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Chromatographic profiling and phytomedicinal properties on leaf of *Memecylon umbellatum* Burm. f.

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Abstract

Memecylon umbellatum Burm. f., a medicinal plant native to the Western Ghats of India, is traditionally used by indigenous communities for its therapeutic potential, including treatments for skin infections, diabetes, and inflammatory disorders. This study investigates the qualitative phytochemical composition and chromatographic profiling of *M. umbellatum* leaves to scientifically validate its bioactive constituents and medicinal properties. Fresh leaves were collected from Gudalur Taluk, Nilgiris District, shade-dried, and subjected to qualitative phytochemical screening and gas chromatography-mass spectrometry (GC-MS) analysis. The qualitative test results confirmed the presence of alkaloids, flavonoids, sterols, phenolic compounds, carbohydrates, tannins, cardiac glycosides, glycosides, and volatile oils. GC-MS analysis identified 26 bioactive compounds, including 5-hydroxymethylfurfural, d-mannose, octadecanedioic acid, tetratetracontane, neophytadiene, and benomyl, correlating with known antioxidant, antimicrobial, antitumor, antidiabetic, and anti-inflammatory activities. The results substantiate the traditional medicinal uses of *M. umbellatum* leaves and highlight their potential as a source for novel pharmaceutical and nutraceutical developments. Further *in vivo* and clinical studies are recommended to confirm the efficacy and safety of these bioactive molecules.

1. Introduction

Medicinal plants have gained remarkable prominence in modern healthcare owing to their wide availability, affordability, strong cultural acceptance, and generally favourable safety profile. These attributes have made herbal remedies highly valued across the globe. The increasing dependence on plant-based therapeutics has consequently emphasized the importance of ensuring their quality, efficacy, and safetyan essential focus for both developed and developing nations. In this context, the scientific validation and standardization of plant-derived pharmaceuticals hold significant potential for advancing therapeutic innovation. Simultaneously, the rapid erosion of ethnobotanical knowledge highlights the urgency of documenting traditional uses and conducting rigorous phytochemical investigations. This global interest has further stimulated research in natural product chemistry and pharmaceutical sciences, particularly toward the discovery of novel antimicrobial and antioxidant agents from medicinal plants (El-Saadony *et al*., 2025).

Traditional medicinal systems have been practiced across the world since ancient times, providing treatments for a wide variety of diseases (Puttaswamy and Achur, 2013). More than 80% of the global population continues to rely on medicinal plants as a primary source of healthcare (Sri *et al*., 2022). The Western Ghats of India is one of the world's recognized biodiversity hotspots and a UNESCO World Heritage Site harbour exceptional plant diversity and endemism, with over 7,402 flowering plant species, of which 1,426 are endemic. Nearly 40 indigenous tribal communities inhabit these regions and possess rich traditional knowledge relating to the medicinal value of plants.

Among these species, *M. umbellatum* (Iron wood or Kaya), belonging to the family Melastomataceae, is an important medicinal plant widely used in the Western Ghats. The plant is characterized by opposite leaves, bright blue flowers in cymose umbels, and bluish-black berry fruits. The leaves possess notable antibiotic and antioxidant properties and are traditionally used to manage skin infections, eye ailments, leucorrhoea, gonorrhoea, and are also valued for natural dyeing applications. Ethnomedicinal reports document the preparation of fermented leaf remedies for diabetes, leaf pastes for herpes lesions, and infusions for snakebite treatment (Krishnamurthy and Asha, 2011). Previous phytochemical studies have reported constituents such as umbellactone, β-amyrin, oleanic acid, ursolic acid, sitosterol, and various organic acids, which together support the plant's broad therapeutic claims.

The global herbal medicine market is projected to reach USD 430-450 billion by 2030, growing at a CAGR of 7-8%, which has significantly increased demand for medicinal plants such as *M. umbellatum*. In India, nearly 80% of medicinal plant raw materials are still sourced from the wild, leading to overexploitation of RET species. *M. umbellatum* is primarily harvested from natural forests, as organized cultivation remains minimal despite its suitability for tropical agroforestry systems. Adoption of seed-based and vegetative

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propagation under controlled cultivation is therefore strongly recommended to meet rising market demand while ensuring conservation.

