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Phytochemical Composition, Antioxidant, and Antibacterial Activities of Macaranga peltata Leaf Extracts

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ABSTRACT

This study aims to assess and compare the phytochemical profile, antioxidant potential, and antibacterial activity of various crude extracts derived from fresh *Macaranga peltata* leaves. The extracts were prepared using different organic solvents, including methanol, ethyl acetate and dimethyl sulfoxide (DMSO). Antioxidant activity was quantified using DPPH and superoxide anion radical scavenging assays, while antibacterial properties were tested using agar disc diffusion method. Phytochemical screening revealed that the methanolic extract showed more positive results compared to those obtained with ethyl acetate and DMSO extracts. In terms of antioxidant activity, the crude extracts followed the order: methanol > ethyl acetate > DMSO. Similarly, the methanolic extract demonstrated moderate antibacterial activity, outperforming the other two solvent extracts. Overall, the methanol extract exhibited the highest bioactivity among the solvents tested. GC-MS analysis of the methanolic extract identified twelve phytochemical constituents. In conclusion, crude extracts from fresh *M. peltata* leaves, especially those prepared with methanol, show promise as potential sources of new antioxidant and antibacterial agents.

INTRODUCTION

Globally, infectious diseases remain one of the most pressing health challenges, accounting for nearly 57 million deaths annually (Fauci et al., 2005). Despite significant advancements in antibiotic development over the past three decades, the effectiveness of these drugs has been undermined by their associated toxicities and the rising prevalence of multidrug-resistant (MDR) microorganisms. The widespread activity of MDR efflux pumps highlights the urgent need for novel and more effective therapeutic agents.

Reactive oxygen species (ROS), generated as byproducts of normal cellular metabolism. These are highly reactive and contribute to the progression of various chronic diseases by damaging lipids, proteins and nucleic acids. Although the human body possesses an intrinsic antioxidant defense system, the use of exogenous antioxidants is often necessary to neutralize excess free radicals (Yanishlieva et al., 2006). While antioxidants may be either synthetic or natural, synthetic variants such as butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT) are increasingly avoided due to their potential toxic and carcinogenic effects (Botterweck, 2000), leading to a growing preference for natural alternatives.

For centuries, medicinal plants have been used in traditional medicine due to their rich content of bioactive compounds capable of exerting physiological effects. Key phytochemicals such as tannins, flavonoids, alkaloids, terpenoids, saponins, and phenolic compounds have drawn considerable interest from pharmaceutical researchers due to low toxicity and their enormous therapeutical potential (Inayatullah et al., 2012). These natural compounds have shown potential in combating bacterial and fungal infections and neutralizing ROS through unique mechanisms of action and minimal side effects (Ahmad and Aqil, 2007).

Macaranga peltata, commonly called Chandwar, belongs to the Euphorbiaceae family and is a small tree native to Indian forests (Gamble, 1967). The genus *Macaranga* comprises around 350 species globally (Verma et al., 2012), with approximately 12 species reported in India (Thrinitha et al., 2019). Traditionally, *M. peltata* has been used in paper sizing and as a substitute for gum arabic (Balasubramanyan et al., 1985). Its gum powder has also been utilized in Indian folk medicine to treat sexual disorders (Ramaiah, 1979). Recent studies have reported a broad spectrum of pharmacological properties in *M. peltata*, including anti-inflammatory (Honnappa et al., 2025), anticancer (Nizar et al., 2024), and analgesic activities (Bhat et al., 2024).

Previous research has explored the phytochemical profile, antioxidant, and antimicrobial potential of *M. peltata* leaf extracts (Purayil et al., 2019; Lim et al., 2009). Methanolic extracts from Indian *M. peltata* leaves have shown variability in their chemical composition and bioactivity in vitro (Thrinitha et al., 2019; Palakkal and Ganesan, 2018; Bijesh and Sebastian, 2013; Verma et al., 2012). However, there is still a need for comprehensive studies to fully understand the medicinal potential of this species.

