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Determination of chemical composition and evaluation of the antioxidant activity of alcoholic extracts from the fruits of *Caryota mitis* Lour. In Việt Nam

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Abstract

Caryota mitis Lour. is a tropical palm species traditionally used in folk medicine and considered a potential source of natural bioactive compounds. The present study aimed to investigate the phytochemical composition and antioxidant activity of the ethanolic fruit extract of *Caryota mitis* Lour. collected in Thai Nguyen province, Viet Nam. Qualitative phytochemical screening revealed the presence of several important secondary metabolites, including flavonoids, tannins, alkaloids, and saponins. The phytochemical profile of the extract was further analyzed using GC–MS, which tentatively identified more than 100 compounds belonging to different chemical groups such as flavonoids, lignans, alkaloids, steroids, ketones, and aromatic amides. Among the detected compounds, 3,3-Dimethoxy-2-butanone and 1-Butanamine were identified as major constituents. Several compounds with known biological activities, including flavonoid and phenolic derivatives, were also detected, suggesting potential pharmacological significance. The antioxidant activity of the extract was evaluated using the DPPH radical scavenging assay. The extract exhibited concentration-dependent antioxidant activity with considerable free radical scavenging capacity compared with vitamin C. The observed antioxidant potential may be associated with the synergistic effects of phenolic and flavonoid constituents present in the extract. These findings indicate that *Caryota mitis* Lour. fruits may serve as a promising natural source of bioactive compounds for pharmaceutical and functional food applications.

Keywords: Antioxidant activity; Bioactive compounds; *Caryota mitis* Lour.; DPPH assay; Ethanolic extract; Flavonoids; GC–MS analysis; Phytochemical screening

1. Introduction

Caryota mitis Lour., commonly known as the fishtail palm, belongs to the family Arecaceae and is widely distributed throughout tropical and subtropical regions of Asia, including Viet Nam, Thailand, India, Malaysia, Indonesia, and southern China. The species is commonly cultivated as an ornamental palm and also occurs naturally in humid forests and mountainous areas [1]. In traditional medicine, different parts of *Caryota mitis* Lour. have been used for the treatment of inflammation, joint pain, digestive disorders, and several other ailments in Asian countries [2].

The species is characterized by clustered stems, bipinnate leaves with fishtail-shaped leaflets, and globose fruits that turn reddish when mature. Previous phytochemical investigations revealed that *Caryota mitis* Lour. contains diverse classes of secondary metabolites, including flavonoids, phenolic compounds, sterols, triterpenoids, alkaloids, and glycosides [3]. Several compounds isolated from the leaves and fruits, such as quercetin, kaempferol, rutin, β-sitosterol, and chlorogenic acid derivatives, have been reported to possess important biological activities, particularly antioxidant and antimicrobial effects [3].

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Recent studies demonstrated that ethanolic and methanolic extracts of *Caryota mitis* Lour. exhibited significant antioxidant activity through DPPH radical scavenging assays, suggesting that the plant may serve as a promising natural source of antioxidants [4]. The antioxidant potential was strongly associated with the presence of flavonoids and phenolic constituents in the extracts. In addition, phytochemical screening of the species revealed the occurrence of bioactive metabolites that may contribute to its pharmacological properties and potential applications in pharmaceutical and functional food industries [3], [4].

More recently, advanced phytochemical analyses using LC-MS/MS and HR-LCMS-QTOF identified numerous bioactive constituents in *Caryota mitis*, including flavonoids, anthraquinones, and phenolic compounds with anti-inflammatory, antidiabetic, and antioxidant activities [5], [6]. Studies on fruit peel extracts further demonstrated their ability to inhibit reactive oxygen species (ROS), suppress inflammatory mediators, and exhibit xanthine oxidase inhibitory activity, supporting the traditional medicinal use of the species [5]. Furthermore, extracts of *Caryota mitis* Lour. fruits were reported to stimulate chondrocyte proliferation and contain several cerebrosides and other biologically active compounds [7].

Although several studies have investigated the pharmacological potential of *Caryota mitis*, information regarding the chemical composition and antioxidant activity of ethanol extracts from fruits collected in Viet Nam remains limited. Therefore, the present study aimed to evaluate the phytochemical composition of the ethanol extract of *Caryota mitis*fruits using GC–MS analysis and to assess its antioxidant activity, thereby providing scientific evidence for the potential utilization of this species as a natural source of bioactive compounds in pharmaceutical and functional food applications.

