

Phytochemical Analysis of *Swietenia Macrophylla* for Its Bioactive Components through Gas Chromatographic Mass Spectrometry (GCMS)

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ABSTRACT

Swietenia Macrophylla King is an endangered species of plant in the Meliaceae family and a medicinally important plant indigenous to tropical and subtropical regions of the world. *S.Macrophylla* has been widely used in Asia and many other countries to treat various ailments based on its antimicrobial, anti - inflammatory, antioxidant effects, antimutagenic, anticancer, antitumour, antidiabetic and also in cardiovascular diseases. The seeds are used traditionally to treat wounds, hypertension, diabetes, malaria, cardiovascular diseases and to relieve pain. However the bioactive components of this seed are not yet established completely. In the present study, the ethanol extract of this seed was subjected to phytochemical qualitative analysis through Gas Chromatographic Mass Spectrometry (GCMS) and the bioactive components were identified. The analysis revealed the presence of flavonoid, tannins, alkaloid, glycosides, terpenoids, steroids and carbohydrates. The detection of these bioactive constituents in the plant extract may provide scientific validation for its diverse pharmacological activities and therapeutic potential.

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INTRODUCTION

Medicinal plants have served as a valuable source of therapeutic agents for centuries and continue to play a significant role in modern drug

discovery. According to the World Health Organization (WHO), nearly 80% of the global population relies on plant - derived medicines for primary health care needs (1). The growing

demand for natural products has stimulated extensive research into the phytochemical constituents of medicinal plants, leading to the identification of numerous bioactive compounds with antioxidant, antimicrobial, anti-inflammatory, antidiabetic and anticancer properties (2). These naturally occurring phytochemicals represent an important reservoir for the development of novel pharmaceuticals. Plants synthesize a wide range of secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, saponins, phenolic acids, glycosides and steroids which contribute to their therapeutic efficacy (3). These phytochemicals not only protect plants against environmental stress and pathogenic attacks but also exhibit significant pharmacological activities in humans. Consequently the characterization and identification of plant-derived bioactive compounds have become a major focus of phytochemical and pharmacological research (4).

S. Macrophylla (Meliaceae) is a tall, lofty, evergreen tree found in tropical and subtropical regions of the world. The species is primarily cultivated for its valuable timber, however increasing scientific evidence suggests that various parts of the plants possess remarkable medicinal properties. *S. Macrophylla* has been widely used in Asia and many other countries to treat various ailments based on its antimicrobial, anti-inflammatory (5), antioxidant effects, antimutagenic, anticancer, antitumour and antidiabetic activities. Various parts of *S. Macrophylla* have been used to treat a great array of ailments in traditional and folk medicine. The seeds of *S. Macrophylla* commonly known as "Sky fruit" as it is pointed towards the sky and locally known as "Thenkai" in Tamil in India (6). Seeds in particular are used in India, Indonesia and Malaysia for the treatment of wounds, diabetes, hypertension and malaria (7). The therapeutic potential of this plant has been attributed to the presence of diverse phytoconstituents, including limonoids, flavonoids, triterpenoids, steroids, fatty acids and phenolic compounds (8).

Previous studies have demonstrated that extracts of *S. macrophylla* exhibit significant antioxidant, antibacterial, antifungal, antidiabetic,

hepatoprotective and anticancer activities (9). The antioxidant properties are particularly important because oxidative stress plays a crucial role in the pathogenesis of numerous chronic diseases and cancer. Similarly, the emergence of multidrug-resistant microorganisms has intensified the search for plant-based antimicrobial agents that can serve as safer and more effective alternatives to conventional antibiotics (13). Therefore, the identification of bioactive compounds, biological properties responsible for these pharmacological activities is of considerable scientific, clinical interest, consumer products, food technology and medical applications (14).