Despite its wide traditional relevance and reported pharmacological potential, comprehensive chromatographic profiling of the leaves of *M. umbellatum* remains inadequate. Most available studies focus on isolated compounds or preliminary qualitative screenings, offering limited insight into the full spectrum of phytochemicals present. This lack of detailed chemical characterization creates a gap in establishing scientific evidence linking ethnomedicinal uses to bioactive constituents. Therefore, a systematic chromatographic investigation is essential not only for identifying key phytochemicals but also for supporting quality control, standardization, and future pharmacological research on the species.

In this context, the present study aims to perform detailed chromatographic profiling of the leaf extract of *M. umbellatum*, identify the major phytoconstituents, and explore their potential phytomedicinal relevance. Generating such baseline chemical information is crucial for strengthening the scientific foundation of this traditionally significant plant and for facilitating its safe and effective utilization in herbal drug development.

2. Materials and Methods

The *M. umbellatum* was found in the Gudalur Taluk, Nilgiris District of Tamil Nadu in Western Ghats, lies between the Tamil Nadu, Kerala, and Karnataka. The elevation ranges from 950 to 1500m above mean sea level. The annual precipitation in 2300 mm. It is present in the following forest types, *viz.,*Semi evergreen forest, Shola forest, and Moist deciduous forest in Gudalur.

2.1 Plant authentication and Collection

The plant was authenticated by the Botanical Survey of India, Coimbatore, Tamil Nadu, India.

The Voucher Specimen No is BSI/SRC/5/23/2025-26/Tech./826.The medicinal plants were collected from the natural forest area of Gudalur range and pandalur range with the help of the local tribals and forest guards. The soil type is well drained laterite to loamy soil with the pH of 5.5 to 7. The disease free fresh and tender leaves were collected in huge amount from the field and shade dried for about 2-3 days and then finely powdered and used for further analysis like phytochemical screening and GC-MS analysis.

2.2 Phytochemical analysis

- **Alkaloids**

Dragendorff's test: The filtrate was treated with Dragendorff's reagent, and the formation of a red-orange precipitate indicated the presence of alkaloids (Morsy, 2014).

Mayer's test: The extract was treated with Mayer's reagent, and the appearance of a cream or yellowish-white precipitate confirmed the presence of alkaloids (Morsy, 2014).

- **Flavonoids**

Shinoda test: The extract was treated with magnesium turnings followed by concentrated HCl. Development of a pink to reddish colour indicated flavonoids (Shaikh and Patil, 2020).

Alkaline reagent test: The extract was treated with 2% NaOH producing a yellow colour. Disappearance of colour upon acid addition confirmed flavonoids (Shaikh and Patil, 2020).

Lead acetate test: Lead acetate solution was added to the extract. Formation of a yellow precipitate indicated flavonoids (Shaikh and Patil, 2020).

- **Sterols**

Liebermann test: The chloroform extract residue was treated with concentrated H_2SO_4. Appearance of a greyish colour indicated terpenoids (Banu and Cathrine, 2015).

- **Terpenoids**

Liebermann test: The chloroform extract residue was treated with concentrated H_2SO_4. Appearance of a greyish colour indicated terpenoids(Yadav and Agarwala, 2011).

- **Anthraquinones**

Borntrager's test: The extract was shaken with benzene and treated with ammonium hydroxide. A pink to violet ammoniacal layer indicated anthraquinones (Morsy, 2014).

- **Anthocyanins**

HCl test: The extract was treated with 2 N HCl producing a pinkish-red colour. The colour turning purplish blue with ammonia confirmed anthocyanins (Shaikh and Patil, 2020).

- **Proteins**

Ninhydrin test: The extract was treated with 0.25% ninhydrin and heated. Formation of a blue-violet colour indicated proteins or amino acids (Yadav and Agarwala, 2011).

- **Phenolic compounds**

Ferric chloride: The extract was treated with 2% $FeCl_3$ solution. Development of blue-green or purple colour indicated phenolic compounds (Shaikh and Patil, 2020).

Gelatin test: Gelatin solution containing NaCl was added to the extract. Formation of a white precipitate confirmed phenolics (Shaikh and Patil, 2020).

Ellagic acid tests: The extract was treated with glacial acetic acid and sodium nitrite. Development of a muddy brown colour indicated phenolics (Shaikh and Patil, 2020).

- **Quinones**

Concentrated HCl test: A few drops of concentrated HCl were added to the extract. Appearance of green colour indicated quinones (Shaikh and Patil, 2020).

Alcoholic KOH test: The extract was treated with alcoholic KOH. Colour change from red to blue confirmed quinones (Shaikh and Patil, 2020).