Therefore, the present study aims to evaluate the phytochemical constituents, antioxidant properties, and antibacterial activity of *M. peltata* leaf extracts prepared using different solvents from India's tropical regions. Additionally, the extract demonstrating the highest bioactivity will be analyzed through gas chromatography-mass spectrometry (GC-MS) analysis to identify its major chemical components.

2. MATERIALS AND METHODS

2.1 Plant Sampling and Processing:

Fresh leaves of *Macaranga peltata* were collected in June 2023 from the Tirunelveli and Kanniyakumari districts of Tamil Nadu, India. The plant specimens were authenticated by the Department of Plant Science, Manonmaniam Sundaranar University, Tirunelveli. The collected leaves were carefully rinsed with distilled water to eliminate surface impurities, then shade-dried at room temperature. After complete drying, the leaves were ground into a fine powder using an electric grinder and stored in airtight containers until further analysis..

2.2 Preparation of Plant Extracts:

Five grams of the powdered leaf material were added to 100 mL of organic solvents—ethyl acetate, methanol, and DMSO—in separate beakers. The mixtures were shaken well and left at room temperature for 48 hours, with intermittent stirring two to three times daily. Following extraction, the mixtures were filtered, and the filtrates were concentrated to dryness using a rotary evaporator (Rotavapor). The resulting dried extracts were stored at 4°C for future analysis, following the method of Swamy et al. (2015).

2.3 Phytochemical Screening and Determination of Total Phenolic Content:

Qualitative phytochemical analysis of M. peltata extracts was performed following the standard protocol outlined by Savitharamma et al. (2011). The total phenolic content was determined using the Folin-Ciocalteu reagent method, with absorbance measured at 765 nm and gallic acid serving as the reference standard (Singleton and Rossi, 1965). The extracts were analyzed at a concentration of 2 mg/mL.

2.4 Antioxidant and Antibacterial Activity:

For antioxidant and antibacterial assays, plant extracts were tested at concentrations of 50, 100, 150, 200, and 250 µg/mL. DPPH radical scavenging activity was assessed following the method of Yen and Chen (1995), and superoxide radical scavenging activity was evaluated based on the protocol by Nishimiki et al. (1972).

Clinical bacterial strains—*Acinetobacter baumannii*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and methicillin-resistant *Staphylococcus aureus* (MRSA)—were obtained from the Department of Microbiology, Manonmaniam Sundaranar University. The antibacterial potential of the extracts was tested using the agar well diffusion method as described by Bauer et al. (1966).

2.5 Gas Chromatography-Mass Spectrometry (GC-MS) Analysis:

Chemical profiling of the methanolic extract of *M. peltata* was performed using GC-MS, following the procedure outlined by Semwal and Painuli (2019). Compound identification was carried out by comparing the retention times (RT) and mass spectra of the detected components with reference data from the National Institute of Standards and Technology (NIST) library.

2.6 Statistical Analysis:

All experiments were carried out in triplicate, and the results are presented as mean ± standard error (SE). Data analysis and the creation of graphical representations were conducted using Microsoft Excel 2007. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Qualitative Phytochemical Analysis of *Macaranga peltate:*

The results of the qualitative phytochemical screening of *Macaranga peltata* leaf extracts obtained using various solvents are presented in Table 1. According to Verma et al. (2012), methanolic extracts of *M. peltata* leaves contained carbohydrates, steroids, sterols, glycosides, flavonoids, tannins, proteins, and amino acids. Similarly, Bijesh and Sebastian (2013) found that methanolic extracts contained high levels of carbohydrates, tannins, and saponins; moderate amounts of flavonoids, alkaloids, and sterols; and lower levels of glycosides and amino acids. In contrast, Purayil et al. (2014) observed the absence of tannins, phlobatannins, flavonoids, terpenoids, and glycosides in chloroform extracts, although tannins and flavonoids were detected in aqueous extracts.