Among the different analytical techniques available for phytochemical characterization, Gas Chromatography – Mass Spectrometry (GC-MS) is regarded as one of the most reliable and sensitive methods for qualitative and quantitative analysis of volatile and semi-volatile organic compounds (8). The technique combines the superior separation capability of gas chromatography with the molecular identification power of mass spectrometry, enabling comprehensive profiling of complex plant extracts. GC-MS has become an indispensable tool in natural product research for the detection of complex mixtures of compounds (12).

The growing scientific interest in *S. macrophylla* has led to the discovery of limonoids and other secondary metabolites, yet the phytochemical composition of different extracts remains incompletely characterized (4,8). Detailed GC-MS profiling can facilitate the identification of compounds with potential pharmaceutical applications (11). Furthermore, understanding the phytochemical composition of *S. macrophylla* may contribute to the development of novel therapeutic agents and natural antioxidant formulations.

Therefore, the present study was undertaken to perform a comprehensive phytochemical analysis of *Swietenia macrophylla* using Gas Chromatography - Mass Spectrometry (GC-MS). The aim was to identify the major bioactive

constituents present in the plant extract and to evaluate their potential biological significance. The findings of this study are expected to provide a scientific basis for the medicinal applications of *S. macrophylla* and support future pharmacological and drug development studies involving its bioactive compounds.

MATERIALS AND METHODS

The dry seeds were procured from local Herbal Medicine Shop, Chennai district, Tamil Nadu in India. The dry seeds were cleared off from the dust and other debris and were kept in sunlight for 48 hours. The shells of the seeds were broken and the seeds were collected. It was grinded using an electric blender into fine powder and was subsequently sieved to obtain a fine powder. Then the ethanol extract of the fine powder was prepared by treating it with 95% ethanol in a soxhlet apparatus by continuous heat exposure for 72 hours. The extract was concentrated in rotary vacuum evaporator at 40°C and reconstituted in minimum amount of dimethyl sulphoxide (DMSO) and dried extract was stored in refrigerator at 4°C in sterile bottle until GC-MS analysis.

Preliminary Phytochemical Screening

The ethanolic seed extract of *S. macrophylla* was subjected to qualitative phytochemical screening using standard protocols to detect the presence of major classes of secondary metabolites including alkaloids, flavonoids, tannins, saponins, phenolics, glycosides, terpenoids, steroids and carbohydrates.

Test for Alkaloids

2 ml of extract was mixed with a few drops of Dragendorff's reagent. Formation of an orange - red precipitate indicated the presence of alkaloids.

Test for Flavonoids

1 ml of extract was mixed with a few drops of 1% ammonia solution. Development of an intense yellow coloration confirmed the presence of flavonoids.

Test for Tannins

To 1 ml of extract, 2 ml of ferric chloride solution (5%) was added. A blue-black or greenish coloration indicated the presence of tannins.

Test for saponins

1 ml of extract was vigorously shaken with distilled water. Persistent froth formation indicated the presence of saponins.

Test for Terpenoids

2ml of extract were mixed with chloroform followed by careful addition of concentrated sulfuric acid. Formation of a reddish-brown interface indicated the presence of terpenoids.

Test for Steroids

The extract was treated with acetic anhydride and concentrated sulfuric acid. Development of a bluish - green colouration indicated the presence of steroidal compounds.

S.no	Phytochemical Components	Ethanol extract of <i>S.macrophylla</i>
1.	Alkaloids	Present
2.	Flavonoids	Present
3.	Tannins	Present
4.	Saponins	Present

S.no	Phytochemical Components	Ethanol extract of <i>S.macrophylla</i>
5.	Terpenoids	Present
6.	Steroids	Present

Table : 1 Phytochemical components ethanol seed extract of *S. macrophylla*

Gas Chromatography - Mass Spectrometry (GC-MS) Analysis

Gas chromatography - Mass Spectrometry (GC-MS) is a widely used analytical technique for the identification and confirmation of chemical constituents present in complex mixtures. It separates all components in a sample and provides a representative spectral output. The sample is injected into the injection port of gas chromatography, where it is rapidly vapourised. Then separates and analyses the various components. Each component ideally produces a specific spectral peak that may be recorded on a paperchart electronically. The elapsed time from sample injection to the detection of a compound at the detector is known as its "Retention time". The retention time helps to differentiate between compounds. The peak is measured from the baseline to the tip of the peak