- **Carbohydrates**

Molisch's test: Alcoholic α-naphthol and concentrated H_2SO_4 were added to the extract. Formation of a violet ring indicated carbohydrates (Shaikh and Patil, 2020).

- **Tannins**

Braymer's test: The extract was treated with 10% alcoholic $FeCl_3$. Blue-black or green colour indicated tannins (Shaikh and Patil, 2020).

NaOH test: The extract was treated with 10% NaOH solution. Formation of an emulsion indicated tannins (Shaikh and Patil, 2020).

Gelatin test: Gelatin solution containing NaCl was added to the extract. Formation of a white precipitate confirmed tannins (Shaikh and Patil, 2020).

- **Saponins**

Froth test: The extract was shaken vigorously with distilled water. Persistent froth formation indicated saponins (Morsy, 2014).

- **Cardiac glycosides**

Baljet's, test: Sodium picrate solution was added to the extract. Development of yellow to orange colour indicated cardiac glycosides (Shaikh and Patil, 2020).

Bromine water test: Bromine water was added to the extract. Formation of a yellow precipitate confirmed cardiac glycosides (Shaikh and Patil, 2020).

Keller-Kiliani tests: The extract was treated with glacial acetic acid, $FeCl_3$, and concentrated H_2SO_3. Appearance of bluish colour indicated cardiac glycosides (Shaikh and Patil, 2020).

- **Glycosides**

Borntrager's test: The extract was shaken with chloroform and treated with ammonia solution. Formation of a pink colour indicated glycosides (Shaikh and Patil, 2020).

Aqueous NaOH tests: The extract was treated with aqueous NaOH solution. Development of yellow colour confirmed glycosides (Shaikh and Patil, 2020).

- **Lignin**

Labat test: Gallic acid was added to the extract. Formation of olive-green colour indicated lignin (Shaikh and Patil, 2020).

- **Coumarins**

Alkaline test: The extract was treated with 10% NaOH and chloroform. Appearance of yellow colour indicated coumarins (Morsy, 2015).

- **Volatile oils**

Fluorescence test: The filtered extract was exposed to UV light. Bright fluorescence indicated the presence of volatile oils (Shaikh and Patil, 2020).

2.3 GC-MS analysis

Gas chromatography-mass spectrometry (GC-MS) analysis of the methanolic bark and leaf extracts was conducted using a PerkinElmer Clarus SQ8C system. The injector, interface and ion source temperatures were maintained at 220°C, 250°C and 220°C, respectively. The oven temperature program began at 75°C for 2 min, increased to 150°C at 10°C/min, and was subsequently raised to 250°C at the same ramp rate. Helium was used as the carrier gas at a flow rate of 1 ml/min with a split ratio of 1:12. Separation was achieved on a DB-5 MS non-polar capillary column (30 m × 0.25 mm ID × 0.25 µm film thickness). Mass spectra were acquired over a range of 50-600 Da with an ionization energy of 70 eV. Chemical constituents were identified by matching the obtained mass spectra with reference spectra from the NIST library, with identification supported by spectral similarity and relative peak area (Suwethaasri *et al.,* 2025).

3. Results

3.1 Phytochemical analysis of *M. umbellatum* leaf

The qualitative phytochemical analysis of methanol extracts of *M. umbellatum* leaf indicated the presence of alkaloids, flavonoids, sterols, phenolic compounds, carbohydrates, tannin, cardiac glycosides, glycoside's and volatile oils (Table 1).

3.2 Major bioactive compounds present in *M. umbellatum* leaf extract by GC-MS analysis

The present investigation stated that, twentysix compounds were identified in the *M. umbellatum* leaf extract by GC-MS analysis (Figure 1). Their molecular formula, percentage composition, molecular masses are given in (Table 2). The prevailing compounds were5-hydroxymethylfurfural, d-mannose, octadecanedioic acid, tetratetracontane, neophytadiene and benomyl (Table 3).