Table 1: Phytochemical screening of *Macaranga peltata* leaves extracts using various solvents

S.NO	Phytochemical test	*Macaranga peltata*		
		Methanol	**Ethyl acetate**	**DMSO**
1	Alkaloid –Wagners	-	-	+
	Alkaloid -Hager's	+	-	-
2	Flavonoids -lead acetate	+	+	+
	Flavonoids -Ferric chloride	+	-	+
3	Tannins-Ferric chloride	+	-	+
4	Glycosides-Sodium hydroxide	+	+	-
5	Saponins-Frothing test	+	-	-
6	Steroids -Libermann burchard	+	+	+

More recently, Bhat et al. (2024) identified nine phytochemicals—including carbohydrates, alkaloids, flavonoids, phenolics, tannins, saponins, anthraquinones, glycosides, and steroids—in ethanolic extracts of *M. peltata*. In the present study, methanolic extracts contained alkaloids, flavonoids, tannins, saponins, glycosides, and steroids. Ethyl acetate extracts revealed the presence of flavonoids, glycosides, and steroids, while DMSO extracts showed alkaloids, flavonoids,

tannins, and steroids. These variations may result from differences in genetic makeup, climatic conditions, geographic location, or extraction techniques used.

3.2 Total Phenolic Content:

Figure 1 illustrates the total phenolic content of *M. peltata* leaf extracts obtained with different solvents. The methanolic extract exhibited the greatest concentration of phenolic compounds compared to the ethyl acetate and DMSO extracts. Palakkal and Ganesan (2018) analyzed total phenolic content in leaf and bark extracts using methanol, ethanol, and hexane, with ethanol yielding the highest phenolic content. Thrinitha et al. (2019) also reported that methanolic extracts had higher phenolic content than petroleum ether and ethyl acetate extracts.

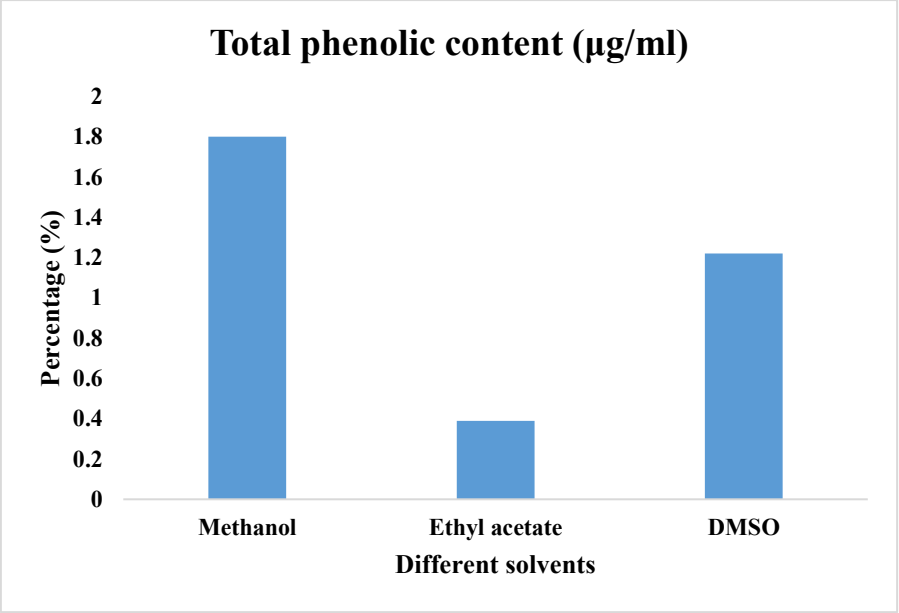

Figure 1: Total phenolic content of *Macaranga peltata* leaves extracts using various solvents

Honnesh et al. (2025) compared ethyl acetate and chloroform fractions of *Pongamia pinnata* and *M. peltata*, observing that the chloroform fraction of *M. peltata* had higher phenolic content. Consistent with previous findings, our study showed the methanolic extract of *M. peltata* leaves had the highest phenolic content among the tested solvents. Such variation is often due to differences in solvent polarity, extraction method, and analysis technique.