Identification of Bioactive Components by GCMS

GC analysis of ethanol seed extract of *S. macrophylla* was performed using Shimadzu

GC17A - QP5050A gas Chromatograph. The oven temperature was programmed to be 290 C at a rate of 10 C/min. The carrier gas helium with a flow rate of 1ml/min. The sample was injected using the split sampling technique in the ratio of 1:10. Retention indices (RI) of the compounds were determined by comparing to the retention times of a series and identification of each component was confirmed by comparison of its retention index either with those of authentic compounds or with data in the literature. Interpretation of Mass- Spectrum was carried out by using the database of National Institute Standard and technology (NIST) having more than 60,000 patterns. The spectrum of the unknown components was compared with the spectrum of known components stored in the NIST library. The name, molecular formula, molecular weight and chemical structure of the components of the test materials were ascertained. The peak in GCMS of ethanol extract of *S. macrophylla* showed the presence of the secondary phytochemical compounds like phenolic acids, fatty acids and esters.

RESULT AND DISCUSSION

SN O	RT (min)	Name of the compound	Compound Nature	Molecular Formula	Molecular weight	Therapeutic Use
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1.	50.507	9,12-Octadecadienoic acid (Z,Z)-,2,3-dihydroxypropyl ester	Monoacylglycerol	$C_{21}H_{38}O_4$	354	Antioxidant, Anti-inflammatory, Antimicrobial
2.	50.626	Butyl 9,12,15-octadecatrienoate	Fatty acid ester	$C_{22}H_{38}O_2$	334	Antioxidant, Anti-inflammatory, Cardioprotective, Neuroprotective, Anticancer
3.	50.255	PREGNA-5,16-DIEN-20-ONE, 3-(ACETYLOXY)	Steroidal ketone	$C_{23}H_{32}O_3$	356	Antioxidant, Anti-inflammatory, Antimicrobial, Anticancer, Hepatoprotective
4.	41.436	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	Long-Chain unsaturated aliphatic diol	$C_{19}H_{34}O_2$	294	Antioxidant, Anti-inflammatory, Antimicrobial

Table - 1 Bioactive components in *S macrophylla* by Gas Chromatography Mass Spectrometry (GCMS)