Table 1: Phytochemical analysis of *M. umbellatum* leaf

S. No.	Metabolite	Test performed	Result
1.	Alkaloids	Mayer's reagent	+
		Dragendorff's reagent	+
2.	Flavonoids	Alkaline test	+
		H_2SO_4	+
		lead acetate	+
		Shinoda test	–
3.	Sterols	Libermann test	+
4.	Terpenoids	Libermann test	–
5.	Anthraquinone	Borntrager's test	–
6.	Anthocyanin	HCl Test	–

7.	Proteins	Ninhydrin test	–
		2% $CuSO_4$ + 95% ethanol + KOH pellet	–
		+ conc. HNO_3	–
8.	Phenolic compounds	+ 5% neutral $FeCl_3$	+
		Gelatin test	+
		Ellagic acid test	+
9.	Quinones	Conc. HCl	–
		Alcoholic KOH	–
10.	Carbohydrates	Molisch's test	+
		Fehling's test	+
11.	Tannin	Braymer's test	+
		+ Gelatin test	+
		10% NaOH test	+
12.	Saponins	Shaken with water	–
13.	Cardiac glycosides	Baljet reagent	+
		Bromine water test	–
		Keller-killani test	+
14.	Glycoside's test	Borntrager's test	+
		Aq. NaOH test	+
15.	Lignin	+ Gallic acid	–
16.	Coumarins	+ 10% NaOH + $CHCl_3$	–
17.	Volatile oils	Fluorescence test	+

Note: Presence (+) and Absence (–)**

Table 2: GC-MS analysis of *M. umbellatum* leaf

Peak No.	Rt	Area	Compound name	Molecular formula	Molecular weight
1.	3.364	1.413	3-(3-Carboxy-4-hydroxyphenyl)-D-alanine	$C_{10}H_{11}NO_5$	225.2 g/mol
2.	3.669	6.616	α-Tetrahydro-3-furanmethanol	$C_5H_{10}O_2$	102.13 g/mol
3.	3.859	0.57	2-Myristynoyl pantetheine	$C_{25}H_{44}N_2O_5S$	484.7 g/mol
4.	6.585	0.56	Cyclopentanone, 2-ethyl-	$C_7H_{12}O$	112.17 g/mol
5.	7.065	0.425	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	144.12 g/mol
6.	7.345	0.393	Dehydromevalonic lactone	$C_6H_8O_2$	112.13 g/mol
7.	7.69	0.545	3-Dodecene, (Z)-	$C_{12}H_{24}$	168.32 g/mol
8.	8.265	0.901	5-Hydroxymethylfurfural	$C_6H_6O_3$	126.11 g/mol
9.	9.096	0.359	Octadecanedioic acid	$C_{18}H_{34}O_4$	314.5 g/mol
10.	10.326	0.675	α-D-Glucopyranose, 4-O-α-D-galactopyranosyl-	$C_{12}H_{22}O_{11}$	342.30 g/mol
11.	10.591	0.55	1-Hexadecanol, 2-methyl-	$C_{17}H_{36}O$	256.5 g/mol
12.	10.651	0.681	Acetic acid, 6-morpholin-4-yl-9-oxobicyclo [3.3.1] non-3-yl ester	$C_{15}H_{23}NO_4$	281.35 g/mol
13.	10.731	0.769	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	$C_{35}H_{68}O_5$	568.9 g/mol
14.	10.756	0.772	9,12,15-Octadecatrienoic acid, 2-phenyl-1,3-dioxan-5-yl ester	$C_{28}H_{40}O_4$	440.6 g/mol

15.	11.372	0.964	d-Mannose	$C_6H_{12}O_6$	180.16 g/mol
16.	12.407	0.448	Tetraacetyl-d-xylonic nitrile	$C_{14}H_{17}NO_9$	343.29 g/mol
17.	13.012	0.325	2,4-Di-tert-butylphenol	$C_{14}H_{22}O$	206.32 g/mol
18.	19.775	0.906	Neophytadiene	$C_{20}H_{38}$	278.5 g/mol
19.	20.635	0.397	13-Heptadecyn-1-ol	$C_{17}H_{32}O$	252.4 g/mol
20.	21.491	0.316	Octadecanedioic acid, dimethyl ester	$C_{20}H_{38}O_4$	342.5 g/mol
21.	22.126	1.19	Eicosanoic acid	$C_{20}H_{40}O_2$	312.5 g/mol
22.	23.802	2.093	3',8,8'-Trimethoxy-3-piperidyl-2,2'-binaphthalene-1,1',4,4'-tetrone	$C_{28}H_{25}NO_7$	487.5 g/mol
23.	24.997	1.431	Heptacosane	$C_{27}H_{56}$	380.7 g/mol
24.	25.072	0.52	Octadecane, 3-ethyl-5-(2-ethylbutyl)-	$C_{26}H_{54}$	366.7 g/mol
25.	25.217	2.853	Tetratetracontane	$C_{44}H_{90}$	619.2 g/mol
26.	25.397	1.813	Corynan-17-ol, 18,19-didehydro-10-methoxy-, acetate (ester)	$C_{22}H_{28}N_2O_3$	368.5 g/mol
27.	25.572	1.298	Benomyl	$C_{14}H_{18}N_4O_3$	290.32 g/mol

