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VOLATILE CONSTITUENTS FROM THE AIR-DRIED LEAVES OF *Mangifera indica* LINN

*[1]Ogunmoye, A. O., [1]Adams, K. A., [2]Rowaiye, G., [1]Olubomehin, O. O., [1]Atewolara-Odule, O.C. and [1]Ogunlade E. J.
[1]Chemical Sciences Department, Olabisi Onabanjo University, Ago-Iwoye, Ogun State.
[2]National Biotechnology Research Development Agency, Federal Ministry of Innovation, Science and Technology, Nigeria.
*Correspondent Author's e-mail address: omotunde.ogunmoye@oouagoiwoye.edu.ng
Orchid no.: https://orcid.org/0000-0003-0686-2472

ABSTRACT

The medicinal plant *Mangifera indica* belongs to the Mangifera genus and the Anacardiaceae family, and it has varied therapeutic properties. This study aimed to characterize the bioactive volatile constituents found in the plant essential oil. The extraction of essential oil from *Mangifera indica* air-dried leaves (200 g) was obtained by hydrodistillation in an all-glass Clevenger apparatus, and gas chromatography mass spectrometry (GC-MS) was carried out to identify the components. The essential oil obtained was a cloudy light yellow liquid with strong herbal odour and a yield of 0.083% (v/w). Fourteen constituents were identified, representing 78.47% of *M. indica* oil. The major components are; 3, 3-Diethyldiaziridine (12.49%), α-Gurjunene (10.95%), 1, 1-dimethyl-2-octyl cyclobutane (9.43%), 1-Undecene-5-methyl (8.52%), Humulene (8.32%), (+)-β-selinene (7.89%), 1,2-diethylcyclobutane (Z) (7.88%) and β-Caryophyllene (5.20%). Sesquiterpenes (32.81%) and hydrocarbons (31.46%) were the predominant classes of chemical constituents in *M. indica,* while the others were heterocyclic compounds (12.49%), and oxygenated sesquiterpenes (1.71%). The presence of sesquiterpenes and hydrocarbons as the major classes of compounds in the essential oil may justify the traditional use of the plant in treating pains, fever, inflammatory conditions, antioxidant activity and as an energy source.

Keywords: Essential oil, *Mangifera Indica*, 3, 3-Diethyldiaziridine, Sesquiterpenes, GC-MS.

INTRODUCTION

Herbal medicine and drug discovery using natural products is still an important issue in the current target-rich, lead-poor scenario (Patwardhan *et al.,* 2004). According to the WHO, between 65% and 80% of the populations of developing countries currently use medicinal plants for therapeutic purposes (WHO, 2011). The development of new products from natural sources is also encouraged because it is estimated that of the 300,000 plant species that exist in the world, only 15% have been evaluated to determine their pharmacological potential (De Luca *et al.,* 2012).

Mangifera indica, commonly known as mango, is a species of flowering plant in the sumac and poison ivy family Anacardiaceae. It is found in the wild in Bangladesh, India and Pakistan, where it is indigenous and cultivated varieties have been introduced to other warm regions of the world. It is a large fruit tree, capable of growing to a height and crown width of about 100 feet and trunk circumference of more than twelve feet. The species was brought to East Asia around 400-500 BCE from India; next, in the 15th century to the Philippines; and then, in the 16th century to Africa and Brazil by the Portuguese. The species was described for science by Linnaeus in 1753 (Sauer and Jonathan, 1993).

