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Volatile Composition and gc-ms Profiling of Essential Oil from Fresh Leaves of *Senna alata* (*l*) roxb. Cultivated in South-West Nigeria

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ABSTRACT
Gas chromatography–mass spectrometry (GC–MS) remains one of the most reliable techniques for the characterization of volatile phytochemicals in essential oils. This study presents the GC–MS profiling of essential oil extracted from the fresh leaves of *Senna alata* (Roxb.), a medicinal plant widely known in traditional medicine for its antimicrobial, antifungal, and anti-inflammatory properties. The fresh leaves of *S. alata* (600 g) were subjected to hydro-distillation using an all-glass Clevenger-type apparatus to obtain the essential oil, which was subsequently analysed by GC–MS for determination of its constituents. The identification of these compounds was achieved by comparing their mass spectra and retention indices with those available in standard libraries such as NIST database. The percentage essential oil yield was 0.12% (v/w) and the essential oil was colourless and had an herbal smell. A total number of seventeen (17) compounds were identified from the essential oil which accounted for 95.7%. The major compounds identified were phytol (35.31%), (Z)-9-octadecamide (16.38%), geraniol (16.31%), and citronellol (14.37%). The predominance of these bioactive terpenoids and fatty acids derivatives strongly supports the traditional use of *S. alata* as an antimicrobial, antioxidant, and anti-inflammatory agents, highlighting its potentials for pharmaceutical and cosmetic applications.

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INTRODUCTION

Plants are considered to be medicinal when they contain rich source of compounds that are beneficial to human health. (Jamshidi-Kia *et al*., 2018; Ahn, 2017; Yuan *et al.,* 2016; Ekor, 2014). Medicinal plants are referred to as parts of a plant, that could be the fruit, seed, stem, bark, flower, leaf or root which are medicinal and could be used in drug developments either pharmaceutical, non-pharmaceutical or synthetic drugs (Ahn, 2017; Li & Weng, 2017). Medicinal plants have been reported to have different therapeutics benefits which ranges from been an antimicrobial (Tyohemba *et al.,* 2025), antioxidant to anti-inflammatory (Adekilekun *et al.*, 2025). Pharmaceutical industries of nowadays uses medicinal plants as important source in their products as essential oils (Sharifi-Rad et al., 2017; Schmidt et al., 2008). Essential oils (EOs) are intricate natural mixtures of volatile, lipophilic, and fragrant chemicals commonly present in aromatic plants. They are sometimes referred to as essences, volatile oils, etheric oils, or aetheroleum. With very few exceptions, most essential oils are colorless or pale yellow, liquid at ambient temperature, and less thick than water (cinnamon, vetiver, and sassafras). Additionally, some of the chemical components of essential oils have low molecular weights (less than 300), are soluble in the majority of organic solvents (such as alcohol, acetone, and ether), and are not soluble in water (de Sousa et al., 2023). The yield of essential oil produced from a plant can vary from 0.01% to 10% of its weight, contingent upon several factors such as climate, location, season, harvest time, and extraction methods (Atewolara-Odule et al., 2026; Hamid et al., 2011).

Senna alata also known as *Cassia alata* Linn. of the family Fabaceae, is an ornamental shrub widely distributed in tropical and subtropical regions, particularly in West Africa. The plant has long been utilised in traditional medicine due to its numerous pharmacological properties, including antimicrobial, purgative, antifungal, anti-inflammatory, antioxidant, antidiabetic, analgesic, and anticancer activities (Muhammad & Muhammad 2022; Oladeji et al., 2020). Different parts of the plant, such as the leaves, stem bark, roots, flowers, and seeds, contain diverse phytochemical constituents responsible for its medicinal importance. Phytochemical investigations of *Senna alata* have revealed the presence of flavonoids, phenolic compounds, tannins, alkaloids, saponins, terpenoids, anthraquinones, steroids, and carotenoids, which contribute significantly to its biological activities (Adeosun et al., 2024; Jenson et al., 2020).