Table 3: Compound and its activity

S. No.	Compound name	Reported activity
1.	3-(3-Carboxy-4-hydroxyphenyl)-D-alanine	Antibacterial activity
2.	ñ-Tetrahydro-3-furanmethanol	Antioxidant
3.	2-Myristynoyl pantetheine	Antimicrobial activity
4.	Cyclopentanone, 2-ethyl-	Antitumor and antibacterial
5.	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	Strong antioxidant
6.	Dehydromevalonic lactone	Bioactive metabolites
7.	3-Dodecene, (Z)-	Antibacterial activity
8.	5-Hydroxymethylfurfural	Antioxidant activity
9.	Octadecanedioic acid	Antitumor activity
10.	α-D-Glucopyranose, 4-O-α-D-galactopyranosyl-	Antioxidant activity
11.	1-Hexadecanol, 2-methyl-	Antimicrobial activity
12.	Acetic acid, 6-morpholin-4-yl-9-oxobicyclo[3.3.1]non-3-yl ester	Strong antidiabetic activity
13.	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	Antioxidant and antiandrogenic
14.	9,12,15-Octadecatrienoic acid, 2-phenyl-1,3-dioxan-5-yl ester	Antifertility activity
15.	d-Mannose	Alternate to antibiotics
16.	Tetraacetyl-d-xylonic nitrile	Insecticidal activity
17.	2,4-Di-tert-butylphenol	Active against *Aspergillus*
18.	Neophytadiene	Antimicrobial agent
19.	13-Heptadecyn-1-ol	Antioxidant activity
20.	Octadecanedioic acid, dimethyl ester	Antiviral activity
21.	Eicosanoic acid	Antifungal activity
22.	3',8,8'-Trimethoxy-3-piperidyl-2,2'-binaphthalene-1,1',4,4'-tetrone	Antimicrobial activity
23.	Heptacosane	Antimicrobial activity
24.	Octadecane, 3-ethyl-5-(2-ethylbutyl)-	Phylogenetic analysis
25.	Tetratetracontane	Human metabolite
26.	Corynan-17-ol, 18,19-didehydro-10-methoxy-, acetate (ester)	Inhibit the metabolic activity
27.	Benomyl	Cholinesterse inhibitor

