Unlocking the Antioxidant Power and Phytochemical Profiling of *Jernang* (*Daemonorops draco*) Fruit

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The growing demand for safer antioxidants has led to increasing interest in plant-derived bioactive compounds. *Daemonorops draco* (Willd.) Blume, locally known as *Jernang* in Indonesian, or Dragon's blood, is a resin-producing fruit traditionally used in medicine and industry, yet its solvent-dependent antioxidant potential and chemical basis remain poorly characterised. This study established a systematic correlation between the solvent polarity, phenolic content, and antioxidant efficacy of *D. draco* resin extracts. *Jernang* resin extracts were obtained through sequential maceration using solvents of increasing polarity: *n*-hexane (hex), dichloromethane (DCM), and methanol (MeOH). The secondary metabolites of phenolic, flavonoid, tannin, and terpenoid groups were confirmed to be present in all extracts through phytochemical screening and FTIR analysis, with alkaloids detected only in the DCM fraction. The total phenolic content (TPC) was highest in the DCM extract followed by MeOH and hex, estimated at 532.9 ± 85.85 mg GAE/g, 462 ± 98.80 mg GAE/g, and 152.3 ± 135.2 mg GAE/g, respectively. Antioxidant activity, measured by DPPH radical scavenging assay, revealed a concentration-dependent inhibition with IC_{50} values of 2.94 ppm, 3.58 ppm, and 26.42 ppm for the DCM, MeOH, and hex extracts, respectively, compared to standard vitamin C (IC_{50} = 0.85 ppm). GCMS profiling identified key bioactive constituents, including methoxylated flavonoids, chalcones, dracorhodin, and other semi-polar antioxidants. A strong negative correlation (r = –0.989) between TPC and IC_{50} further supported the role of phenolic compounds in driving antioxidant activity. These results highlight DCM as the most effective solvent for extracting potent antioxidant compounds from *D. draco* resin, underscoring its potential as a valuable source for pharmaceutical and nutraceutical development. This work extends previous research by elucidating the solvent, composition, and activity relationships of *D. draco* resin.

Keywords: *Daemonorops draco*; antioxidant; free radical; DPPH; phenolic

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Antioxidants are compounds that play a crucial role in protecting cells from damage caused by molecular instability, particularly due to free radicals. Their function is vital for maintaining physiological health, as they act to inhibit or delay the oxidation of other molecules. Antioxidants have been widely applied in various domains, including skincare [1], where they serve to protect the skin from premature ageing induced by oxidative processes. Free radicals are known to trigger oxidative stress, which is a contributing factor in the pathogenesis of numerous degenerative diseases, including cancer [2] and cardiovascular disorders [3]. Consequently, the exploration of natural antioxidant sources, particularly those derived from plants, continues to expand as a promising alternative to synthetic antioxidants, such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA), which have been associated with adverse long-term side effects [4].

Jernang, the local name of the fruit of a non-timber forest product of *Daemonorops draco* commonly called Dragon's blood fruit, is of considerable ecological and economic value. This species grows exclusively in tropical regions, especially in Indonesia's islands of Sumatra, Kalimantan, and Java, as well as some parts of the Malay peninsula [5]. It yields a distinctive red resin traditionally utilised for its antiseptic [6], wound-healing [7], and anti-inflammatory properties [6]. In the healthcare sector, Dragon's blood fruit resin has shown potential in the formulation of therapeutic agents for conditions such as chronic wounds [8] and diabetes mellitus [9]. Some of these command high market values, thereby enhancing the appeal of *D. draco* as a cultivated species. In industrial applications, the resin serves as a natural pigment [10] for varnishes, marble, ceramics, stone-based tools, bamboo, rattan, paint, paper, wood products, etc. Several studies have identified the presence of bioactive compounds in the resin, including flavonoids [11], tannins, triterpenoids [12], and dracorhodin [13], all of which exhibit strong antioxidant activity. However, most existing

studies have used single-solvent extractions or qualitative assays, leaving the relationship between the solvent polarity, phenolic content, and antioxidant strength of *D. draco* resin largely unexplored. Likewise, the mass-spectral characterisation of its key antioxidant flavonoids has not been previously reported.

Given that solvent polarity strongly influences the extraction efficiency of bioactive compounds and their resulting bioactivity, the goal of the current study was to assess the antioxidant activity of *Jernang* resin extracted sequentially using non-polar (*n*-hexane), semi-polar (dichloromethane), and polar (methanol) solvents. The extracts were subjected to phytochemical screening, FTIR characterisation, quantitative determination of total phenolic content (TPC), and compound detection using gas chromatography-mass spectroscopy (GCMS), followed by DPPH-based antioxidant assays. Further, a correlation analysis was performed between the TPC and IC_{50} values to elucidate the contribution of phenolic compounds to the overall antioxidant activity.