The stem bark and leaf extracts of *Senna alata* have been reported to contain several bioactive compounds with potent antimicrobial and antioxidant activities. Studies have shown that extracts of the plant exhibit inhibitory effects against pathogenic microorganisms such as Pseudomonas aeruginosa infection-causing *Pseudomonas aeruginosa*, Staphylococcal infection-associated *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, and *Aspergillus niger* (Adeosun et al., 2024; Jenson et al., 2020; Singh et al 2016). In addition, recent pharmacological studies have demonstrated that the plant possesses anticancer, anti-inflammatory, and hypoglycaemic potentials, thereby supporting its extensive use in ethnomedicine for the management of several diseases and health conditions (Ngouana et al., 2025). These therapeutic properties have continued to attract scientific attention toward the isolation and characterization of novel phytochemicals from *Senna alata* for drug discovery and pharmaceutical applications. Despite the growing body of literature on *S. alata*, most studies have focused on solvent extracts rather than the essential oil, and there remains limited comprehensive data on the volatile composition of its leaves using advanced analytical techniques. In particular, there is a paucity of detailed GC–MS profiling of *S. alata* essential oil from many parts of Africa, including Nigeria, where the plant is widely used in traditional medicine, hence this study is aiming at providing the detailed GC–MS profiling of *S. alata* leaves essential oil from South West Nigeria.

MATERIALS AND METHODS

Plant Material Collection and Identification

Fresh leaves of *Senna alata* were collected in Ago-Iwoye, situated in Ijebu north local government area, Ogun state, Nigeria. The plant was identified and authenticated by Mr. A. Adeyemo at Forest Research Institute of Nigeria (FRIN), Ibadan, Oyo state, Nigeria and a voucher specimen with herbarium number FHI 113092 was deposited. The fresh leaves were washed with distilled water, cut into smaller bits and extracted immediately.

Extraction of Essential Oil

600 g of *Senna alata* were subjected to hydro-distillation in an all-glass Clevenger-type apparatus for 3 hours following the established procedure (British Pharmacopoeia, 1980). The volatile oil which distilled over water was collected separately into a clean and previously weighed sample bottle. The essential oil was refrigerated (4°C) until the moment of analysis.

Gas Chromatography (GC) and Gas Chromatography–Mass Spectrometry (GC–MS) Analysis

The essential oil was run by Gas Chromatography GC on an Agilent Model 7890A. fitted with a flame ionisation ***detector and*** HP-5MS (30 x 1.0 mm, 0.25 μm film thickness). The GC oven temperature was at 75 °C held for 3 min. at 4 °C/min. heated to 250 °C held for 10 min. with final hold time is 60min. The injector and detector temperatures were fixed at 75 °C and 250 °C respectively.

Gas Chromatography–Mass Spectrometry (GC–MS) analysis of the essential oil was carried out using an Agilent Technologies 7890A gas chromatograph coupled with a 5977A mass selective detector and fitted with an HP-5MS fused silica capillary column (30 m × 0.32 mm i.d., film thickness 0.25 μm). The oven temperature was programmed from 80 °C to 240 °C at a heating rate of 4 °C/min with helium used as the carrier gas at a constant flow rate of 1.0–2.0 mL/min. Injector and ion source temperatures were maintained at 250 °C and 230 °C, respectively, while electron ionization was performed at 70 eV. A diluted sample of the essential oil in n-hexane (1.0 μL) was injected in split mode. Mass spectra were recorded within a scanning range of 35–500 amu. Identification of the volatile constituents was achieved by comparison of their mass spectra and retention indices within the homologous series of C_7-C_{27} n-alkanes with data available in the NIST Mass Spectral Library and published literature (NIST, 2020; Adams, 2017).

