GC–MS-Based Phytochemical Profiling and Antioxidant Activity of Tecoma stans Flowers

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Abstract

This study analyzed the chemical constituents of *Tecoma stans* flower extracts using Gas chromatography–mass spectrometry (GC-MS) and evaluated their antioxidant activity via DPPH and ABTS assays. Dried flowers were extracted with solvents of different polarities: hexane (TS-F-Hex), ethyl acetate (TS-F-EtOAc), and methanol (TS-F-MeOH). The methanol extract, the most polar solvent, gave the highest yield (52.75%). GC-MS analysis showed that methanol extract contained major polar compounds, including Glyceraldehyde, γ-Sitosterol, Stigmasterol, Dihydroxyacetone, and Vitamin E. Ethyl acetate extract contained Hydroxy-4,3'-dimethyl-bicyclohexyl-3,3'-dien-2-one, Cyclobutanecarboxylic acid decyl ester, and 2-Cyclohexyl-hexan-2-ol, while hexane extract, a non-polar solvent, contained Pentacosane, Tetracontane, Tetradecanoic acid hexadecyl ester, and D-Limonene. Antioxidant tests showed that methanol extract had the highest activity in the DPPH assay (IC_{50} = 620.54 µg/mL), while ethyl acetate extract showed the highest activity in the ABTS assay (IC_{50} = 293.50 µg/mL). Hexane extract had the lowest activity (IC_{50} > 1000 µg/mL). Although all extracts were less active than Trolox (DPPH IC_{50} = 6.65 ± 0.12 µg/mL; ABTS IC_{50} = 7.87 ± 0.11 µg/mL), the results indicate that most active compounds are in polar extracts, especially methanol. These extracts could be further explored as sources of bioactive compounds for pharmaceuticals, dietary supplements, and related applications.

Keywords: *Tecoma stans* flowers, Phytochemical, Antioxidant, DPPH, and ABTS

1. Introduction

Tecoma stans (L.) Juss. ex Kunth, commonly known as yellow trumpetbush, yellow bells, yellow elder, or ginger Thomas, is an ornamental shrub belonging to the Bignoniaceae family. Native to the Americas, this species is now widely distributed across tropical and subtropical regions. In Thailand, T. stans is extensively cultivated as an ornamental plant due to its vibrant yellow flowers, delicate fragrance, and evergreen foliage, which enhance the aesthetic appeal and provide year-round greenery in gardens and urban landscapes. Its botanical status is formally recognized in The Plant List and the Medicinal Plant Names Services (The Plant List, 2023; Medicinal Plant Names Services, 2023).

The medicinal use of *T. stans* can be traced back to the 16th century. Traditionally, different plant parts have been used to manage hyperglycemia, inflammation, gastrointestinal disorders, and various forms of poisoning. These uses are supported by pharmacological studies reporting hypoglycemic, antimicrobial, anti-inflammatory, and antioxidant activities (Wichayapreechar, P. et al., 2024; Gonçalves et al., 2022). Bioactive constituents such as tecomine and chlorogenic acid have been shown to significantly reduce blood glucose levels (Ramirez et al., 2009), while chrysoeriol and apigenin inhibit pancreatic lipase, indicating potential as lead compounds for lipid-lowering therapeutics (Ramirez et al., 2012).

Most reported bioactive constituents of *T. stans* are secondary metabolites with pharmaceutical relevance, including monoterpene alkaloids, phenolic acids, flavonoids, carotenoids, terpenoids, glycosides, phytosterols, volatile oils, and unsaturated fatty acids (Gonçalves et al., 2022). Among these, antioxidant compounds are of particular interest due to their capacity to mitigate oxidative stress, a key factor associated with the onset of chronic diseases such as cancer, diabetes, and cardiovascular disorders (Liguori et al., 2018). Gas chromatography–mass spectrometry (GC–MS) is one of the most powerful analytical techniques for the identification of volatile and semi-volatile phytochemicals in medicinal plants. It enables structural elucidation through chromatographic separation coupled with mass spectral libraries, making it particularly suitable for profiling bioactive constituents such as terpenoids, fatty acid derivatives, and aromatic compounds (Altemimi et al., 2017; Khoddami et al., 2021). GC–MS-based metabolite profiling has been widely used to correlate phytochemical composition with biological activities such as antioxidant, antimicrobial, and anti-inflammatory effects. However, while previous studies have largely focused on the leaves and bark, information on the chemical composition and biological activities of the flowers remains limited. Therefore, this study aims to identify and characterize the major bioactive compounds in *T. stans* flowers and evaluate their antioxidant potential, providing insight into the chemical–biological relationships and supporting future applications in traditional medicine and product development.