EXPERIMENTAL

Chemicals and Materials

The materials used in this study included *Jernang* fruit, ethanol, methanol, dichloromethane, *n*-hexane, gallic acid, sodium carbonate, 2,2-di(4-*tert*-octylphenyl)-1-picrylhydrazyl (DPPH) ($C_{34}H_{44}N_5O_6$), dimethyl sulfoxide (DMSO), ascorbic acid, Mayer's reagent, Wagner's reagent, Dragendorff's reagent, Liebermann-Burchard reagent, Folin–Ciocalteu reagent, gallic acid, and others. All chemical reagents used were of pro-analysis grade, purchased from Sigma-Aldrich (USA).

Sample Preparation

A kilogram of *Jernang* fruit samples were collected in 2024 from Bener Meriah regency, Aceh province, Indonesia. The species was confirmed as *Daemonorops draco* (Willd.) Blume by Dr. Saida Rasnovi, S.Si., M.Si., a taxonomist at Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala of Banda Aceh. The dried pericarp and pulp of the fruit were ground to a fine powder with a mortar and pestle, and stored for further analysis.

Sequential Extraction

The extraction procedure was adapted from the method described by Asmara *et al.* (2023) [14] with appropriate modification. A total of 70 g of *Jernang* powder was subjected to maceration extraction, beginning with *n*-hexane (hex) solvent. The sample was soaked in the solvent for 24 hours, after which the mixture was filtered. The filtrate was then concentrated using a rotary evaporator at 50 °C until a solvent-free viscous extract was obtained. The remaining solid residue was successively re-extracted using dichloromethane (DCM) and methanol (MeOH) following the same procedure. The resulting *Jernang* extracts were used for further testing.

Phytochemical Screening

Phytochemical screening was conducted based on a modified procedure from Recuenco *et al*. (2020) [15] to detect the presence of major classes of secondary metabolites from the *Jernang* resin extracts. Each extract was tested for the presence of alkaloids, flavonoids, tannins, terpenoids, steroids, saponins, and phenolics using standard qualitative reagents (Table 1). Observable colour changes or precipitate formation were recorded as positive results for each compound class.

Table 1. Qualitative phytochemical tests used for *Jernang* resin extracts.

Phytochemical group	Reagent/ Test used	Positive Indication
Alkaloid	Mayer's and Dragendorff's reagents	White or brick-red precipitate
Flavonoid	Shinoda test (Mg + conc. HCl + EtOH)	Orange colouration in EtOH layer
Tannin	1% $FeCl_3$ solution	Dark green to blackish colouration
Terpenoid	Acetic anhydride + conc. H_2SO_4	Brown ring formation
Steroid	Acetic anhydride + conc. H_2SO_4	Green or blue colouration
Saponin	Vigorous shaking in water (1:20)	Stable foam layer
Phenolic	5% $FeCl_3$ solution	Blue or black colouration

Total Phenolic Content (TPC) Determination

The determination of total phenolic content was conducted using a modified version of the Folin–Ciocalteu method as described by Mendez *et al*. (2023) [16] using gallic acid standard solution (10 – 100 ppm). 0.5 mL of each extract solution (100 ppm) was mixed with 0.5 mL of Folin–Ciocalteu reagent. After 5 minutes, 1 mL of 20 % sodium carbonate solution was added, and the solution was diluted to volume with distilled water. The mixture was incubated for 2 hours, and its absorbance was measured at 765 nm. The TPC was calculated using the standard calibration equation and expressed in mg GAE/g dried sample.

Phytochemical Characterisation of Extracts using Fourier Transform Infrared Spectroscopy (FTIR)

The IR spectra of the *Jernang* extracts were recorded within the wavenumber range of 400–4000 cm^{-1}. A small amount of the extract was placed directly onto the ATR crystal of the spectrometer and gently pressed with the pressure arm to ensure optimal contact between the sample and the crystal surface. The analysis was conducted to identify the functional groups present by measuring the percent transmittance (%T) of the sample across the infrared region.