RESULTS AND DISCUSSION

The essential oil from the fresh leaves yielded 0.12% (v/w). The essential oil obtained from the sample was colourless and had an herbal smell. GC–MS analysis of the essential oil obtained from fresh leaves of *Senna alata* revealed a total of 17 compounds accounting for 100% of the constituents, as shown in Table 1. The major constituents detected were Phytol (35.31%), (Z)-9-octadecamide (16.38%), Geraniol (16.31%), and Citronellol (14.37%). The other constituents present in the essential oil were n-hexadecanoic acid (2.79%), levomenthol (2.48%), 1-hexacosene (1.98%), neophytadiene (0.85%), hexacosane (0.77%), 2-pentadecanone- 6,10,14-trimethyl (0.7%), 1-hexadecyne (0.62%), 5,9,13-pentadecatrien-2-one, 6,10,14-trimethly-,(E,E)- (0.61%), tetradecanal (0.59%), tricosane (057%), p-cymene (0.54%), citral (0.44%), 1-nonadecene (0.44%).The classes of compounds gotten from the essential oil are terpenoids (71.6%), fatty acids & fatty acid derivatives (19.17%), hydrocarbons (4.38%), aldehydes (0.59%) with terpenoids constituting the largest proportion of the compounds.

The high level of phytol found in this study is in line with pr evious research on *S. alata* and related *Senna* species, where phytol has regularly been identified as one of the main volati le components (Essien et al., 2011). However, the amount of phytol found here (35.31%) is much greater than the 7.0% previously recorded by Essien et al. (2011), where α-turmerone (13.5%) and β caryophyllene (7.3%) were the mai n compounds. This large difference in quantity shows a signi ficant chemical variation within the Nigerian populations of *S. alata,* and could be due to differences in ecological factors , the plant's growth stage, the time of harvest, or the method used for extraction (Essien et al., 2011; Gobbo Neto & Lope s, 2007). When comparing this study with research done in o ther parts of the world, it becomes clear that environmental c onditions have a major impact on the makeup of essential oil s. For instance, essential oils from Cameroonian leaves are k nown for their high levels of linalool, borneol, pentadecanal, and α-terpineol, while those from India, Thailand, and Malaysia are mostly made up of β-caryophyllene, germacrene D, α-humulene, and caryophyllene oxide (Schmidt et al., 2009). In contrast, this study found that the essential oil from *S. alata* was mainly composed of the diterpene alcohol phyt ol, along with (Z)9 octadecamide and methyl hexadecanoate. These findings align with earlier reports that the geographic al origin of plant greatly influences the production and accu mulation of volatile, secondary metabolites in medicinal plan ts (Figueiredo et al., 2008). One particularly important discovery in this study is t he high level of (Z)-9 octadecamide, also known as oleamide, which accounted for 16.83% of the total essential oil. Unlike phytol, oleamide is rarely reported as a major compo nent of *S. alata* essential oils from other countries. Its high le vel in this study may therefore greatly contribute to the biolo gical properties traditionally associated with *S. alata* in Nige rian traditional medicine.

The high amount of phytol observed in this study may offer a possible explanation for the antioxidant and antimicrobial properties seen in the essential oil of Nigerian *S. alata*. The d ifferences seen in this study compared to earlier findings fro m Nigeria and other regions are likely due to several interact ing factors. Environmental factors like temperature, rainfall, altitude, soil type, and the length of daylight can affect the synthesis of essential oil s (Gobbo-Neto & Lopes, 2007).

Phytol is commonly found as chlorophyll in essential oils, oleoresins, and plant tissues. It is also found to have many medicinal and industrial applications (Almeida-Bezerra et al., 2024). It serves as a fundamental precursor in the biosynthesis of vitamins and can undergo various chemical modifications (e.g., sulfation) for use in surfactant or disinfectant formulations (Prabha et al., 2019). In medicinal fields, phytol has shown antinociceptive and antioxidant activities (Santos et al., 2013) as well as anti-inflammatory and antiallergic effects (Ryu et al., 2011). Phytol has been reported to be an excellent immunostimulant, anxiolytic, metabolism-modulating, cytotoxic, antinociceptive, autophagy- and apoptosis-inducing, immune-modulating, and antimicrobial (Islam et al., 2018). It is a natural acyclic monoterpenoid that can be used as perfumes and insect repellents (Revay et al., 2013). Citronellol is a good flavouring agent for foods and beverages. In traditional medicine, Citronellol oil has been used as an antispasmodic, a vermifuge, a diuretic, and an aromatic tea, (Khan & Abourashed, 2011). Geraniol is a commercially important terpene alcohol (monoterpenoid) which is found in the essential oils of several aromatic plants. It is a common component of consumer goods made by the flavour and fragrance industries and is one of the most significant compounds in both sectors. In addition to its pleasant odour, geraniol is known to exhibit insecticidal and repellent properties, anti-inflammatory, antibacterial, antiseptic, and analgesic properties, anticancer and used as a natural pest control agent exhibiting low toxicity (Chen & Viljoen, 2010). The presence of geraniol and citronellol supports the ethnomedicinal use of *S. alata* to microbial diseases and in treating skin infections. 9-octadecamide, (Z), also known as oleamide, is a fatty acid amide used in drugs to induce drowsiness or sleep or to reduce psychological excitement or anxiety (Fedorova et al., 2001). It is also a good memory booster. Oleamide has found to demonstrate superior anti-seizure efficacy and as an antiepileptic drug (Akanmu et al., 2007). The essential oil from Cameroonian *S. alata* is dominated by oxygenated monoterpenes, whereas this is rich in diterpenes (phytol) and fatty acid amides. This shows a marked difference in chemotype (Hennebelle *et al.,* 2009).

