with our findings, Abu Bakar et al. (2015) reported that phenolic compounds tend to accumulate in the outer parts as a defence mechanism against pathogens and predators in *Artocarpus* species. Low TPC values have also been observed in the flesh parts of several *Artocarpus* species (Abu Bakar et al., 2015) and Ceri Terengganu (Looi et al., 2020) when compared to their non-edible parts. The differential phenolic distribution can be explained by their physiological roles in plant defence mechanisms. Phenolic compounds serve as both natural pesticides and protective agents against oxidative stress induced by UV radiation (Osorio-Esquivel et al., 2011). Furthermore, they contribute to structural integrity in plant cell walls. As the outer parts are directly exposed to environmental stressors including sunlight, pathogen attack, and physical damage, they typically exhibit higher phenolic biosynthesis compared to the protected inner flesh (Abu Bakar et al., 2015; Looi et al. 2020). This defence-related metabolic investment explains the significantly higher phenolic content observed in the non-edible portions of *D. graveolens*.

The mesocarp (inner peel) of durian exhibited higher phytochemical content than the exocarp. This may be due to the exposure of the outer peel (exocarp) to direct sunlight, temperature fluctuations, and mechanical injury, which disrupt cellular integrity and promote the degradation of bioactive compounds (Feng et al., 2022). Another factor is prolonged post harvest exposure, which can accelerate oxidative loss of phenolics and other secondary metabolites, while the surface is highly susceptible to microbial colonisation that can metabolise or transform native phytochemicals (Narra et al., 2023; ShivShankar et al., 2024; Rawson et al., 2011). In contrast, the mesocarp, being more shielded from light and microbial attack, can better preserve its phenolics and flavonoids, as also observed in Malaysian *Durio zibethinus* mesocarp (Noorhashim et al., 2025).

The 60% acetone extraction demonstrated superior efficacy for flavonoid recovery compared to 80% methanol, consistent with previous reports for brewer's spent grains (Meneses et al., 2013) and *Scurrula ferruginea* (Roxb. ex Jack) Danser leaves (Justine et al., 2019). This enhanced extraction efficiency likely stems from acetone's intermediate polarity, which facilitates solubilisation of diverse flavonoid compounds. Notably, the flesh portion showed consistently low flavonoid content (0.56–2.15 mg CE/g) regardless of solvent system. These findings suggest that flavonoid accumulation patterns in fruit tissues are conserved across species, with protective outer tissues typically containing higher concentrations than edible flesh portions.

Antioxidant activities (DPPH, ABTS and FRAP assays)

The mesocarp with 60% acetone extract demonstrated the strongest activity, with IC_{50} values of 70.4 ± 1.6 µg/ml (DPPH) and 50.0 ± 1.3 µg/ml (ABTS), consistent with its high phenolic and flavonoid contents. This enhanced antioxidant capacity likely results from synergistic interactions among its phytochemical constituents. Comparative analysis revealed superior radical scavenging activity in our samples relative to other *Durio* species. The ethyl acetate extract of *D. kutejensis* (Hassk.) Becc. fruit showed higher IC_{50} values (97.4 µg/ml DPPH;

100.8 µg/ml ABTS) (Arung et al., 2015). Similarly, methanol extracts of *D. zibethinus* peel exhibited reduced activity (IC_{50} = 102.37 ± 1.98 µg/ml) despite containing 33.77 ± 1.77 mg GAE/g phenolics (Wang & Li, 2014). Ethanol extracts of *D. zibethinus* cultivars (Medan and Monthong) displayed intermediate activity (78.83 ± 1.67 and 72.77 ± 6.60 µg/ml, respectively; Muhtadi & Ningrum, 2019).

Consistent with our DPPH and ABTS results, the mesocarp displayed the highest ferric reducing antioxidant power (71.15 ± 0.40 mg TE/g in acetone; 59.96 ± 1.03 mg TE/g in methanol, $p < 0.01$), followed by exocarp > seed > flesh. This tissue-specific pattern correlates with the observed phenolic and flavonoid distribution, explaining the notably lower antioxidant capacity in the flesh portion. These findings align with previous reports on *Myristica fragrans* Houtt., where the seed demonstrated superior reducing activity compared to the flesh (Assa et al., 2014). The redox properties of phenolic compounds, as described by Rice-Evans et al. (1997), provide a mechanistic basis for these observations. Phenolics function as effective antioxidants through multiple pathways: (1) serving as reducing agents, (2) donating hydrogen atoms, and (3) quenching reactive oxygen species. The variation in FRAP values across fruit parts reflects differences in both the concentration and redox potential of their constituent phytochemicals (Nasr et al. 2019).

Influence of total phenolic and total flavonoid content on antioxidant performance

Strong associations were observed between total phenolic and flavonoid content and ferric reducing antioxidant power, indicating that samples richer in phenolics exhibited greater reducing capacity. These findings align with previous studies reporting similar correlations in *Lepidium meyenii* Walp. (r = 0.941, $p < 0.01$; Gan et al., 2017) and *Eucalyptus camaldulensis* Dehnh. (r = 0.985, $p < 0.01$; Nasr et al., 2019) extracts. Additionally, an inverse relationship was noted between phytochemical content and IC_{50} values in both DPPH and ABTS assays. These results demonstrate that extracts with higher phenolic and flavonoid concentrations require lower doses to achieve 50% radical scavenging, consistent with the findings of Evary et al. (2019). The observed patterns support the established mechanism wherein antioxidant efficacy is directly proportional to phenolic concentration, which function as hydrogen donors to neutralise free radicals and mitigate oxidative stress (Evary et al. 2019).

CONCLUSIONS

This study evaluated the phytochemical composition and antioxidant potential of 80% methanolic and 60% acetone extracts from different parts of *D. graveolens* fruit. The findings showed that the mesocarp contained significantly higher levels of total phenolic and flavonoid compounds and exhibited stronger antioxidant activity in FRAP, DPPH, and ABTS assays compared to other parts of the fruit. A strong correlation between these compounds and antioxidant activity suggests they are the main contributors to the observed effects. The high antioxidant capacity of the mesocarp extracts points to their potential as natural sources for pharmaceutical, nutraceutical, and cosmetic applications. These results also support the traditional use of *D. graveolens* and provide useful information for developing value-added products from this under-utilised durian species. Further research should aim to isolate the key active compounds, examine their bioavailability, and investigate their health benefits through *in vivo* studies.

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DECLARATIONS

Research permit(s). JKM/MBS.1000-2/2 JLD.10-45. Sabah Biodiversity Council.
Ethical approval/statement. Not applicable.
Generative AI use. The authors declare that generative AI has been used in compliance with the JTBC policies, and that we have reviewed and edited the content after using this tool/service and we take full responsibility for the content of the publication.

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