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Short Communication

Essential oil composition of *Terminalia ivorensis* A. Chev. flowers from Northern Nigeria

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ABSTRACT

In the present study, the volatile compounds identified in the essential oil from the flowers of *Terminalia ivorensis* A. Chev (Combretaceae) collected from Kaduna, Northern Nigeria, are reported. Essential oils were obtained using hydrodistllation in a Clevenger-type apparatus. The yield of the light yellow oil was found to be 0.22% (v/w, dry weight basis). The content and composition of the oil were analyzed by gas chromatography (GC-FID) and gas chromatography with electron impact mass spectrometry (GC-MS). The main compounds of the oil were δ-3-carene (29.4%) and α-pinene (20.9%). To the best of our knowledge, this is the first report on the essential oil constituents of any part of *T. ivorensis*.

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1. Introduction

Essential oils are odouriferous mixture of complex organic substances (Huong et al., 2018). At room temperature, they usually appear as pungent liquids. Given their volatility, these molecules can be extracted using steam distillation, although other methods exist. On the whole, essential oils are responsible for the aromas of plants. Essential oils are made up of several organic volatile substances involving terpenes, alcohols, ketones, ethers, aldehydes etc. and are produced and stored in the secretion canals of plants. The volatile contents of several medicinal plants have been characterized (Oanh et al., 2018; Ogunwande et al., 2018). Essential oils and their compounds have exhibited a number of diverse biological activities such as anti-inflammatory and anti-nociceptive (Aboluwodi et al., 2017; Adeosun et al., 2017; Oluwa et al., 2017; Ogunwande et al., 2018), insecticidal (Sotubo et al., 2016; Ogunwande et al., 2017), antibacterial, anti-platelet aggregation and cytotoxic activities (Lawal et al., 2017).

Terminalia ivorensis A. Chev (Combretaceae) is a deciduous tree growing to 30 m (98ft) at a fast rate. The bark is smooth and light gray to dark brown when young and on branchlets; in mature trees often blackish, with deep longitudinal fissures. The bark flakes off in long thin strips. It's flowering stage usually begins in April after the new leaves have begun to appear and last until June, in its native range. The interval between the opening of the leaf buds and flowering is 3-4 weeks. The flowers are fertilized by insects. Fruiting, which begins in December, is abundant from January to March (Hong et al., 1996). Previously, extracts of *T. ivorensis* were reported to exhibit significant antibacterial activity against tested organisms such as *Candida albicans*, *Aspergillus fumigatus* and *Trichophyton mentagrophytes* var. *interdigitale* amongst others (Ouattara et al., 2013; Sitapha et al., 2013; Coulibaly et al., 2014). In addition, recent findings indicated the antipsychotic-like activity (Ben-Azu et al., 2016), antipsychotic activity (Ben-Azu et al., 2018), sedative (Adeoluwa et al., 2015), analgesic effects (Adeoluwa et al., 2015; Avoseh et al., 2018), anti-inflammatory (Avoseh et al., 2018) and trypanocidal

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(Agbedahunsi et al., 2006) actions of extracts of *T. ivorensis*.

The phytochemical compounds isolated from *T. ivorensis* include ivorengenin A, ivorengenin B arjungenin, arjunic acid, betulinic acid, sericic acid, and oleanolic acid (Beaudelaire et al., 2011). These compounds exhibited significant antioxidant and antiproliferative activities against MDA-MB-231, PC3, HCT116, and T98G human cancer cell lines (Ponou et al., 2011a). The isolation and characterization of sericic acid and lonchoterpene have been reported (Iwu and Anyawu, 1982). In addition, ivorenosides A, B and C were isolated from the bark of *T. ivorensis* (Ponou et al., 2011b). Ivorenoside B and C exhibited scavenging activity against DPPH and ABTS(+) radicals while ivorenoside A showed antiproliferative activity against MDA-MB-231 and HCT116 human cancer cell lines (Ponou et al., 2011a).

However, a literature survey demonstrates that there is no published article yet on the analysis of chemical constituents of essential oils from any parts of *T. ivorensis* from Nigeria or elsewhere. The present study was undertaken to evaluate the volatile composition of essential oil from the flowers of *T. ivorensis* for the first time.