2. Materials and methods

2.1. Materials

Fresh fruits of *Caryota mitis* Lour. were collected in March 2026 from naturally growing plants in Thai Nguyen province, Viet Nam, and subsequently used for ethanol extraction, phytochemical profiling, and antioxidant activity evaluation. The collected fruits were cleaned, air-dried under shade conditions, pulverized into fine powder, and preserved in airtight containers prior to extraction and chemical analysis.

The plant material was taxonomically authenticated by Assoc. Prof. Dr. Sỹ Danh Thường, Thai Nguyen University of Education – Thai Nguyen University, based on standard botanical identification methods and comparison with published taxonomic descriptions. A voucher specimen was deposited at the Biological Museum, Faculty of Biology, Thai Nguyen University of Education, under the reference code TNUE-CAM2026-03.

2.2. Methods

2.2.1. Preparation of Ethanol Extract:

Fresh fruits of Caryota mitis Lour. were washed thoroughly with distilled water to remove dirt and impurities, then dried at 55°C in a convection oven until a constant weight was achieved. The dried fruits were mechanically ground into a fine powder. A total of 100 g of fruit powder was macerated in 99% ethanol at a ratio of 1:10 (w/v) at room temperature for 72 hours with occasional shaking to improve extraction efficiency. The mixture was filtered through Whatman No. 1 filter paper to separate the solid residues. The filtrate was concentrated under reduced pressure using a rotary evaporator at 40°C to obtain the crude ethanolic extract. The resulting extract was stored in airtight containers at 4°C for further phytochemical and antioxidant analyses. The ethanolic extract of *Caryota mitis* Lour. fruits was expected to contain various bioactive compounds associated with antioxidant potential.

2.2.2. Qualitative Phytochemical Analysis

Qualitative phytochemical screening of the ethanolic extract obtained from the fruits of Caryota mitis Lour. was carried out using standard phytochemical identification methods. The presence of major secondary metabolites was evaluated as follows: alkaloids using Wagner's and Dragendorff's reagents, flavonoids using the cyanidin reaction and NaOH test, tannins using ferric chloride ($FeCl_3$) solution, and saponins using the frothing test with hot water. All analyses were performed under standard laboratory conditions, and each assay was conducted in triplicate to ensure reliability and reproducibility of the results. The occurrence of phytochemical constituents was determined based on characteristic color changes or precipitate formation according to established protocols.

2.2.3. GC/FID and GC/MS Analysis

The ethanol extract obtained from the fruits of *Caryota mitis* Lour. was subjected to GC/FID and GC/MS analyses to determine its volatile chemical constituents. After ethanol extraction and concentration under reduced pressure, the crude extract was partitioned with n-hexane to obtain the fraction containing volatile compounds. The n-hexane-soluble fraction was then used for chromatographic analysis. GC/MS analysis was carried out using a Hewlett Packard 5890 Series II GC system coupled with an HP 5971 MSD quadrupole mass spectrometer (Agilent Technologies, USA). Separation was achieved on an HP-5MS fused silica capillary column (30 m × 0.25 mm i.d.; film thickness 0.25 μm) coated with a non-polar stationary phase. Helium (99.99% purity) served as the carrier gas at a constant flow rate of 0.9 mL/min. The oven temperature program was initially maintained at 50 °C for 3 min, then increased at a rate of 3 °C/min to 200 °C, followed by a further increase at 10 °C/min to 240 °C and held for 3 min. The total analytical run time was approximately 60 min. The injector and ion source temperatures were maintained at appropriate operating conditions, and ionization was performed in electron impact (EI) mode at 70 eV with a mass scan range of 30–600 amu. A flame ionization detector (FID) was additionally employed for GC-FID analysis to support compound detection and quantification. Identification of individual constituents was based on comparison of their retention indices (RIs) and mass spectra with reference data from the NIST Chemistry WebBook and the Wiley NBS75K.L and NIST/EPA/NIH mass spectral libraries.