Phytochemical Screening using Gas Chromatography-Mass Spectroscopy (GCMS)

The chemical composition of the *D. draco* resin extracts was analysed using an Agilent 7890B Gas Chromatograph coupled with an MSD 5977B mass selective detector (Agilent Technologies, USA). Separation was achieved using an HP-5MS capillary column (30 m × 0.25 mm i.d., 0.25 µm film thickness). Helium was employed as the carrier gas at a constant flow rate of 1.0 mL/min. The oven temperature was initially held at 70 °C for 3 min, then increased at 10 °C/min to 290 °C, and held for 10 min, giving a total run time of 60 min. The injector temperature was set at 250 °C, and electron impact (EI) ionization at 70 eV was used in scan mode (m/z 40–550). Samples were injected in splitless mode (1 µL injection volume). No chemical derivatization was applied prior to GC–MS analysis. Only concentrated extract solutions were directly injected after filtration through a 0.22 µm PTFE syringe filter. Compound identification was performed by comparing the obtained mass spectra with those in the NIST 17 and Golm Metabolome Database (GMD) libraries. Tentative identifications were accepted for similarity index (SI) values ≥ 65%, which corresponds to a fair-to-good match based on NIST library quality classifications [17, 18]. This threshold has been commonly applied in GC–MS-based phytochemical profiling to minimise false positives while allowing inclusion of compounds with acceptable spectral agreement under natural matrix conditions [19]. Identification of each compound was further confirmed by comparing their retention times and fragmentation patterns with literature data.

Antioxidant Activity Assay

A DPPH free radical inhibition assay was conducted following a modified protocol adapted from Asmara *et al*. [14]. Each concentration of the test solution (12.5–800 ppm for the hex extract and 1.25–80 ppm for the DCM and MeOH extracts) and the positive control of vitamin C (0.391–6.25 ppm) was prepared in triplicate (n = 3). A 2 mL aliquot of each test solution was transferred into individual vials, followed by the addition of 3 mL of 0.1 mM DPPH solution. The mixtures were incubated in the dark for 30 min to prevent photodegradation of DPPH, after which the absorbance was measured at 517 nm. The percentage of inhibition was calculated for each concentration relative to the negative and positive controls, and the IC_{50} values were determined by interpolation from a fitted spline regression curve using GraphPad Prism statistical software.

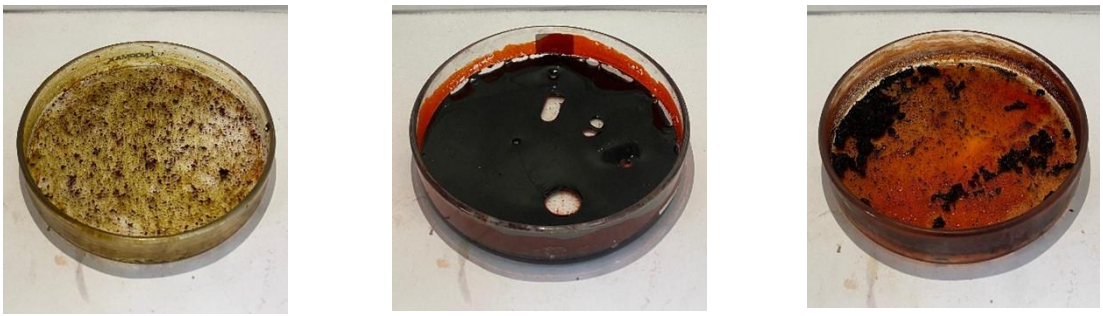
Statistical Analysis

All experiments were performed in triplicate (n = 3), and the data was expressed as mean ± standard deviation (SD). The correlation between TPC and IC_{50} was evaluated using Pearson's correlation test in GraphPad Prism. Differences between the mean values of antioxidant activity and TPC across the three solvent extracts were analysed using one-way ANOVA, followed by Tukey's post-hoc test to determine pairwise significance. A p value < 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Extraction

The maceration process yielded reddish-brown *Jernang* resin extracts with varying quantities depending on the solvent used. Extraction with hex solvent produced a yield of 0.57 %, followed by DCM and MeOH extraction which yielded 21.87 % and 3.01 %, respectively. Previous studies [6, 20] reported that extraction with ethyl acetate or DCM resulted in the highest yield, indicating that *D. draco* resin predominantly possesses semipolar characteristics. The high yield in DCM may be due to the fact that many of the resin's bioactive compounds are neither completely non-polar nor fully polar. Semi-polar solvents achieve a balance, dissolving aromatic backbones, methoxy/hydroxy substituents, and less polar chromophores more effectively, leading to greater extraction efficiency. The appearance of the extracts is shown in Figure 1**.**



A **B** **C**

Figure 1. Photographs of (A) hex, (B) DCM, and (C) MeOH extracts of *D. draco* fruit.