2. Experimental

2.1. Collection of flower sample of *T. ivorensis*

Flowers of *T. ivorensis* were collected from premises of Headquarters of Jammat Nasrul Islam (JNI), Kaduna (10º31′23′′N 7º26′25ºE), Nigeria, in March 2018. Botanical identification was accomplished as described previously with herbarium number Ife 17708 (Avoseh et al., 2018).

2.2. Preparation of flower for hydrodisitllation

Before the hydrodisitllation process, the flowers were air-dried and separated from sediments and other unwanted materials by handpicking. Afterwards, samples were pulverized to coarse powder using locally made grinder as described previously (Ogunwande et al., 2018).

2.3. Hydrodistillation of the essential oils

The hydrodistillation procedure was performed with 120 g of air-dried and pulverized flowers of *T. ivorensis*. The experiment was carried out with a Clevenger-type distillation unit designed according to the established specification (British Pharmacopoeia, 1980). The distillation time was 4 h. The distilled oils were collected separately and kept under refrigeration (4 ºC) until the moment of analysis.

2.4. Gas chromatography (GC) analysis of the oil

GC analysis was accomplished with an HP-5890 Series II instrument equipped using HP-Wax and HP-5 capillary columns (both 30 m x 0.25 mm, 0.25 µm film thickness), working with the following temperature program: 60 ºC for 10 min, rising at 5 ºC/min to 220 ºC. The injector and detector temperatures were maintained at 250 ºC; carrier gas nitrogen (2 mL/min); detector dual, FID; split ratio 1:30. The volume injected was 0.5 µL (10% *n*-hexane solution). Retention indices (RI) value of each component was determined relative to the retention times of a homologous n-alkane series (C_6-C_{32}), under the same operating conditions, with linear interpolation on the HP-5 column as described previously (Ogunwande et al., 2018). The relative proportions of the oil constituents were percentages obtained by FID peak area normalization without the use of a response factor.

2.5. Gas chromatography with electron impact mass spectrometry (GC-EIMS) analysis of the oil

Gas chromatography with electron impact mass spectrometry (GC-EIMS) analysis was performed with a Varian CP-3800 gas-chromatograph equipped with an HP-5 capillary column (30 m x 0.25 mm; film thickness 0.25 µm) and a Varian Saturn 2000 ion trap mass detector. Analytical conditions: injector and transfer line temperature 220 ºC and 240 ºC, respectively; oven temperature programmed from 60 ºC-240 ºC at 3 ºC/min.; carrier gas helium at a flow rate of 1mL/min; injection volume 0.2 µL (10% *n*-hexane solution); split ratio 1:30. Mass spectra were recorded at 70 eV. The acquisition mass range was *m/z* 30-300 at a scan rate of 1 scan/sec.

2.6. Identification of the constituents

Identification of the constituents was based on comparison of the retention times with those of authentic samples, comparing their linear indices relative to a series of *n*-alkanes. Further identifications were also made possible by the use of a homemade library of mass spectra built up from pure substances and components of known oils, and MS literature data as described previously (NIST, 2011). Moreover, the molecular weights of all the identified substances were confirmed by gas chromatography with chemical ionization mass spectrometry (GC-CIMS), using MeOH as CI ionizing gas.

3. Results and discussion

3.1. Chemical constituents of *T. ivorensis* essential oil

The yield of the essential oil was 0.22% (v/w), calculated on a dry weight basis. The oil sample was

Table 1
Essential oil constituents of *Terminalia ivorensis* flower.

Compounds[a]	RI[b]	RI[c]	Percent composition
n-Nonane	900	900	1.8
Santolina triene	909	902	0.4
α-Thujene	931	926	0.7
α-Pinene	941	932	20.9
Camphene	954	946	1.6
Sabinene	976	964	1
β-Pinene	982	978	0.8
Myrcene	993	988	2
n-Decane	1000	1000	0.9
δ-3-Carene	1011	1008	29.4
o-Cymene	1024	1022	1
1,8-Cineole	1034	1032	4.1
γ-Terpinene	1062	1056	1.1
Terpinolene	1088	1088	5.2
n-Undecane	1100	1100	0.6
Nonanal	1102	1102	1.3
4-Terpineol	1178	1177	0.3
γ-Terpinyl acetate	1341	1340	0.4
(*E*)-β-Damascenone	1384	1382	0.7
1,7-*di-epi*-β-Cedrene	1414	1412	0.7
β-Caryophyllene	1420	1419	6.3
(*E*)-α-Ionone	1427	1427	0.4
α-Humulene	1456	1455	5
γ-Muurolene	1477	1477	1.7
(*E*)-β-Ionone	1490	1494	0.6
α-Selinene	1495	1496	0.5
trans-γ-Cadinene	1513	1513	0.5
δ-Cadinene	1524	1522	0.7
(*E*)-Nerolidol	1565	1563	1.2
Caryophyllene oxide	1581	1581	0.4
Globulol	1583	1586	0.5
Viridiflorol	1590	1590	0.6
Cedrol	1596	1600	5.9
	Total identified		**99.2**
	Monoterpene hydrocarbons		**64.1**
	Oxygenated monoterpenes		**4.8**
	Sesquiterpene hydrocarbons		**15.4**
	Oxygenated sesquiterpenes		**8.6**
	Apocarotenoids		**1.7**
	Non-terpenes		**4.6**