2.2.4. Determination of Antioxidant Activity by DPPH Radical Scavenging Assay

The antioxidant capacity of the ethanolic extract prepared from the fruits of Caryota mitis Lour. was assessed using the DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical scavenging method with slight modifications from the procedure described by Tabart et al. (2009) [12]. Serial concentrations of the extract (0.5, 1, 2, 4, 8, 16, 32, 64, and 128 μg/mL) were prepared in methanol. For each assay, 100 μL of the extract solution was combined with 2.9 mL of freshly prepared 0.1 mM DPPH methanolic solution. The reaction mixtures were vortexed thoroughly and maintained in the dark at room temperature for 30 min to facilitate complete interaction between the antioxidant compounds and DPPH radicals. Following incubation, absorbance measurements were taken at 517 nm using a UV–Vis spectrophotometer. The radical scavenging efficiency of the extract was calculated using the following equation: DPPH scavenging activity (%) = 100 x (Ac - As)/Ac.

where Ac denotes the absorbance of the control sample containing DPPH solution without extract, while As refers to the absorbance measured in the presence of the tested extract. The antioxidant potential was expressed as the IC5050 value, representing the concentration of extract required to inhibit 50% of DPPH free radicals. All experiments were performed in triplicate, and the results were presented as mean ± standard deviation.

3. Results and discussion

3.1. Qualitative Phytochemical Analysis

The qualitative phytochemical screening results of the ethanolic extract obtained from the fruits of *Caryota mitis* Lour. are presented in Table 1. The analysis demonstrated the presence of several major groups of secondary metabolites, including flavonoids, tannins, alkaloids, and saponins. These phytochemicals are widely recognized as important bioactive compounds contributing to antioxidant and other pharmacological activities in medicinal plants. Previous investigations on species belonging to the genus *Caryota* have also reported the occurrence of phenolic compounds, flavonoids, proanthocyanidins, and other antioxidant-related metabolites in fruits and other plant parts (El-Akad et al., 2021 [9]; Sujitha & Kripa, 2019 [10]).

In the present study, positive reactions were observed through characteristic color changes and precipitate formation during standard phytochemical tests. The detection of flavonoids and tannins suggests that the ethanolic fruit extract may possess considerable free radical scavenging potential, since these compounds are known to donate hydrogen atoms or electrons to neutralize reactive oxygen species. Similarly, alkaloids and saponins have been associated with anti-inflammatory, antimicrobial, and cytoprotective effects in various medicinal plant extracts.

Table 1 Qualitative phytochemical analysis of ethanolic fruit extract of *Caryota mitis* Lour

No.	Compound Class	Specific Test	Observation	Result
1	Alkaloids	Wagner's reagent	Brown precipitate	(+)
		Dragendorff's reagent	Orange precipitate	
2	Flavonoids	Cyanidin reaction	Orange-red coloration	(+)
		NaOH test	Intense yellow solution	
3	Tannins	$FeCl_3$ solution	Greenish-brown coloration	(+)
4	Saponins	Frothing test	Stable foam formation	(+)

The diversity of phytochemicals detected in the ethanolic extract may be related to the extraction efficiency of ethanol, which is capable of dissolving both polar and moderately polar constituents. Earlier metabolomic profiling studies of *Caryota mitis* Lour. revealed the presence of flavonoid derivatives and phenolic metabolites in fruit tissues, supporting the phytochemical observations obtained in this study (El-Akad et al., 2021 [10]). Moreover, studies on related species such as *Caryota urens* and *Caryota ochlandra* demonstrated strong antioxidant properties associated with phenolic-rich fractions and proanthocyanidins (Sujitha & Kripa, 2019 [11]; Shi et al., 2014 [12]). Therefore, ethanol was considered an appropriate extraction solvent for recovering antioxidant-associated compounds from *Caryota mitis* Lour. fruits.

3.2. Phytochemical Profiling of the Extract by GC–MS Analysis

The phytochemical composition of the ethanolic extract of *Caryota mitis* Lour. fruits was investigated using GC–MS analysis. The chromatographic analysis revealed the presence of a chemically diverse mixture of secondary metabolites. Based on comparison with the NIST20 mass spectral library, more than 100 compounds were tentatively identified in the extract. However, only representative constituents with relatively high peak areas, acceptable match factors, and potential biological significance were selected and summarized in Table 2 to facilitate interpretation of the phytochemical profile.