Phytochemical Analysis

The phytochemical screening showed that the hex and MeOH extracts tested positive for flavonoids, tannins, terpenoids, steroids, and phenolics, whereas alkaloids and saponins were not detected (see Table 2). This indicates that these compounds were either absent or present below the detection limit of the qualitative assays used. Moreover, the maceration technique could be considered an ineffective approach to obtain poorly soluble compounds from both missing groups at room temperature [21]. These findings align with those reported by Sari et al. [22], which stated that *Jernang* fruit predominantly contains flavonoids, tannins, and phenolic compounds, while saponins and alkaloids are often absent or insignificant. Indeed, flavalium derivatives such as dracorhodin **5** were commonly identified in these three solvents [23, 24]. As the colour marker of the resin, this compound has been recognised as the standard of quality for commercial Dragon's blood resin [25]. Interestingly, while saponins were also absent in the DCM extract, alkaloids were detected. Two alkaloid compounds, taspine and 2-hydroxy-1-naphthaldehyde isonicotinoyl hydrazone, were previously isolated from the DCM extract of *D. draco* fruit [6].

Table 2. Phytoconstituent groups screened in the *D. draco* extracts.

Group	Hex	DCM	MeOH
Alkaloid	-	+	-
Flavonoid	+	+	+
Tannin	+	+	+
Terpenoid	+	+	+
Saponin	-	-	-
Phenolic	+	+	+

+ = detected, - = not detected

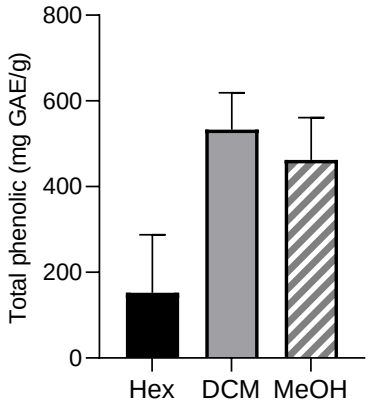


Figure 2. TPC values of the three fruit extracts of *D. draco* as estimated by the Folin–Ciocalteu method (n = 3, values were in mean ± SD).

The TPC of *Jernang* fruit resin extracts varied significantly across different solvents. The values were calculated from a linear equation of gallic acid solution curve ($y = 0.0143x + 0.1013$, $r^2 = 0.999$). As shown in Figure 2, the DCM extract exhibited the highest phenolic concentration, reaching approximately 532.9 ± 85.85 mg GAE/g. This was followed by the MeOH extract with a slightly lower phenolic content (462 ± 98.80 mg GAE/g), while the hex extract showed the lowest phenolic concentration, estimated at 152.3 ± 135.2 mg GAE/g. Instead of phenolics, the hexane-soluble extract is predominately used to obtain long-chain and saturated cyclic hydrocarbons [26]. Our study showed higher TPC values in DCM and MeOH solvents compared to that reported for EtOH extraction of *D. draco* fruit, of 263.93 mg GAE/g [1]. Hence, the observed trend highlights the efficiency of the semi-polar solvent DCM in extracting phenolic compounds from *Jernang*, in comparison to polar MeOH and non-polar hex solvents.

FTIR Analysis

The FTIR spectral analysis, presented in Figure 3, revealed that similar functional groups with different intensities were identified across all three sample extracts. The absorption band at 3500–3200 cm^{-1} corresponded to the O–H stretching vibration of alcohol groups, while the band at 3000–2800 cm^{-1} is attributed to aliphatic C–H (sp^3) stretching. The region between 1600–1450 cm^{-1} indicated the presence of aromatic C=C stretching, and the 1300–1000 cm^{-1} region suggests the presence of C–O stretching of alcohols. These findings supported the positive results for flavonoids and phenolics obtained from the qualitative phytochemical screening of all three extracts. The presence of O–H, C–H, C=C, and C–O functional groups indicates the existence of phenolic and flavonoid compounds [27]. Additionally, both the hex and DCM extracts exhibited typical absorption bands for C=O stretching within the 1870–1780 cm^{-1} range, suggesting the presence of carbonyl-containing compounds. While these spectral characteristics are consistent with functional groups found in phenolic and flavonoid compounds reported in *D. draco* resin, further identification requires complementary spectroscopic evidence, such as GCMS analysis. Moreover, the presence of alkaloids in the DCM extract was indicated by peaks at 3223 cm^{-1} and 1264 cm^{-1} representing N-H stretching and C-N stretching, respectively.