3.3 DPPH Radical Scavenging Activity:

The DPPH radical scavenging activity of *M. peltata* leaf extracts is shown in Figure 2. Among the tested solvents, the methanolic extract demonstrated the highest antioxidant activity at a concentration of 250 µg/mL, with a scavenging rate of 55.73%, followed by the ethyl acetate extract at 48.44% and the DMSO extract at 39.02%. Verma et al. (2012) found that methanolic stem bark extracts exhibited greater activity than leaf extracts. Purayil et al. (2019) reported that chloroform extracts were more effective than aqueous extracts.

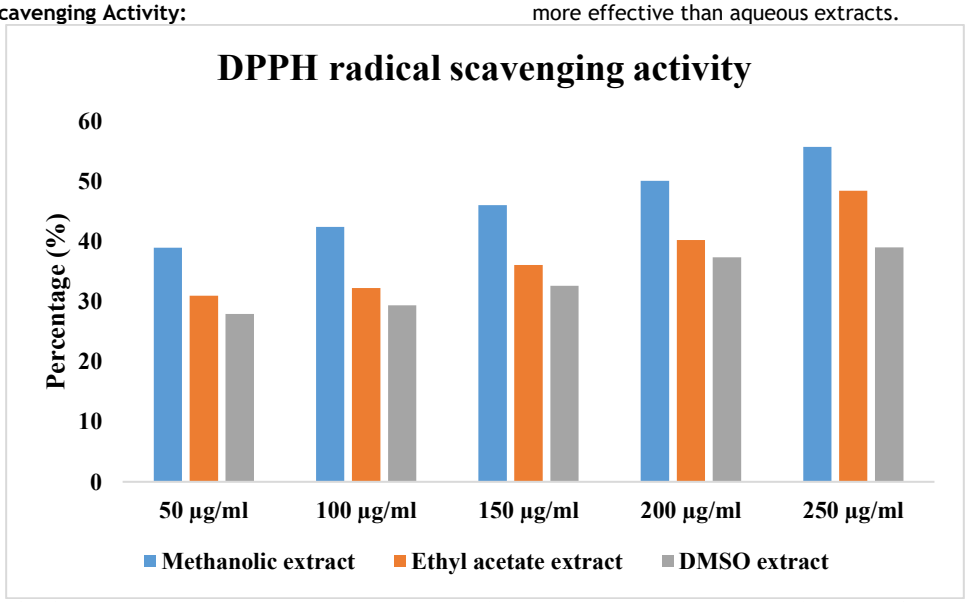

Figure 2: DPPH radical scavenging activity of *Macaranga peltata* leaves extracts using various solvents at different concentrations

In our study, the methanolic extract showed higher scavenging activity across all concentrations tested (50–250 µg/mL), with values of 38.95%, 42.43%, 46.04%, 50.07%, and 55.73%, respectively. These results are slightly lower than those reported by Palakkal and Ganesan (2018), who observed values ranging from 56.9% to 65% for methanolic extracts. The differences in DPPH activity may arise from variations in solvent efficiency, plant maturity, or environmental conditions during plant growth.

3.4 Superoxide Anion Radical Scavenging Activity:

Figure 3 presents the superoxide anion radical scavenging activity of *M. peltata* extracts. The methanolic extract showed the highest activity at 250 µg/mL (53.76%), followed by ethyl acetate (41.32%) and DMSO (38.88%). Thrinitha et al. (2019) found similar results, with methanolic extracts exhibiting 52.48% activity at 250 µg/mL. In this study, the methanolic extract exhibited 50.07% at 200 µg/mL and 53.76% activity at 250 µg/mL, while the ethyl acetate extracts recorded 40.25% and 41.32% at the same concentrations.