2. Research Objective

1. To characterize the phytochemical profile of *Tecoma stans* flower extracts using GC-MS.
2. To evaluate the antioxidant activity of the *Tecoma stans* flower extracts *Tecoma stans*.

3. Materials and Methods

3.1 Extraction of compounds from flowers

were collected from Samut Songkhram Province, Thailand. The plant material was air-dried in the shade and subsequently ground into a fine powder. A 326.4 g portion of the dried powder was subjected to sequential extraction by maceration at room temperature using hexane, followed by ethyl acetate, and finally methanol. After each extraction step, the mixture was filtered through Whatman No. 1 filter paper to remove solid residues. The resulting filtrates were concentrated using a rotary evaporator to obtain the crude extracts for each solvent. All

extracts were stored properly until further analysis of their chemical constituents and biological activities.

3.2 Gas chromatography–mass spectrometry (GC-MS) analysis for Phytochemical Profiling

The phytochemical profiles of the *Tecoma stans* flower extracts were determined using a Shimadzu GC-MS-QP2020 system equipped with 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. Sample aliquots (1 µL) were injected in split mode with a split ratio of 1:20. The oven temperature was programmed as follows: held at 70 °C for 2 min, increased at 5 °C/min to 200 °C and maintained for 20 min, then raised to 230 °C for 15 min, followed by 250 °C for 15 min, and finally increased to 320 °C and held for 20 min. The ion source temperature was maintained at 250 °C under electron impact (EI) ionization. Total ion chromatograms (TIC) were recorded over a mass range of 35–500 amu. Compound identification was achieved by comparing the acquired mass spectra with those in the NIST17 mass spectral library.

3.3 2,2-diphenyl-1-picrylhydrazyl (DPPH) Assay

The DPPH assay was performed by combining the extracts at various concentrations with an equal volume of DPPH solution in a 96-well plate. The mixture was incubated in the dark for 30 minutes, after which the absorbance was recorded at 517 nm. Trolox was used as a positive control. The percentage of radical scavenging activity (% inhibition) and the IC_{50} values were calculated from the resulting data. All measurements were carried out in triplicate to ensure reliability and reproducibility (Maneechai & Pikulthong, 2017; Ckokchaisiri et al., 2025).

3.4 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay

ABTS radical scavenging activity of *Tecoma stans* flower extracts was determined according to the method described by Ckokchaisiri et al. (2025). The ABTS solution was prepared by reacting 7 mM ABTS diammonium salt with 2.45 mM potassium persulfate in distilled water and incubating in the dark for 18 h. The solution was then diluted to a uniform absorbance. In a 96-well plate, 100 µL of ABTS solution was mixed with 100 µL of extract at concentrations of 5–1000 µg/mL. After 15 min incubation in the dark, absorbance was measured at 734 nm. Trolox was used as a positive control. All assays were performed in triplicate.

% Inhibition was calculated as:

$$\%\text{Inhibition} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100$$

where *A_control* is the absorbance of the control and *A_sample* is the absorbance of the sample. The IC_{50} value, representing the concentration of extract required to inhibit 50% of the ABTS radical, was obtained from a plot of % inhibition versus extract concentration

4. Results and discussion

Extraction Yields

The flowers of *Tecoma stans* were subjected to sequential extraction to obtain three fractions: hexane, ethyl acetate, and methanol. The extraction yields varied depending on the polarity of the solvent, with the highest yield obtained from the most polar solvent, methanol (TS-F-MeOH), which gave 172.16 g (52.75%). In contrast, the yields from ethyl acetate (TS-F-EtOAc) and hexane (TS-F-Hex) were much lower, at 15.51 g (4.75%) and 14.48 g (4.44%), respectively. These results indicate that most of the compounds extracted from the dried flowers of *T. stans* are highly polar and are best solubilized in methanol.