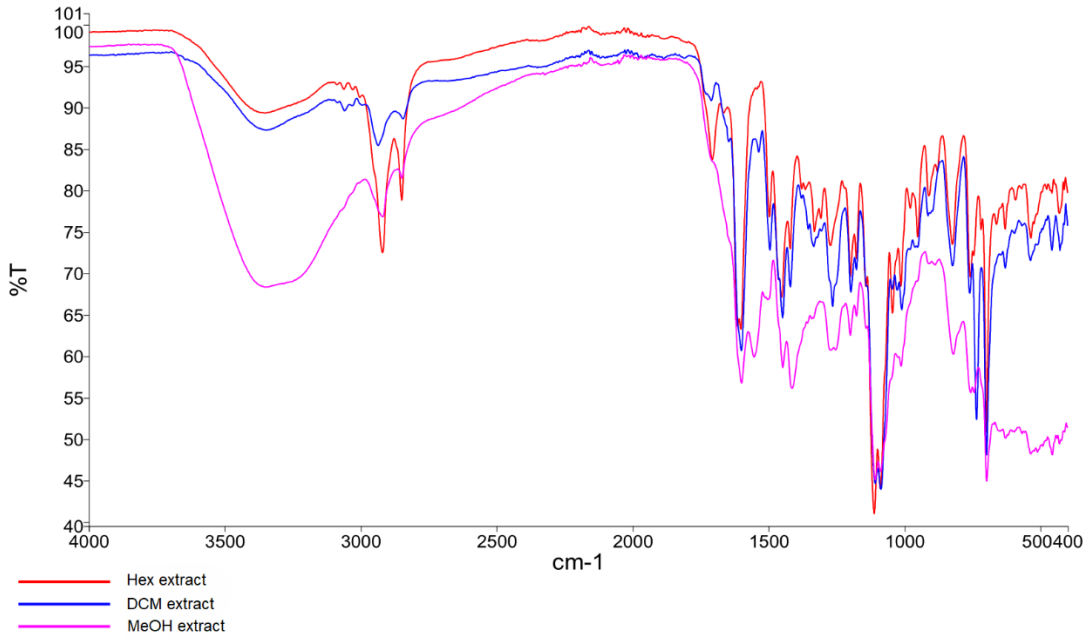


Figure 3. IR spectra of three *D. draco* fruit extracts. A distinctively weak peak at 3223 cm^{-1} associated with N-H stretching was found in the DCM extract.

GCMS Analysis

Structurally diverse classes of compounds (Figure 4) were identified in the three fruit extracts by GCMS analysis. Flavonoids, predominantly flavan derivatives, were detected in all extracts, as shown in Tables 3–5. Notably, 5-methoxy-7-flavanol **1** and 5-methoxy-6-methylflavan-7-ol **2** were identified in all extracts, while the resin's characteristic pigment, dracorhodin **5**, appeared in both DCM and MeOH extracts. The mass spectral fragmentation profiles of these compounds showed strong agreement with NIST library spectra. 5-Methoxy-7-flavanol **1** exhibited major ions at *m*/*z* 152 and 256, attributed to retro-Diels–Alder cleavage of the flavan C-ring and a high-mass flavanyl fragment [28]. 5-Methoxy-6-methylflavan-7-ol **2** displayed characteristic ions at *m*/*z* 270, 239, and 166, corresponding to the molecular ion, demethylated fragment, and aromatic ring fragment, respectively [29]. Meanwhile, dracorhodin **5** showed prominent ions at *m*/*z* 266, 251, and 77, representing the molecular ion, loss of a methyl group, and a phenyl cation from aromatic cleavage [23]. These diagnostic ions and consistent fragmentation pathways are typical of methoxy- and hydroxy-substituted flavonoid or anthraquinone derivatives. Typical flavans such as 5-methoxy-7-flavonol **1** and 5-methoxy-6-methylflavan-7-ol **2** [13] and dracorhodin **5** [30] have been isolated and recognised as the bioactive constituents of Dragon's blood fruit. A chalcone derivative, 3,4-dimethoxychalcone **4**, was found in DCM and methanol extracts, further supporting the presence of various methoxylated flavonoid structures [9]. The detected flavonoids not only highlighted the chemical richness of *D. draco* but also implied its significant pharmacological potential, particularly in antioxidant applications.

Table 3. Prominent compounds identified in the hex extract of *D. draco* fruit by comparison with Database Data (Golm Metabolome Database/ NIST).

Number	Retention time (min)	Identified compound	*m*/*z*	Relative abundance (%)	Similarity (%)
1	40.54	5-Methoxy-7-flavanol **1**	256	15.96	77.2
2	40.99	5-Methoxy-6-methylflavan-7-ol **2**	270	66.65	92
3	52.99	*β*-Sitosterol **3**	415	6.85	77.7

Table 4. Prominent compounds identified in the DCM extract of *D. draco* fruit by comparison with Database Data (Golm Metabolome Database/ NIST).

Number	Retention time (min)	Identified compound	*m*/*z*	Relative abundance (%)	Similarity (%)
1	41.17	5-Methoxy-6-methylflavan-7-ol **2**	270	36.64	92.3
2	40.68	5-Methoxy-7-flavanol **1**	256	35.08	74.5
3	43.001	3,4-Dimethoxychalcone **4**	268	7.51	72.1
4	46.85	Dracorhodin **5**	266	8.16	80.9

Table 5. Prominent compounds identified in the MeOH extract of *D. draco* fruit by comparison with Database Data (Golm Metabolome Database/ NIST).