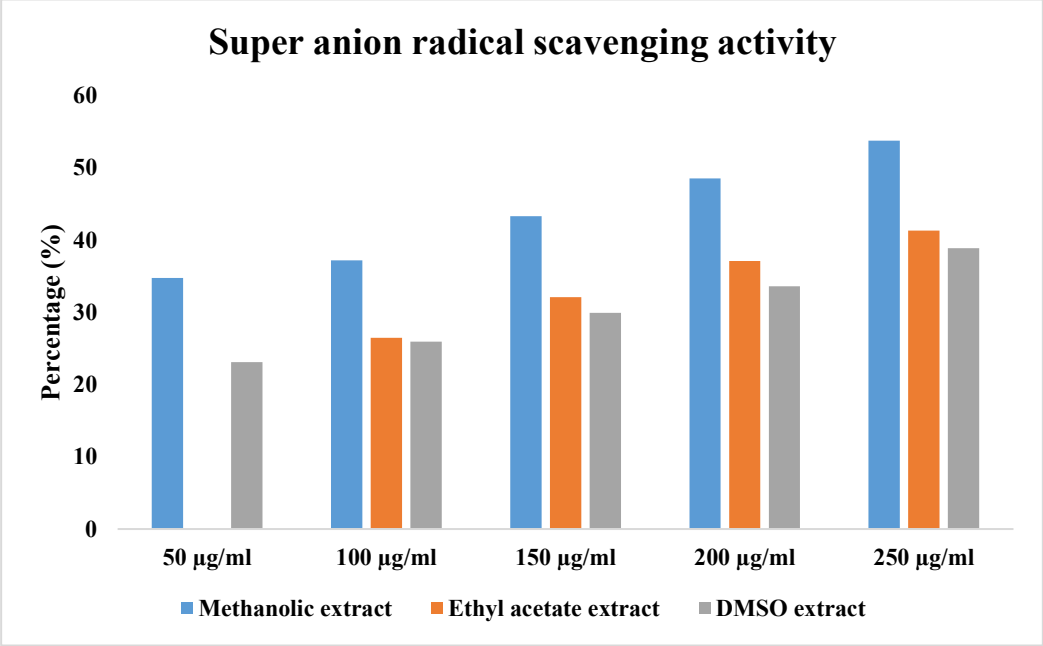

Figure 3: Superoxide anion radical scavenging activity of *Macaranga peltata* leaves extracts using various solvents at different concentrations

Antioxidant activity is influenced by multiple factors, including plant species, part used, growth conditions, extraction procedures, and analytical methods. The consistently higher activity observed in methanolic extracts may be due to the solvent's superior ability to dissolve phenolic compounds.

3.5 Antibacterial Activity:

The antibacterial effects of *M. peltata* leaf extracts (methanol, ethyl acetate, and DMSO) against four bacterial strains are shown in Figures 4a-d. All extracts exhibited activity against *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and methicillin-resistant *Staphylococcus aureus* (MRSA). Among the tested solvents, the methanolic extract demonstrated the strongest antibacterial effect, with zones of inhibition ranging from 7 mm (*K. pneumoniae*) to 23 mm (*A. baumannii*). The ethyl acetate extract showed inhibition zones between 15 mm (MRSA, *K. pneumoniae*) and 20 mm (*A. baumannii*). DMSO extracts showed lesser activity, ranging from 5 mm (*K. pneumoniae*, *P. aeruginosa*) to 16 mm (MRSA).