The detected compounds belonged to several major classes of phytochemicals, including amines, flavonoids, alkaloids, ketones, lignans, steroids, aromatic amides, phenolic derivatives, and silicon-containing compounds. Among the detected constituents, 3,3-Dimethoxy-2-butanone was identified as the predominant compound, accounting for 13.72% of the total peak area, followed by 1-Butanamine (8.73%). In addition, Silicon tetrafluoride (2.67%) and N-(3,4-Difluorophenyl)thiophene-2-carboxamide (1.31%) were also detected in considerable amounts.

Several compounds identified in the extract are known to possess potential biological activities. Notably, flavonoid-related compounds such as 5,6,4'-Trihydroxy-7,8-dimethoxyflavone and chromone derivatives were detected in the GC–MS profile. Flavonoids are widely recognized as natural antioxidants because of their ability to donate hydrogen atoms or electrons and stabilize free radicals, thereby reducing oxidative damage in biological systems (Panche et al., 2016) [13] . Similarly, chromone and flavone derivatives have been reported to exhibit antioxidant, anti-inflammatory, and antimicrobial activities (Kumar & Pandey, 2013) [14].

The lignan compound Podofilox identified in the extract has previously been associated with cytotoxic, antiviral, and antioxidant properties. Podophyllotoxin-related compounds are important bioactive metabolites frequently investigated for their pharmaceutical applications, particularly in anticancer drug development (Imbert, 1998) [15]. Moreover, alkaloid compounds such as Yohimban derivatives and Ethyl 5-methoxy-3-methyl-2-indolecarboxylate were also detected. Alkaloids are known to exhibit a wide spectrum of pharmacological activities, including antimicrobial, anti-inflammatory, analgesic, and antioxidant effects (Aniszewski, 2007) [16].

Steroidal constituents including Cholestan-16-one and Estrone octanoate were additionally identified in the extract. Steroidal compounds isolated from medicinal plants have been reported to contribute to membrane stabilization, anti-inflammatory activity, and physiological regulation (Saeidnia et al., 2014) [17]. The occurrence of multiple classes of phytochemicals in the present study suggests that *Caryota mitis* Lour. fruit extract may represent a promising natural source of bioactive secondary metabolites with potential pharmaceutical and nutraceutical applications.

The present findings are consistent with previous reports demonstrating that medicinal plants rich in phenolic compounds, flavonoids, and alkaloids generally exhibit significant antioxidant activity. Harborne (1998) [18] emphasized that flavonoids and phenolic constituents play essential roles in plant defense systems against oxidative stress. Dai and Mumper (2010) [19] reported that phenolic compounds can effectively scavenge reactive oxygen species and contribute substantially to the antioxidant capacity of medicinal plant extracts.

Table 2 Representative compounds identified in the extract by GC–MS

RT	Representative compound	Molecular formula	Area (%)	Chemical group
3.1284	1-Butanamine	$C_4H_{11}N$	8.73	Amine
3.8939	3,3-Dimethoxy-2-butanone	$C_6H_{12}O_3$	13.72	Ketone/Oxygenated compound
3.8827	Silicon tetrafluoride	F_4Si	2.67	Silicon-containing compound
20.4907	5,7-Dihydroxy chromone derivative	$C_{20}H_{18}O_7$	0.37	Flavonoid
24.7457	5,6,4'-Trihydroxy-7,8-dimethoxyflavone	$C_{17}H_{14}O_7$	0.25	Flavonoid
12.1160	Podofilox	$C_{22}H_{22}O_8$	0.61	Lignan
53.5450	Ethyl 5-methoxy-3-methyl-2-indolecarboxylate	$C_{13}H_{15}NO_3$	0.38	Alkaloid
31.3771	Yohimban derivative	$C_{22}H_{28}N_2O_4$	0.29	Alkaloid
41.2978	Cholestan-16-one	$C_{27}H_{46}O$	0.32	Steroid
32.0928	Estrone octanoate	$C_{26}H_{36}O_3$	0.49	Steroid
59.3593	N-(3,4-Difluorophenyl)thiophene-2-carboxamide	$C_{11}H_7F_2NOS$	1.31	Aromatic amide

Note: Only representative compounds with relatively high peak areas or characteristic compounds representing major chemical groups detected in the extract are presented in the table.