[a]Elution order on an HP-5MS column; [b]Retention indices on an HP-5MS column; [c]Literature retention indices (NIST, 2011)

light yellow. The compounds identified in the flower oil of *T. ivorensis* were displayed in Table 1. Thirty-three compounds representing 99.2% of the total volatile compounds were identified in *T. ivorensis*. Monoterpene hydrocarbons (64.1%), sesquiterpene hydrocarbons (15.4%) and oxygenated sesquiterpenes (8.6%) represent the classes of compounds occurring in higher quantity. The main constituents of the flower oil were δ-3-carene (29.4%) and α-pinene (20.9%). There were significant amounts of β-caryophyllene (6.3%), cedrol (5.9%), terpinolene (5.2%), α-humulene (5.0%) and 1,8-cineole (4.1%).

3.2. Comparison of present data with available literature information

The present results could not be compared with any other data since there is no published work on the volatile components of *T. ivorensis*. However, the compositions of essential oils from *T. catappa* growing in Nigeria have been reported. The leaf oil was dominated by (*Z*)-phytol (41.2%) and palmitic acid (11.0%) (Owolabi et al., 2013). On the other hand, the fruit oil of *T. catappa* was found to contain mainly α-farnesene (21.3%), octadedecane (11.7%) and palmitic acid (9.5%) (Moronkola and Ekundayo, 2000). Hexadecanoic acid (21.0%) and 2-ethyl-3,6-dimtheylpyrazine (19.2%) were the main aroma constituents of roasted *T. catappa* from Malaysia, as well (Lasekan et al., 2012). It has been previously found that citronellyl acetate (64.9%) dominated the composition of water-distilled essential oil of *T. bentzoë* from the Island of Rodrigues (Gurib-Fakim and Demarne, 1994). The composition of essential oil from the fruit oil of *T. chebula* obtained from India was found to consist mainly of palmitic acid (35.7%), furfural (26.8%) and phenylacetaldehyde (13.1%) (Naik et al., 2010). It is evident that each *Terminalia* plant contained essential oil with distinct chemical composition. The essential oils of *T. ivorensis* iand *T. bentzoë* were dominated by terpenes while *T. catappa* and *T. chebula* contained fatty acids and non-terpenoids. It has been shown that different plant encompass different phytochemicals, this along with other parameters such as environmental and climatic conditions between the different regions of analysis, are some other factors that may be responsible for the observed qualitative and quantitative variations between the studied *T. ivorensis* oil sample and other species in the genus.

It is also well-known that the biological activities of essential oils may depend on the major constituents or synergy between some major and minor compounds. The main compounds identified in *T. ivorensis* are known for their biological potentials. For example, α-pinene possessed antimicrobial (da Silva et al., 2012), gastroprotective (de Almedia Pinheiro et al., 2015), anti-inflammatory and chondoprotective (Rufino et al., 2014), antioxidative, anticancer and genotoxic (Aydin et al., 2013) properties. On the other hand, δ-3-carene was also reported to have displayed Anti-inflammatory, antifungal and sedative effects (Ocete et al., 1989). Further studies will be require to confirm the biological potentials of *T. ivorensis* oil.

4. Concluding remarks

In the present paper, the chemical compositions of the essential oils from the flower of *T. ivorensis* has been reported for the first time. The main components characterized in the studied essential oil were δ-3-carene and α-pinene.

Conflict of interest

The authors declare that there is no conflict of interest.

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