Some of the therapeutic properties of *M. Indica* include its use as an astringent for diarrhoea, fever, diabetes, hypertension, rheumatism, chronic dysentery, catarrh of the bladder, and chronic urethritis resulting from gonorrhoea (Morton, 1987). Similarly, they have been reported to show anti-inflammatory, analgesic, immunomodulatory, and antioxidant properties (García *et al.,* 2003; Núñez-Sellés *et al.,* 2007; Khan *et al.,* 2017). It has also been reported that essential oils from the leaves, peel, seed and bark of Mangifera indica L. contain active ingredients that are utilised in the food and pharmaceutical industry (Maharaj *et al.,* 2022)

Previous studies have also identified the presence of phenolic compounds, tannins, saponins, flavonoids, steroids, alkaloids, xanthones, terpenoids, anthraquinones, and glycosides in mango leaves (Chisom *et al.,* 2023; Jhaumeer Laulloo *et al.,* 2018). Mangiferin is the most active biological constituent of *M. indica* leaves among all total phenol compounds (TPCs), followed by phenolic acids, antioxidants (carotenoids, flavonoids, quercetin, ascorbic acid, tocopherols, and isoquercetin), and

benzophenones (Kumar *et al.,* 2021).
In continuation of our research into the volatile constituents of Nigerian flora, we report in this paper the constituents identified in the essential oil of the leaves of *M. Indica,* growing in Nigeria.

MATERIALS AND METHODS

Plant materials

Fresh and mature leaves of *Mangifera indica* were obtained from plants growing at Olabisi Onabanjo University (OOU), behind Mini-campus Ago-Iwoye, Ogun State. The sample was identified and authenticated at the Forestry Research Institute of Nigeria (FRIN), Ibadan, with herbarium number FHI-110463, and a voucher specimen of the sample was deposited at the herbarium. The leaves were further air-dried at room temperature and crushed before further study.

Extraction of Essential Oil

The air-dried and pulverised leaves of *Mangifera indica* (200 g) were subjected to hydrodistillation in an all-glass Clevenger-type apparatus for 3 h in accordance with an established procedure (British Pharmacopoeia, 1980; Clevenger, 1928; Dash and Pattnaik, 2025). The oil collected was preserved in a sample tube and stored under refrigeration until the moment of analysis.

Gas Chromatography-Mass Spectrometry (GC/MS) Analysis

GC-MS remains one of the most powerful analytic tools due to its peaky sensitivity, specificity, and robustness in separating and identifying volatile and semi-volatile compounds (Sparkman *et al.,* 2011; Kusuma *et al.,* 2020; Muhammad & Lawal, 2025). The GC-MS analysis of the oil was performed on an Agilent Technology 7890A. A gas chromatograph equipped with an FID and fitted with a fused silica capillary HP-5 MS column (30 m x 0.32 mm ID, film thickness 0.25 µm). The oven temperature was programmed from 80 to 240 °C at the rate of 8°C/min. The ion source was set at 240 °C and electron ionisation at 70eV. Helium was used as the carrier gas at a flow rate of 2 mL/ min. The scanning range was 35-425 amu. Diluted oil in n-hexane (1.0 µL) was injected into the GC/MS. The research was carried out at D.K. Olukoya Central Research and Reference Laboratories at University of Lagos.

Identification of the Constituents

The identification of the constituents was performed on the basis of retention indices (RI) determined by co-injection with reference to a homologous series of n-alkanes, under identical experimental conditions. Further identification was performed by comparison of their mass spectra with those from NIST (Database 69) and Wiley 9th Version and the home-made MS library built up from pure substances and components of known essential oils, as well as by comparison of their retention indices with literature values (Joulain and Koenig, 1998; Adams, 2007).

RESULTS AND DISCUSSION

The essential oil obtained from *Mangifera indica* leaves had a yield of 0.083% (v/w), calculated on a dry-weight basis. The oil was light yellow in colour and possessed a strong characteristic odour. Gas chromatography–mass spectrometry (GC–MS) analysis identified fourteen constituents, accounting for 78.47% of the total chromatographic peak area. The identified compounds, arranged according to their order of elution on the HP-5 MS column, are presented in Table 1.0, while the corresponding chromatographic profile is shown in Figure 1.0.