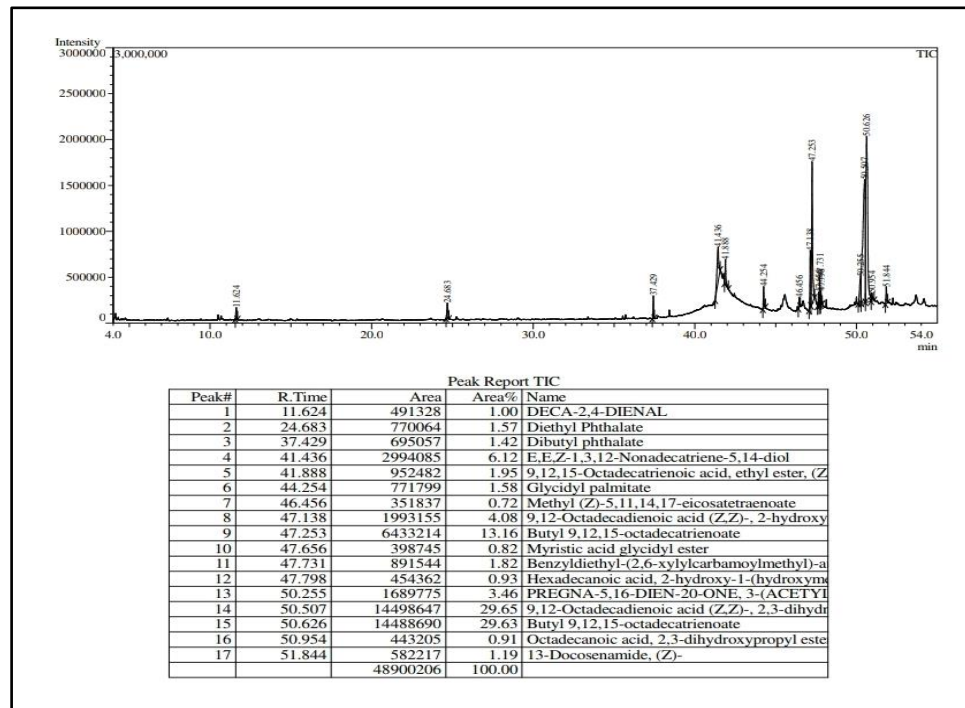


Figure - 1 & Table - 2 GC-MS total ion chromatogram (TIC) of the ethanol extract of *Swietenia macrophylla*, showing the retention times and relative abundance of the identified phytochemical constituents.

The Total Ion Chromatogram (TIC) and corresponding peak table obtained from the GC-MS analysis are presented in **Fig 1 and Table 1** respectively. A total of 17 chemical constituents were successfully resolved and identified. The elution profile spans from a retention time of 11.624 min to 51.844 min, revealing a complex chemical matrix predominantly composed of polyunsaturated fatty acid (PUFA) derivatives, long - chain lipid esters, and specialized lipophilic molecules. The analysed sample is characterized by two exceptionally dominant co - eluting chromatographic components in the high - boiling fraction. The primary constituent identified is 9,12 - Octadecadienoic acid (Z,Z) -, 2,3-dihydroxypropyl ester (RT- 50.507 min), representing 29.65% of the total relative abundance. This compound is structurally a monoglyceride of linoleic acid. Concurrently, Butyl 9,12,15 - octadecatrienoate co - elutes as a major pair, appearing at both RT of 47.253 min (13.16%) and 50.626 min (29.63%). Together, these linoleic and linolenic acid derivatives constitute 72.44% of the entire profile, establishing the highly unsaturated lipidic nature of the extract. Other notable components in moderate concentrations include E,E,Z-1,3,12-Nonadecatriene-5,14-diol with RT of 41.436 min (6.12%) and the steroid derivative PREGNA-5,16-DIEN-20-ONE, 3-(ACETOXY) with RT

of 50.253 min (3.4%). Trace amounts of lower molecular weight volatiles, such as the flavour/aroma - active aldehyde DECA-2,4-DIENAL, RT - 11.624 min (1.00%) were also recorded.

The overwhelming prevalence of long chain fatty acid esters, specifically derivatives of linoleic acid (9,12-octadecadienoic) and linolenic (9,12,15 - octadecatrienoic) acids underscores the potential bioactive properties of this sample. These structural groups are widely documented to possess significant antioxidant, anti inflammatory and antimicrobial properties (10). The GC-MS analysis in the present study confirmed the presence of several bioactive phytoconstituents that may contribute to the medicinal and physiological properties of the plant extract. Among the identified phytochemicals, tannins, alkaloids, terpenoids, steroids and saponins have been widely recognized for their diverse pharmacological activities. Similarly, saponins commonly found in traditional chinese and japanese medicinal herbs, have been documented to function as tonic and stimulant agents, enhancing overall physiological well - being. (10) Furthermore, several of these phytochemicals have been extensively reported to exhibit broad- spectrum antimicrobial activity, supporting their potential role in the prevention and treatment of infectious diseases(4).