Number	Retention time (min)	Identified compound	*m*/*z*	Relative abundance (%)	Similarity (%)
1	40.58	5-Methoxy-7-flavanol **1**	256	33.54	74.4
2	41.09	5-Methoxy-6-methylflavan-7-ol **2**	270	41.67	92.2
3	43.001	3,4-Dimethoxychalcone **4**	268	3.37	66.5
4	46.86	Dracorhodin **5**	266	9.52	78.5

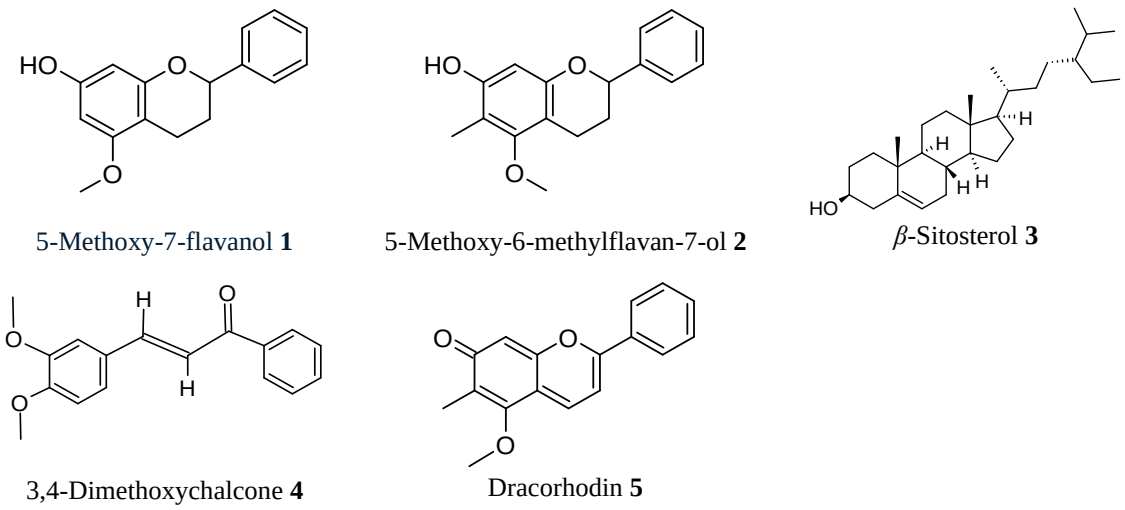


Figure 4. Molecular structures of compounds identified in this study.

Alkaloids were detected in the DCM extract through qualitative and FTIR analyses. GCMS analysis identified minor peaks corresponding to ergoline-type alkaloids in both DCM and MeOH extracts. This apparent discrepancy may arise from differences in method sensitivity and chemical form. The qualitative assays and FTIR primarily detect ionised alkaloid salts, which are more soluble in semi-polar solvents such as DCM, whereas GCMS detects volatile free-base forms after sample vaporisation. During GCMS analysis, partial thermal or solvent-induced conversion of alkaloid salts to free bases can occur, allowing detection even in the MeOH fraction where they were not detected by colorimetric tests [31]. The group was absent from the hex extract, as the non-polar solvent is ineffective at extracting the naturally occurring salt forms of alkaloids [32]. Indeed, previous work isolated two different alkaloids of taspine and 2-hydroxy-1-naphthaldehyde isonicotinoyl hydrazone from the DCM fraction of *D. draco* fruit [6].

Steroidal compounds were detected in the hex extract, including *β*-sitosterol **3** and spirost-8-en-11-one. This distribution suggested a spectrum of lipophilicity among the steroidal constituents, with some structures amenable to non-polar extraction and others favouring a semi-polar solvent. Terpenoids were limited to the hex extract, with the detection of 3-hydroxy-(3*S*,5*a*,14*β*,20*β*,20*β*,25*R*)-spirost-8-en-11-one, consistent with the typical non-polar nature of triterpenoids and their preference for non-polar solvent systems.

Fatty acids and their esters were detected primarily in the hex extract, including methyl-11-methyldodecanoate. These compounds reinforced the expected extraction behaviour of fatty acids, which typically favour less polar solvents. However, an amphipathic ester of octadecanoic acid, *cis*-(2-phenyl-1,3-dioxolan-4-yl)methyl ester, was also present in the MeOH extract, reflecting a solubility profile compatible with polar solvents. Although GCMS analysis revealed several amphiphilic compounds, these molecules are not classified as saponins. True saponins are characterised by a triterpenoid or steroidal aglycone covalently linked to sugar moieties through glycosidic bonds. In contrast, the amphiphilic compounds detected here lacked carbohydrate linkages and thus do not meet the structural definition of saponins. Moreover, saponins are thermally unstable and non-volatile, making them poorly detectable under GCMS conditions without prior hydrolysis [33].