Table 1: Extraction Yields of Tecoma stans Flowers

Sample	Yield (g)	Yield (%)
TS-F-Hex	14.48	4.44
TS-F-EtOAc	15.51	4.75
TS-F-MeOH	172.16	52.75

Note: **TS-F-Hex** =Hexane extract, **TS-F-EtOAc** =Ethyl acetate extract and **TS-F-MeOH**: Methanol extract

Phytochemical Analysis

The GC–MS analysis of *Tecoma stans* flower extracts showed clear variations in phytochemical composition among the three solvent fractions, reflecting the influence of solvent polarity on metabolite extraction. A total of 43 compounds were identified, representing diverse classes such as sterols, monoterpenes, aldehydes, fatty acid esters, hydrocarbons, and long-chain alcohols. These results are consistent with previous studies reporting the chemical richness and structural diversity of *T. stans* secondary metabolites (Gonçalves et al., 2022). The methanol extract contained the highest proportion of polar compounds. Major constituents included glyceraldehyde, γ-sitosterol, stigmasterol, dihydroxyacetone, and vitamin E. Several studies on *T. stans* have reported that polar fractions—particularly methanol or ethanol extracts—are rich in sterols, polyols, and phenolic-like constituents that contribute strongly to antioxidant and anti-inflammatory effects (Wichayapreechar et al., 2024; González-Larena**,** et. al, 2012**;** Jiang**,** 2014). Phytosterols such as stigmasterol and β/γ-sitosterol have previously been isolated from *T. stans* leaves and flowers and are recognized for their ability to reduce oxidative stress and modulate inflammatory pathways (Ramirez et al., 2012). The ethyl acetate extract contained a diverse mixture of semi-polar metabolites, including oxygenated monoterpenes, medium-chain esters, and aliphatic alcohols. The presence of these compounds suggests that the ethyl acetate fraction of *T. stans* may possess broad-spectrum bioactivity, intermediate between the methanol and hexane extracts. The hexane extract primarily yielded long-chain hydrocarbons and fatty acid esters, including pentacosane, tetracontane, and tetradecanoic acid hexadecyl ester. Similar classes of non-polar metabolites have previously been identified in flowers, which

typically contain waxes, saturated hydrocarbons, and lipid derivatives. (Fernandes et al., 2018). These non-polar constituents generally exhibit low antioxidant activity due to the absence of reactive functional groups capable of hydrogen or electron donation. Although D-limonene was present in this extract—as also reported in *T. stans* leaf and flower essential oils—its relatively low abundance likely limits its contribution to overall antioxidant potential . Consequently, the hexane extract showed the least promising chemical profile for antioxidant activity, which agrees with reports that non-polar extracts of *T. stans* typically display weaker bioactivity compared with polar extracts (Khattab, 2022). Taken together, the findings demonstrate that solvent polarity plays a decisive role in determining the phytochemical composition and likely bioactivity of *T. stans* flower extracts. Methanol preferentially extracted sterols, tocopherols, aldehydes, and polyols—compounds repeatedly reported as major contributors to antioxidant capacity in *T. stans*. The semi-polar ethyl acetate extract captured structurally diverse terpenoids and esters with intermediate antioxidant and antimicrobial potential, while the hexane extract predominantly contained hydrocarbons with limited relevance to radical-scavenging mechanisms. These results are in line with previous research showing that polar and semi-polar fractions of *T. stans* exhibit stronger pharmacological properties due to their higher content of bioactive secondary metabolites (Abo Khaled et al., 2025).

Table 2: Phytochemical Compounds in *Tecoma stans* Flowers by GC–MS

No.	Name	Retention time (min)			Peak area (%)		
		TS-F-Hex	TS-F-EtOAc	TS-F-MeOH	TS-F-Hex	TS-F-EtOAc	TS-F-MeOH
1	Glyceraldehyde	-	-	3.04	-	-	20.00
2	Dihydroxyacetone	-	-	3.92	-	-	11.43
3	D-Limonene	6.60	6.60	-	1.78	1.14	-
4	Isoborneol	10.11	-	-	0.24	-	-
5	endo-Borneol	10.35	-	-	0.31	-	-
6	N-[12-Aminododecyl]aziridine	-	15.04	-	-	2.21	-
7	1'-Hydroxy-4,3'-dimethyl-bicyclohexyl-3,3'-dien-2-one	16.65	16.65	-	0.92	27.21	-
8	9-Oxabicyclo[3.3.1]nonan-2-one, 5-hydroxy-	-	16.99	-	-	7.15	-
9	1,2,3,4,7,7a-Hexahydro-2,4,7-trimethyl-6H-2-p	18.21	18.19	18.19	0.36	3.35	10.68
10	2,4-Di-tert-butylphenol	-	19.08	-	-	0.54	-
11	2H-Pyran-2-one, tetrahydro-4-hydroxy-6-penty	-	19.24	-	-	3.10	-
12	1-Heptanol, 2,4-dimethyl-, (R,R)-(+)-	-	19.62	-	-	7.89	-
13	Cyclobutanecarboxylic acid, decyl ester	-	20.08	-	-	14.61	-
14	Hexadecane	-	21.24	-	-	0.53	-
15	2-Cyclohexyl-hexan-2-ol	-	21.72	-	-	10.87	-
16	Lauryl acetate	-	22.19	-	-	4.89	-
17	trans-Undec-4-enal	-	22.30	-	-	4.03	-
18	Cyclohexanone, 4,4-dimethoxy-	-	24.18	-	-	2.67	-
19	6-Hydroxy-4,4,7a-trimethyl-5,6,7,7a-tetrahydro	-	25.19	-	-	0.73	-
20	Glycidyl palmitate	40.94	-	-	0.63	-	-