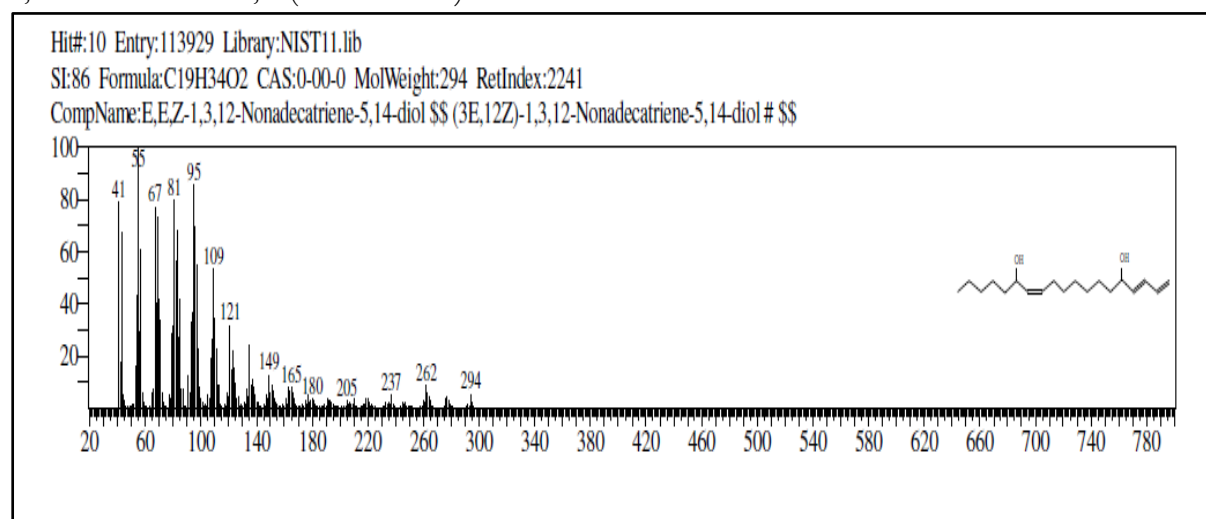


Figure -2 Mass spectrum of E,E,Z-1,3,12-Nonadecatriene-5,14-diol

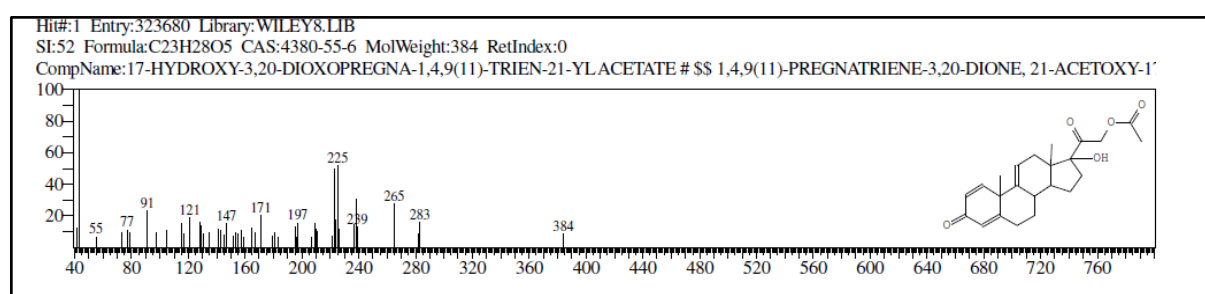


Figure 3- Mass Spectrum of PREGNA-5,16-DIEN-20-ONE, 3-(ACETYOXY)

CONCLUSION

The present GC-MS analysis of the ethanol seed extract of *Swietenia macrophylla* successfully identified a diverse range of bioactive phytoconstituents with significant pharmacological potential. The presence of these bioactive constituents provides scientific evidence supporting the traditional medicinal application of *S. macrophylla* and highlights the therapeutic potential of its seeds as a valuable

source of natural bioactive molecules. Overall, the findings of this study demonstrate the *Swietenia macrophylla* seed extract represents a promising natural reservoir of bioactive compounds with considerable potential for the development of novel pharmaceuticals and functional therapeutic agents

CONFLICT OF INTEREST

There is no conflict of interest

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