Phenolic compounds were surprisingly limited in the GCMS detection, with only 2,4-bis(1-methyl-1-phenylethyl)phenol detected in the hex extract. This apparent discrepancy arises from the analytical limitations of GCMS, which preferentially detects volatile, low-molecular-weight, and thermally stable compounds. In contrast, many plant phenolics, particularly flavonoid glycosides, tannins, and polymeric phenols, are non-volatile and thermolabile. Furthermore, another notable compound detected in both the DCM and MeOH extracts was 4,14-retro-retinol. Another member of the retinoid group was previously isolated from a DCM fraction [6].

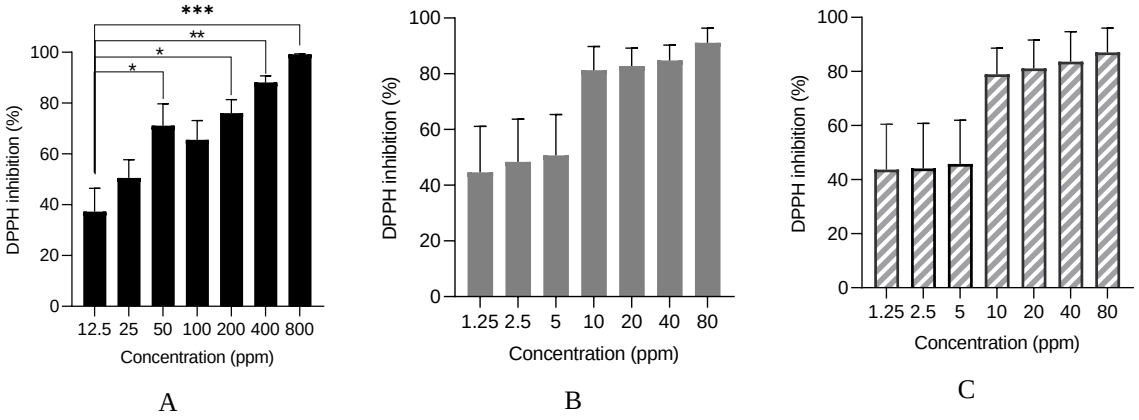


Figure 5. The inhibition activities of the (A) hex, (B) DCM, and (C) MeOH extracts of *D. draco* fruit against DPPH (n = 3, values reported as mean ± SD, $^{*}p = 0.01$, $^{**}p = 0.001$, $^{***}p = 0.0002$).

Although the MeOH extract tested positive for terpenoids in the qualitative assay, no terpenoid compounds were detected in its GCMS profile. This discrepancy can be attributed to differences in the analytical principles of the two methods. The Salkowski and Liebermann–Burchard tests used for terpenoid screening detect unsaturated triterpenoids or steroidal structures based on colorimetric reactions with functional groups such as double bonds and carbonyl moieties. These assays respond to both free terpenoids and bound or oxidised derivatives, including non-volatile glycosides or conjugated forms. In contrast, GCMS selectively identifies volatile and thermally stable compounds. In fact, many terpenoids, particularly oxygenated or polymerised triterpenes, are thermolabile and decompose during GC injection unless chemically derivatized.

Antioxidant Activity

Based on the DPPH inhibition graphs in Figure 5, all three extracts demonstrated concentration-dependent antioxidant activity. However, the degree of inhibition significantly varied depending on the solvent used. The DCM extract showed the highest antioxidant activity, achieving nearly 90 % inhibition at only 80 ppm. This result correlated strongly with its lowest IC_{50} value of 5.255 ppm. The MeOH extract also performed well, reaching close to 85 % inhibition at 80 ppm, with an IC_{50} of 6.181 ppm. In contrast, the hex extract required substantially higher concentrations, from 400 to 800 ppm, to reach similar inhibition levels, and its IC_{50} value was 20.656 ppm, the weakest among the three. All extracts' activities were below the IC_{50} value of 0.85 ppm of the positive control, vitamin C (data not shown).