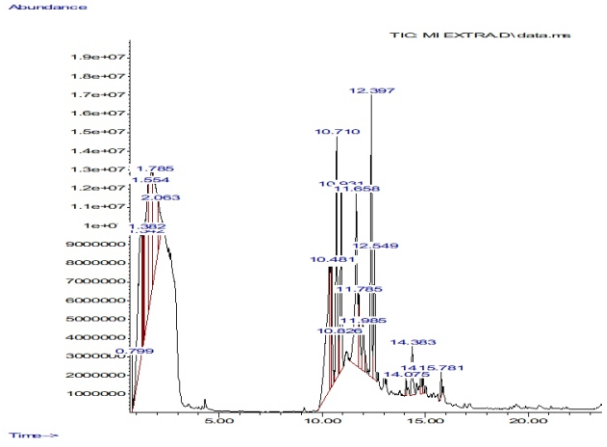


Figure.1.0 Chromatogram of *Mangifera indica* Essential Oil Component

Table 1.0: Essential Oil Composition of *M. indica*

S/N	COMPOUNDS	RETENTION TIME	% COMPOSITION	KOVAT INDEX	MOLECULAR FORMULA
1.	Cis-2-Butene	0.796	0.30	328	C_4H_8
2.	3,3-Diethyldiaziridine	1.214	12.49	1087	$C_5H_{12}N_2$
3.	10-Methyl-Undecene	1.283	4.01	791	$C_{12}H_{24}$
4.	Ethyl-2-heptyl cyclopropane	1.380	1.32	1058	$C_{12}H_{24}$
5.	Cis-1,2-diethylcyclobutane	1.557	7.88	1301	C_8H_{16}
6.	1,1-dimethyl-2-octyl cyclobutane	1.729	9.43	1100	$C_{14}H_{28}$
7.	5-methyl-Undecene	1.786	8.52	1401	$C_{12}H_{24}$
8.	α-Gurjunene	10.712	7.53	1493	$C_{15}H_{24}$
9.	β-Caryophyllene	10.930	5.20	1500	$C_{15}H_{24}$
10.	α-Humulene	11.656	8.32	1500	$C_{15}H_{24}$

11.	(+)-β-selinene	12.395	7.89	1500	$C_{15}H_{24}$
12.	γ-Gurjunene	12.549	3.42	1500	$C_{15}H_{24}$
13.	isoaromadendrene epoxide	14.386	1.71	1500	$C_{15}H_{24}O$
14.	(+)-9-epi-β-Caryophyllene	15.782	0.45	1646	$C_{15}H_{24}$

CLASSES OF COMPOUNDS	%
Sesquiterpene (6)	32.81
Saturated & Unsaturated Hydrocarbons (6)	31.46
Heterocyclic compounds (1)	12.49
Oxygenated sesquiterpene (1)	1.71
Total	**78.47**

The major constituents of the essential oil were 3,3-diethyldiaziridine (12.49%), 1,1-dimethyl-2-octylcyclobutane (9.43%), 5-methylundecene (8.52%), α-humulene (8.32%), (+)-β-selinene (7.89%), *cis*-1,2-diethylcyclobutane (7.88%), α-gurjunene (7.85%), and β-caryophyllene (5.20%). In contrast, *cis*-2-butene (0.30%) was the least abundant constituent detected.

A notable finding in the present study was the detection of 3,3-diethyldiaziridine as the most abundant individual constituent, representing 12.49% of the total chromatographic peak area. The predominance of this compound is particularly noteworthy because diaziridines are nitrogen-containing, strained three-membered heterocyclic compounds with distinctive chemical reactivity. Although 3,3-diethyldiaziridine itself has not been widely established as a biologically active pharmaceutical compound, the biological relevance of the diaziridine scaffold has been investigated using structurally related derivatives. Substituted diaziridines have been associated with various biological activities, including enzyme inhibition, antidepressant activity with tranquillising effects, and central nervous system-related effects (Ilya *et al.,* 2021). Consequently, the relatively high abundance of 3,3-diethyldiaziridine in the present oil warrants further investigation to establish its biological properties and possible contribution to the pharmacological activities of the essential oil.