3.3. Evaluation of Antioxidant Activity

The antioxidant potential of the ethanolic fruit extract of *Caryota mitis* Lour. was evaluated using the DPPH free radical scavenging assay. The results revealed that the scavenging activity increased progressively with increasing extract concentration, indicating a concentration-dependent antioxidant effect (Figure 1). At lower concentrations, the extract exhibited moderate radical scavenging capacity, whereas higher concentrations produced substantially greater inhibition percentages, approaching the activity of the reference antioxidant, vitamin C.

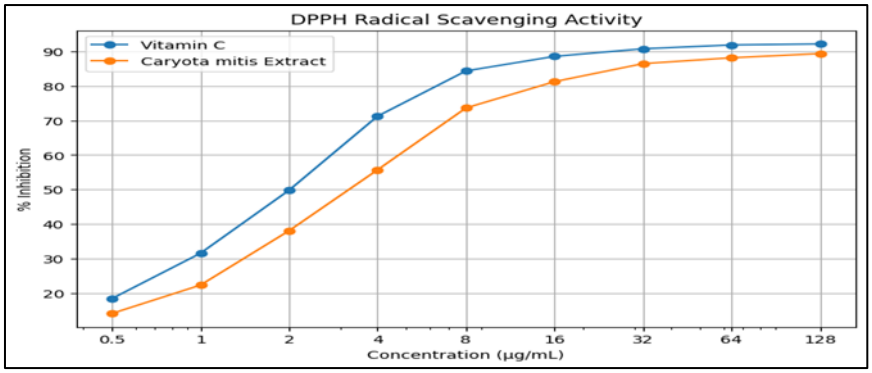

Figure 1 Relationship between extract concentration and DPPH radical scavenging activity (%) of *Caryota mitis* Lour. fruit extract and vitamin C

The ethanolic extract of *Caryota mitis* Lour. fruits demonstrated considerable antioxidant activity with an IC50 value within the range generally categorized as strong antioxidant potential. Previous phytochemical investigations on *Caryota* species have reported the presence of phenolic compounds, flavonoids, and proanthocyanidins that may

contribute significantly to free radical scavenging activity (Shi et al., 2014 [11]; El-Akad et al., 2021 [9]). These compounds are capable of donating hydrogen atoms or electrons to stabilize DPPH radicals and reduce oxidative stress.

Comparative studies on related palm species such as *Caryota urens* also demonstrated notable antioxidant properties associated with flavonoid-rich and phenolic-rich fractions (Sujitha & Kripa, 2019) [10]. The antioxidant activity observed in the present study may therefore be attributed to the synergistic effects of multiple secondary metabolites detected during phytochemical screening, including flavonoids, tannins, alkaloids, and saponins.

Although vitamin C exhibited stronger antioxidant efficiency than the plant extract, the fruit extract of *Caryota mitis* Lour. still showed promising radical scavenging activity. However, the DPPH assay only reflects one aspect of antioxidant action, specifically hydrogen or electron donation capacity. Additional assays such as ABTS, FRAP, lipid peroxidation inhibition, and cellular antioxidant activity tests would be necessary to further clarify the overall antioxidant mechanism and potential biological applications of the extract.

4. Conclusion

The present study demonstrated that the ethanolic fruit extract of *Caryota mitis* Lour. contains diverse bioactive phytochemicals, including flavonoids, tannins, alkaloids, and saponins. GC–MS analysis tentatively identified more than 100 compounds belonging to various chemical groups such as flavonoids, lignans, alkaloids, steroids, and aromatic amides, with 3,3-Dimethoxy-2-butanone and 1-Butanamine as the major constituents. The extract also showed considerable DPPH radical scavenging activity in a concentration-dependent manner, indicating promising antioxidant potential. These findings suggest that *Caryota mitis* Lour. fruits may serve as a valuable natural source of bioactive compounds for pharmaceutical and functional food applications.

Compliance with ethical standards

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Disclosure of conflict of interest

All the authors hereby declare that no conflicts of interest exist related to this article.

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