No.	Name	Retention time (min)			Peak area (%)		
		TS-F-Hex	TS-F-EtOAc	TS-F-MeOH	TS-F-Hex	TS-F-EtOAc	TS-F-MeOH
21	Heneicosane	47.40	-	-	3.20	-	-
22	Pentacosane	56.14	-	-	11.96	-	-
23	Tetracontane	63.56	-	-	11.43	-	-
24	Triacontane, 1-iodo-	66.82	-	-	1.22	-	-
25	beta-Sitosterol acetate	68.14	-	-	0.48	-	-
26	Vitamin E	69.49	69.48	69.47	2.22	0.60	7.32
27	Triacontane, 1-iodo-	70.77	-	-	0.46	-	-
28	3-Buten-2-one, 4-(4-hydroxy-2,2,6-trimethyl-7-	71.21	-	71.19	2.44	-	6.56
29	Stigmasterol	71.70	71.70	71.68	3.75	2.51	15.32
30	gamma-Sitosterol	72.81	72.80	72.79	3.58	3.00	16.67
31	Stigmasta-5,24(28)-dien-3-ol, (3.beta.,24Z)-	-	-	73.07	-	-	3.14
32	24-Norursa-3,12-diene	74.11	-	-	1.15	-	-
33	9,19-Cyclolanostan-3-ol, 24-methylene-, (3beta)	75.00	-	-	0.78	-	-
34	Phytyl tetradecanoate	76.61	-	-	0.40	-	-
35	Ursolic aldehyde	77.68	-	-	0.59	-	-
36	Phytyl stearate	79.39	-	-	0.61	-	-
37	Hexadecanoic acid, tetradecyl ester	79.70	-	-	3.42	-	-
38	2-Undecanol myristate	82.34	-	-	1.03	-	-
39	Hexadecanoic acid, 2-hydroxy-1,3-propanediyl	83.46	-	83.40	3.45	-	4.62
40	2-Undecanol myristate	85.96	-	-	0.95	-	-
41	9-Octadecenoic acid (Z)-, octadecyl ester	90.00	-	-	2.10	-	-
42	Tetradecanoic acid, hexadecyl ester	93.51	-	-	7.27	-	-
43	Succinic acid, 3,7-dimethyloct-6-en-1-yl heptadecyl ester	95.86	-	-	4.09	-	-