Comparison of the present GC–MS profile with previously reported chemical compositions of *M. indica* revealed considerable qualitative and quantitative variations. Alwala *et al.,* (2010), for instance, identified 26 major hydrocarbon compounds in *M. indica* leaf oil and reported α-pinene (33.3%), α-phellandrene (22.6%) limonene (13.2%), and *p*-cymene (6.1%) as the predominant constituents. These findings differ markedly from the present profile, in which 3,3-diethyldiaziridine, 1,1-dimethyl-2-octylcyclobutane, 5-methylundecene, α-humulene, (+)-β-selinene, *cis*-1,2-diethylcyclobutane, α-gurjunene, and β-caryophyllene were the major constituents. Also, α-pinene, camphene, β-pinene, α-copaene, and β-elemene, which were reported among the major constituents of six different mango species from Kenya, were conspicuously absent from the present oil sample (Wetunga *et al.,* 2015). Similarly, GC–MS analysis of essential oils from three varieties of *M. indica* peel and pulp identified compounds such as 4-carene, α-terpinolene, cyclohexadecane, and *n*-hexadecanoic acid among the major constituents, and these are not detected in the present study (Osman & Ramlan, 2015).

Tamura *et al.,* (2001) identified γ-terpinene, (E)-β-ocimene, (E)-2-hexenal, hexanal, and (Z)-3-hexen-1-ol as major volatile components of the peel and pulp of the popular green Thai mango cultivar Khieo Sawoei, from Thailand, which is at variance with the current study. Likewise, the analysis of volatile components from 20 mango cultivars using simultaneous distillation–extraction, GC, and GC–MS identified 372 compounds, with terpene hydrocarbons constituting the major volatile group. The dominant terpenes included δ-3-carene, limonene, terpinolene, and α-phellandrene (Jorge *et al.,* 2005). These observations further demonstrate the extensive chemical diversity of *M. indica* volatile oils and support the differences observed between the present Nigerian sample and previously investigated mango cultivars from other countries.

Despite these differences, several compounds detected in the present study have also been reported in *M. indica* samples from Nigeria and other geographical regions. All the dominant compounds reported in mango leaf oil (α-gurjunene, β-selinene and β-caryophyllene) were present in the current study except δ-3-carene, though in varying composition (Dzamić *et al.,* 2010). The occurrence of these compounds in the present Nigerian sample suggests some degree of chemical similarity among *M. indica* populations despite differences in the relative abundance of individual constituents. Auwal *et al.,* (2024)

reported 52 compounds from *M. indica* leaf essential oil from Nigeria, with alloaromadendrene (13.65%), humulene (12.45%), bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene (10.80%), and bicyclo[7.2.0]undec-4-ene, 4,11,11-trimethyl-8-methylene-, [1R-(1R,*4Z,9S*)] (8.98%) among the predominant constituents. These compounds and their relative proportions differ from those observed in the present investigation. Similarly, a base-assisted extraction of *M. indica* leaves identified 28 bioactive compounds, with 9,12-octadecadienoyl chloride (34.83%), 9,12-octadecadienoic acid (12.64%), hexadecenoic acid methyl ester (10.57%), palmitic acid ethyl ester (8.15%), and linoleic acid ethyl ester (5.77%) as the most abundant constituents (Muhammad & Lawal, 2025). The marked difference between these findings and those of the present study may be attributed partly to the extraction methodology, since solvent-assisted or base-assisted extraction can recover compounds that differ substantially from the volatile constituents obtained through hydrodistillation.