These antioxidant patterns are strongly supported by the phytochemical screening results and total phenolic content data. Phytochemical tests confirmed that the DCM extract contained flavonoids, tannins, and alkaloids. Moreover, the DCM extract contained the highest total phenolic content. The MeOH extract also exhibited a high phenolic content and was positive for flavonoids, tannins, and phenolics based on the phytochemical tests. The presence of strong FTIR absorption bands in the region of 3200–3500 cm^{-1} confirmed the abundant O–H stretching vibrations, typical of hydroxyl groups found in phenolic and flavonoid compounds. GCMS profiling further complemented the spectroscopic data by identifying prominent bioactive constituents of the flavan sub-class. It is worth noting that flavan members, such as 5-methoxy-7-flavanol **1** and dracorhodin **5**, along with chalcone derivative of 3,4-dimethoxychalcone **4** were consistently detected in the two higher antioxidant extracts. These compounds are distinguished by their multiple hydroxyl and methoxy groups, which enhance antioxidant potential through both hydrogen atom transfer (HAT) and single electron transfer (SET) mechanisms. The detection of dracorhodin **5** is especially significant because this compound, in the form of synthesised dracorhodin perchlorate, has previously been reported to protect mitochondria from the damaging effects of reactive oxygen species in sepsis patients [34]. In addition, the presence of alkaloids, retinoid-like molecules, and spirocyclic sulphur compounds added to the pool of redox-active molecules contributing to the observed antioxidant activity.

Table 6. Pearson's correlation coefficient of TPC and IC_{50}.

TPC (mg GAE/g)			IC_{50} (ppm)			Coefficient of Pearson's correlation
hex	**DCM**	**MeOH**	**hex**	**DCM**	**MeOH**	
152.3 ± 135.2	532.9 ± 85.85	462 ± 98.80	26.42	2.94	3.58	–0.989

On the other hand, the hex extract, which showed the lowest phenolic content, exhibited the weakest antioxidant activity. Although it also contained flavans, this non-polar solvent is generally less effective at extracting phenolic and flavonoid compounds. The FTIR spectra indicated the vibrations of aliphatic C–H and weak O–H bands, with notably weaker signals in the aromatic C=C and C=O regions compared to the DCM extract. These spectral characteristics are consistent with the dominance of saturated hydrocarbons, steroids, and long-chain fatty acids in the hex fraction, as confirmed by the GCMS chromatogram which detected *β*-sitosterol **3**, spirost-8-en-11-one, fatty acid esters, and terpenoids. Such compounds are typically poor radical scavengers due to the absence of extended π-systems or electron-donating groups to neutralise the DPPH free radicals. Importantly, compared to the other two extracts, fewer flavonoid derivatives were detected in the hex extract by GCMS, including 5-methoxy-7-flavanol **1** and 5-methoxy-6-methylflavan-7-ol **2**. This finding was in line with its TPC and IC_{50} values, which were the lowest among the three extracts.

Correlation Analysis

The Pearson's correlation coefficient (*r*) yielded a strong negative value of –0.989 as shown in Table 6, indicating a near-perfect inverse relationship between TPC and IC_{50}. This result implies that as the phenolic content of an extract increases, the IC_{50} value significantly decreases, meaning the extract becomes more effective at scavenging free radicals. This strong negative correlation confirms that phenolic compounds play a major role in determining the antioxidant potential of *Jernang* fruit extracts. Although this value indicates a clear trend, it should be interpreted with caution, as it is based on only three solvent extracts and therefore lacks statistical significance in a formal sense. Nevertheless, the consistent pattern across the extracts supports the qualitative inference that phenolic compounds substantially contribute to the radical-scavenging activity of *D. draco* resin.

It is also recognised that the GCMS data underestimated phenolic representation relative to the strong responses observed in TPC and FTIR analyses. This limitation arises from the selectivity of GCMS for volatile and thermally stable molecules, whereas most phenolics in plant resins are non-volatile, polymeric, or thermolabile compounds that degrade during GCMS injection. Consequently, while GCMS detects only a small fraction of low-molecular-weight phenolics, colorimetric and spectroscopic assays capture the broader pool of non-volatile phenolic constituents responsible for the observed antioxidant activity. Future work should include LCMS or HPLC quantification of specific phenolics to confirm this relationship with greater statistical robustness and molecular coverage.

CONCLUSION

This study presents a comparative assessment of *Jernang* resin extracts obtained through sequential maceration with solvents of increasing polarity. Among the extracts, the DCM fraction exhibited the highest total phenolic content (532.9 ± 85.85 mg GAE/g) and the strongest antioxidant activity (IC_{50} = 2.94 ppm), with a strong inverse correlation to phenolic concentration (*r* = –0.989). Phytochemical and GCMS analyses revealed methoxylated flavonoids, chalcones, and dracorhodin as the principal constituents contributing to the radical scavenging effect. While previous studies have reported the antioxidant potential of *D. draco*, this work extends current knowledge by establishing a quantitative link between solvent polarity, phenolic content, and antioxidant efficiency, supported by mass-spectral evidence of the major antioxidant compounds. These results suggest the potential of *Jernang* resin as a promising natural antioxidant source, warranting further investigation through bioassay-guided isolation and in vitro or in vivo evaluations before considering pharmaceutical or nutraceutical applications.

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