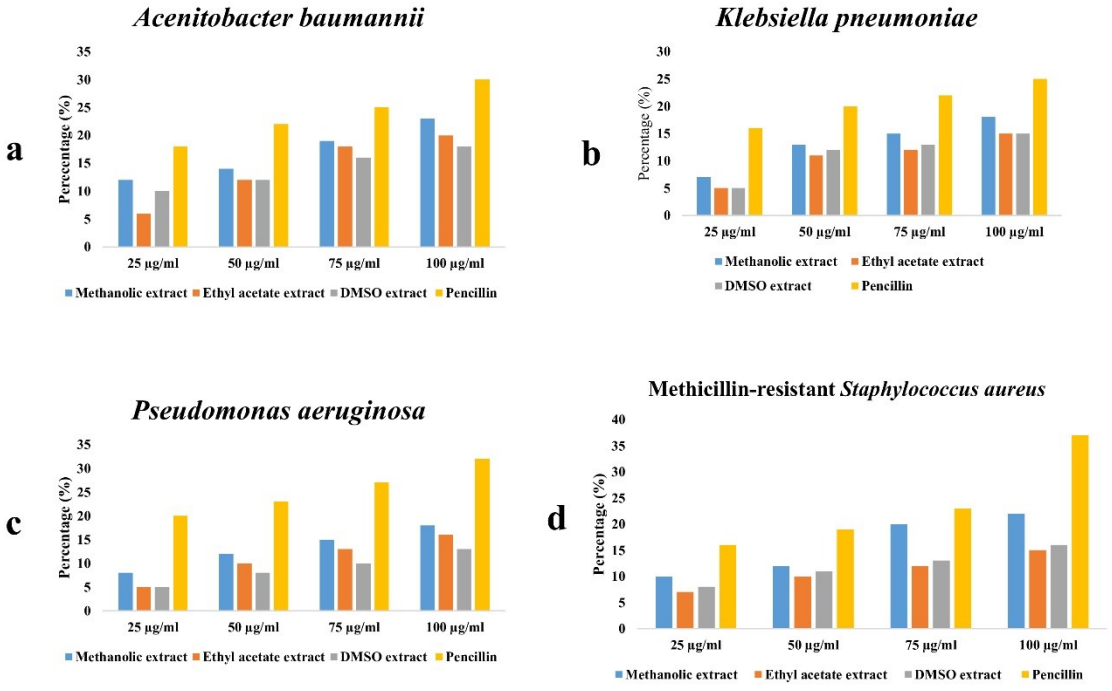

Figure 4 (a-d): Antibacterial activity of *Macaranga peltata* leaves extracts using various solvents at different concentrations

Verma et al. (2013) reported greater antibacterial efficacy of methanolic leaf extracts over stem extracts against *E. coli* and *S. aureus*. Bijesh and Sebastian (2013) observed the highest antibacterial activity in methanolic extracts compared to

ethanol, ether, and water extracts, with water being the least effective. Badarudheen et al. (2015) noted higher activity in acetone extracts than petroleum ether against *E. coli*, *P. vulgaris*, and *K. pneumoniae*.

In this study, extract efficacy was concentration-dependent, with peak activity generally observed at 100 µg/mL. The absence of activity in controls confirms the extracts' antimicrobial properties. Methanol's high polarity likely enhances the solubility of active phytoconstituents, contributing to its superior antibacterial effect. These findings align with previous studies (Duraipandiyan et al., 2006; Adegoke et al., 2010), though further research is necessary to isolate and identify the specific antibacterial compounds responsible.

3.6 Gas Chromatography-Mass Spectrometry (GC-MS) Analysis of *Macaranga peltate:*

The GC-MS analysis was performed on the methanolic extract of *Macaranga peltata* leaves (Figure 5). The chromatogram revealed twelve distinct peaks which indicate the presence of twelve different phytochemicals. The major compounds identified included: Benzene, 1,2-bis(trimethylsilyl); 2-[(tert-butyldimethylsilyl)oxy]phenol; Trimethyl(4-tert-butylphenoxy)silane; Cyclotrisiloxane, hexamethyl; N-Methyl-1-adamantaneacetamide; Arsenic acid; Silicic acid, hexamethyl ester; 1,2-Benzisothiazol-3-amine; and 3,3-Diisopropoxy-1,1,1,5,5,5-hexamethyltrisiloxane. These compounds, previously reported in other plant species, are thought to play an important role in plant defense mechanisms (Al-Owaisi et al., 2014). The mass spectra of the compounds showed over 90% similarity with entries in the NIST library, confirming their structural identities.

The results of this study highlight the therapeutic potential of these phytochemicals for applications in pharmaceuticals, cosmetics, and other therapeutic products. Moreover, the findings support the traditional medicinal uses of *M. peltata*, suggesting that its leaf extract contains bioactive compounds with pharmacological and nutritional relevance. However, further studies are required to isolate and purify these bioactive constituents, determine their molecular structures, and evaluate their toxicity and safety profiles for both human and animal use.