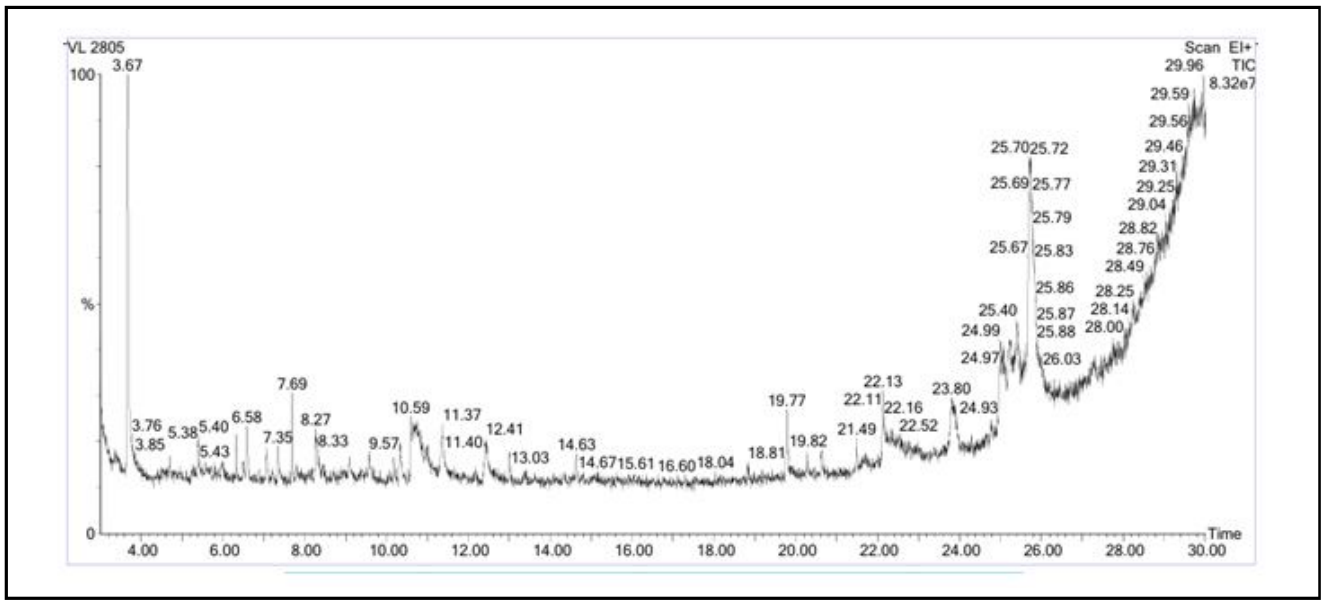

Figure 1: GC-MS Analysis of *M. umbellatum*.

4. Discussion

4.1 Phytochemical analysis of *M. umbellatum* leaf

The phytochemical screening of *M. umbellatum* leaf revealed the presence of major secondary metabolites including alkaloids, flavonoids, sterols, phenolic compounds, tannins, carbohydrates, glycosides, cardiac glycosides and volatile oils. These groups are known to impart significant therapeutic properties and validate the plant's traditional medicinal use. Alkaloids and flavonoids, which are associated with antimicrobial, antioxidant and anti-inflammatory activities, have also been previously reported in *M. umbellatum* and other medicinal species (Eleazu *et al.,* 2012; Harborne and Williams, 2000). The strong presence of phenolics and tannins indicates notable free-radical-scavenging potential, supporting earlier reports linking these compounds to antioxidant, cardioprotective and anti-carcinogenic effects (Han *et al.,* 2007; Rajurkar and Gaikwad, 2012). Sterols and volatile oils contribute additional antimicrobial and anti-inflammatory actions (Yadav and Agarwala, 2011; Sharma *et al.,* 2020). Carbohydrates and glycosides detected in the extract provide further therapeutic relevance due to their reported hypoglycaemic and detoxifying properties (Zhang *et al.,* 2018; Nyarko and Addy, 1990). Overall, the diverse phytochemical profile supports the ethnomedicinal value of *M. umbellatum* leaves and highlights their potential for future pharmacological and isolation studies.

4.2 Bioactive compounds through GC-MS analysis

M. umbellatum leaf extractshowed the presence of 5-hydroxymethylfurfural, octadecanedioic acid, d-mannose, tetratetracontane, neophytadiene and benomyl. The similar study was also conducted by Morinaga *et al.* (2004) who reported that, benomyl compound had an aromatase activity. Zhao *et al.* (2013) revealed the presence of 5-hydroxymethylfurfural in their study and concluded that it had *in vitro* antioxidant and antiproliferative activity. Scribano *et al.* (2020) had a similar finding of d-mannose which acted as an alternative antibiotic and prevent the urinary tract infections. Raman *et al.* (2012) conducted the study on *Eupatorium odoratum* and the GC-MS analysis resulted the similar compound neophytadiene that possessed the antipyretic, antimicrobial, anti-inflammatory, analgesic and antioxidant activity. The similar study was conducted by Amudha *et al.* (2018) on *Enhalus acoroides* seagrass extract showed the presence of tetratetracontane, which possesses antioxidant and cytoprotective activity.

5. Conclusion

The species reveals the presence of a wide range of bioactive compounds with diverse pharmacological properties. The detected metabolites exhibit strong antioxidant, antimicrobial, antibacterial, antifungal, antiviral, antitumor, antidiabetic, insecticidal, antiandrogenic, and cholinesterase inhibitory activities, indicating the species broad therapeutic potential. Compounds such as 4H-pyran-4-one derivatives, 5-hydroxymethylfurfural, neophytadiene, 2,4-di-tert-butylphenol and octadecanedioic acid derivatives highlight its potential role in combating oxidative stress, microbial infections, and metabolic disorders like diabetes.

The presence of bioactive fatty acids, phenolic compounds, sugars, and alkaloid derivatives further strengthens its medicinal importance and supports its traditional usage in herbal medicine. Overall, this species can be considered a promising natural source for the development of novel pharmaceutical and nutraceutical agents. However, further *in vivo* and clinical studies are essential to validate its safety, efficacy, and therapeutic applications

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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