The GC-MS profile shows that Senna *alata* leaves essential oil contains a high concentration of pharmacologically significant components. The synergy of monoterpenes, diterpenes, and fatty acid derivatives implies potential antibacterial, antioxidant, and anti-inflammatory properties, confirming its historic therapeutic usage and emphasizing its pharmaceutical and industrial possibilities

Table 1: The Chemical Constituents in Essential Oil of *Senna alata*

S/No	Compound Name	Molecular formula	Mol. Weight (g/mol)	Retention time	Literature Retention index	Area%
1	P-Cymene	$C_{10}H_{14}$	134.22	3.420	1026	0.54
2	Levomenthol	$C_{10}H_{20}O$	156.27	5.442	1158	2.48
3	Citronellol	$C_{10}H_{20}O$	156.27	6.297	1225	14.37
4	Geraniol	$C_{10}H_{18}O$	154.25	6.664	1238	16.31
5	Citral	$C_{10}H_{16}O$	152.23	6.831	1237	0.44
6	Tetradecanal	$C_{10}H_{28}O$	212.37	12.208	1910	0.59
7	Neophytadiene	$C_{20}H_{38}$	278.52	13.530	1838	0.85
8	2-pentadecanone, 6,10,14-trimethyl	$C_{18}H_{36}O$	268.48	13.597	1846	0.70
9	1-hexadecyne	$C_{16}H_{30}$	222.41	13.963	1664	0.62
10	5,9,13-pentadecatrien-2-one, 6,10,14-trimethly-,(E,E)-	$C_{19}H_{34}O$	278.50	14.330	1924	0.61
11	n-hexadecanoic acid	$C_{16}H_{32}O_2$	256.42	14.896	1976	2.79
12	Phytol	$C_{20}H_{40}O$	296.53	16.252	2633	35.31
13	Tricosane	$C_{23}H_{48}$	324.63	17.829	2300	0.57
14	(Z)-9-octadecamide	$C_{18}H_{35}NO$	281.48	18.407	2397	16.38
15	1-hexacosene	$C_{26}H_{52}$	364.70	18.574	2596	1.98
16	Hexacosane	$C_{26}H_{54}$	366.70	20.200	2600	0.77
17	1-nonadecene	$C_{19}H_{38}$	266.51	21.718	1892	0.44
						Total=95.7

CONCLUSION

In conclusion, the hydro-distillation of fresh *Senna alata* leaves from Soth-West Nigeria yielded an essential oil characterised by a rich and distinct volatile profile, predominantly composed contains phytol, geraniol, citronellol, and (Z)-9-octadecamide. The high concentration of these bioactive terpenoids and fatty acid derivatives provides a scientific basis for the plant's extensive ethnomedicinal use in managing microbial infections, inflammation, and oxidative stress. These findings not only expand the phytochemical database of *S. alata* but also highlight its potential as a valuable natural source for the development of novel antimicrobial and anti-inflammatory agents in the pharmaceutical and cosmetic industries. Future studies should focus on the in vivo validation of these pharmacological properties and the exploration of seasonal variations in the oil's chemotype.

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