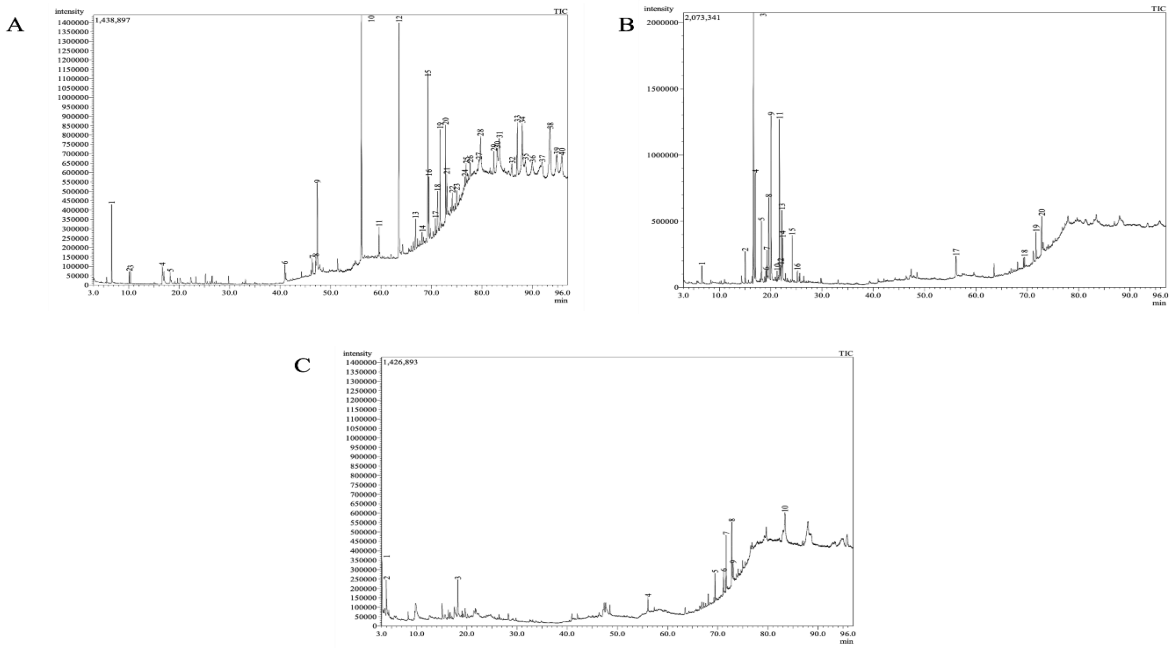

Figure 1: GC–MS chromatograms of *Tecoma stans* flower extracts obtained using solvents of different polarity: TS-F-Hex (hexane) (A), TS-F-EtOAc (ethyl acetate) (B), and TS-F-MeOH (methanol) (C).

Antioxidant activity

The antioxidant capacities of *Tecoma stans* flower extracts obtained using three different solvents—hexane, ethyl acetate, and methanol—were evaluated using the DPPH and ABTS radical scavenging assays, with Trolox serving as the reference standard (Table 4).

The results from the DPPH assay revealed that the methanolic extract (TS-F-MeOH) exhibited the highest antioxidant activity, with an IC_{50} value of 620.54 ± 8.98 µg/ml, followed by the ethyl acetate extract (TS-F-EtOAc) with an IC_{50} value of 791.96 ± 5.81 µg/ml. In contrast, the hexane extract (TS-F-Hex) showed the lowest activity, with an IC_{50} value greater than 1000 µg/ml. The reference compound Trolox demonstrated a much stronger antioxidant effect, with an IC_{50} value of 6.65 ± 0.12 µg/ml.

In the ABTS assay, the ethyl acetate fraction (TS-F-EtOAc) demonstrated the best radical scavenging potential, with an IC_{50} value of 293.50 ± 5.52 µg/ml. The methanolic fraction (TS-F-MeOH) followed, showing an IC_{50} of 586.81 ± 1.62 µg/ml. Consistent with the DPPH results, the non-polar hexane fraction (TS-F-Hex) showed negligible activity (IC_{50} > 1000 µg/ml). The IC_{50} values of the active fractions (TS-F-EtOAc and TS-F-MeOH) were substantially higher than that of Trolox, which recorded an IC_{50} of 7.87 ± 0.11 µg/ml.

Overall, the results indicate that the *Tecoma stans* flower extracts possess relatively low antioxidant activity compared to Trolox. However, the observed trend suggests that the major antioxidant constituents are predominantly present in the more polar fractions, particularly the ethyl acetate and methanol fractions.

Table 3: DPPH and ABTS Radical Scavenging Activity (IC_{50}) of Tecoma stans Flower Extracts

Name	DPPH IC_{50} (µg/ml)	ABTS IC_{50} (µg/ml)
TS-F-Hex	>1000	>1000
TS-F-EtOAc	791.96 ± 5.81	293.50 ± 5.52
TS-F-MeOH	620.54 ± 8.98	586.81 ± 1.62
Trolox	**6.65 ± 0.12**	**7.87 ± 0.11**

5. Conclusion

This study analyzed the chemical composition and antioxidant potential of *Tecoma stans* flower extracts. The methanol extract gave the highest yield (52.75%), indicating that most compounds are highly polar. GC–MS analysis identified glyceraldehyde, γ-sitosterol, stigmasterol, and vitamin E as major components. In contrast, the non-polar hexane extract mainly contained long-chain hydrocarbons and showed low antioxidant activity. DPPH and ABTS assays showed that antioxidant activity correlated with extract polarity, with methanol and ethyl acetate extracts exhibiting the highest activity, though still lower than the Trolox

standard. These findings suggest that the main bioactive compounds, especially sterols and vitamin E, are in the highly polar fraction, highlighting the potential of *T. stans* flowers for health supplements and oxidative stress-related applications.

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