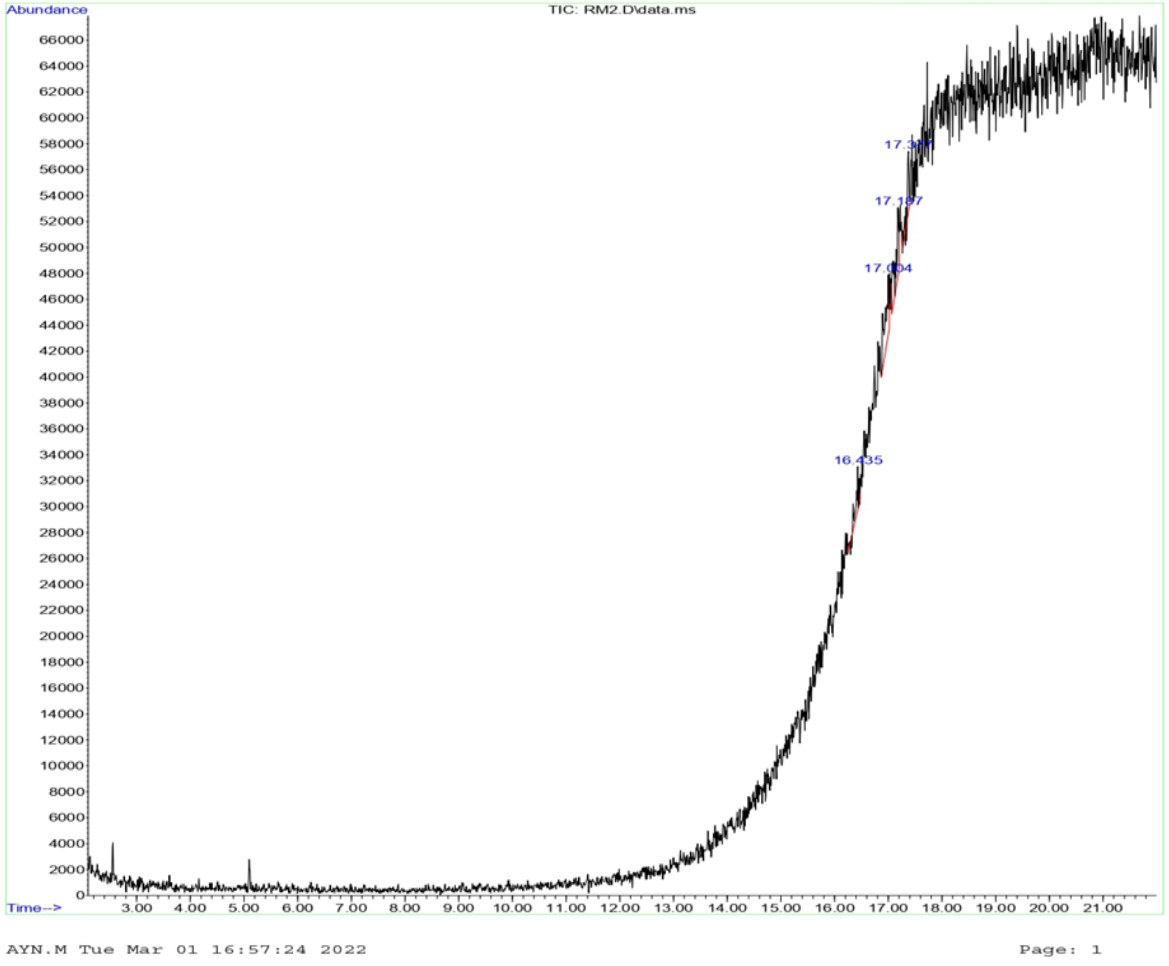

Figure 5: GC-MS analysis of methanol extract of *Macaranga peltata* leaves

CONCLUSION

In conclusion, the methanol-based extract of *Macaranga peltata* leaves demonstrated the presence of several phytochemicals. Among the tested solvents, the methanolic extract exhibited better antibacterial and antioxidant activities compared to ethyl acetate and DMSO extracts. GC-MS analysis of the methanolic extract identified twelve phytochemical constituents with potential biological activity. These findings suggest that *M. peltata* holds promise as a valuable source of natural bioactive compounds. Further research focusing on the purification and characterization of these compounds may lead to the discovery of new therapeutic agents and elucidate their mechanisms of action.

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