Geographical and varietal differences have also been demonstrated in mango leaves. The leaves of two *M. indica* varieties from Campo Grande, Brazil, were characterized by the predominance of β-selinene, (E)-caryophyllene, and α-humulene (Cardoso *et al.,* 2013). Similarly, studies employing headspace solid-phase micro extraction (HS-SPME) and hydrodistillation reported cyperene, (E)-caryophyllene, α-humulene, terpinolene, carotol, gualol, and α-cadinol in immature mango leaves, whereas mature leaves contained cyperene, α-gurjunene, (E)-caryophyllene, α-cedrene, and α-humulene (Gerbara *et al.,* 2011). The presence of α-gurjunene, α-humulene, β-caryophyllene, and β-selinene in the present study is therefore consistent with some previous reports on *M. indica* leaves, although their relative abundances differ. Considerable variations in the identities and relative abundances of individual constituents have been documented among different plant parts, cultivars, geographical locations, and extraction methods (Gerbara *et al.,* 2011; Pino *et al.,* 2005; Adeyinka *et al.,* 2022).

Other investigations have similarly demonstrated that mango volatiles comprise diverse chemical classes. In the present study, the identified class of compounds comprised sesquiterpenes (32.81%), hydrocarbons (31.46%), heterocyclic compounds (12.49%), and oxygenated sesquiterpenes (1.71%). Chinese mango fruit varieties analyzed using HS-SPME coupled with GC–MS and GC–olfactometry revealed alcohols, alkenes, aldehydes, esters, ketones, and ethers among the principal classes of volatile compounds (Liu *et al.,* 2020). In addition, volatile compounds from fresh and dried mango analyzed using the solvent-assisted flavour evaporation (SAFE) technique and GC–MS yielded 41 and 55 compounds, respectively, with monoterpenes, sesquiterpenes, lactones, and alcohols representing the major classes (Bonneau et al., 2016). These findings further highlight the chemical complexity of mango-derived volatile fractions and the influence of sample type and analytical methodology on the resulting chemical profile.

The predominance of sesquiterpenes (32.81%) in the present essential oil is particularly relevant because this class of natural products has been associated with a broad range of biological activities. Sesquiterpenes and their derivatives have been investigated for antimicrobial, antioxidant, antibacterial, antiviral, anti-inflammatory, antitumor, anticancer, and neuroprotective activities, among others (Li *et al.,* 2016; Arjmand *et al.,* 2023; Jingjing *et al.,* 2024; Muller, 2025; Wang *et al.,* 2024). The substantial representation of sesquiterpenes in the present *M. indica* essential oil may therefore contribute to its potential biological activities. However, the biological effects of an essential oil cannot necessarily be attributed to a single constituent because interactions among major and minor components may produce additive, synergistic, or antagonistic effects.

CONCLUSION

The present study reveals a distinctive chemical profile for *Mangifera indica* essential oil, with fourteen identified constituents accounting for 78.47% of the total chromatographic composition and sesquiterpene (32.81%) representing the predominant chemical class. Notably, 3,3-diethyldiaziridine was the most abundant constituent (12.49%), representing an unusual nitrogen-containing heterocyclic component that distinguishes the present oil profile from many previously reported *M. indica* essential oils. Although several sesquiterpenes, including α-gurjunene, α-humulene, β-caryophyllene, and β-selinene, were consistent

with earlier reports, marked qualitative and quantitative variations underscore the influence of geographical origin, plant material, cultivar, environmental conditions, plant maturity, soil composition, plant age, developmental stage, seasonal variation, and extraction methodology on the chemical composition of *M. indica* oils. The occurrence and relatively high abundance of 3,3-diethyldiaziridine provide a novel observation that warrants targeted structural confirmation and further investigation of its biological and toxicological properties. Overall, the findings expand the chemical knowledge of *M. indica* essential oil from Nigeria and provide a basis for future studies aimed at elucidating its biological potential and the contribution of its major constituents to observed pharmacological effects.

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CONFLICT OF INTEREST

Authors declare that there is no conflict of interest related to this study.

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