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Research Article

The sesquiterpene-rich composition of the leaf essential oil of *Croton lobatus* L. growing in north-central Nigeria

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Abstract

The genus *Croton* is important in local traditional medicines wherever these species are found. In addition, *Croton* essential oils have shown notable biological activities, which can be attributed to their major components. In this study, the leaf essential oil of *Croton lobatus* from north-central Nigeria was obtained by hydrodistillation (0.45% w/w yield) and analyzed by gas chromatography – mass spectrometry. The essential oil was dominated by sesquiterpene hydrocarbons (93.0%), including *trans*-α-bergamotene (56.9%), *trans*-β-bergamotene (12.9%), *trans*-calamenene (6.4%), and α-santalene (6.0%). A literature survey revealed that several *Croton* leaf essential oils are also rich in sesquiterpene hydrocarbons. However, (*E*)-β-caryophyllene and bicyclogermacrene were the most common. So far as we know, this is the first report on the essential oil composition of *C. lobatus* and serves to add to our understanding of the phytochemistry of this important genus.

1. Introduction

Croton (Euphorbiaceae) is one of the largest aromatic genera of flowering plants, comprising of about 1300 species. The plant is native to South America, Asia, and West Africa, but it is distributed among all the tropics and subtropics of the world with high ecological importance [1-3]. *Croton* species have been used to treat a wide range of illnesses, infections, and digestive issues [4-6], as well as sources of food flavoring and spices [7-9].

Croton lobatus L. (syn. *Astraea lobata* (L.) Klotzsch) is a perennial woody herbaceous shrub plant with common medicinal and ecological importance widely spread in Caribbean countries as well as tropical Africa [10]. *C. lobatus* is known as lobed croton in English [11], while in Nigeria, the plant is called *Gaásàyaá* (*Hausa*), *Òkwè* (*Igbo*), *Àjẹ̀ìofọ̀lé* or *ẹ̀Ìru* (*Yoruba*) [3].

Ethnobotanically, decoctions of *C. lobatus* are used in folk medicine for the treatment of several ailments, for example malaria, dysentery, pregnancy troubles, hypertension, ulcers, diabetes, and other diseases [9]. Previous studies have revealed that *C. lobatus* contains significant amounts of primary metabolites, such as protein, carbohydrates, and fibers, which serve as food supplements to remedy malnutrition in traditional medicine [12, 13]. Compounds isolated from *Croton* species have been reported to exhibit a range of biological properties, including cytotoxic, anti-inflammatory, anti-fungal, acetylcholinesterase inhibitory, and neurite outgrowth-promoting activities [5, 9, 14-16]. The non-volatile phytochemicals from *C. lobatus* have been reviewed [17]. The isolated and identified compounds included the triglyceride lobaricide, triterpenoid betulinic acid, alkaloids, tannins, and saponins. The plant is believed to be toxic, but it is an important livestock feed in Namibia [9]. Its essential oils and phytochemicals were investigated and found to have antibacterial properties, but little antioxidant properties due to the minimal concentrations of polyphenols in the investigated extracts [10, 12, 18, 19]. As part of our interest in the chemical characterization of essential oils of aromatic and medicinal plants of the Euphorbiaceae family, we present the essential oil composition of *C. lobatus* leaves collected from north-central Nigeria. To the best of our knowledge, there have been no previous reports on the volatile components of *C. lobatus*.

2. Materials and methods

2.1. Plant material collection and identification

Fresh leaves of *Croton lobatus* (1.5 kg) were collected in February 2024 from Saboganri (11.1766° N, 7.6765° E) in the Saboganri local government, Kaduna state, Nigeria. The plant was validated by Mr. Namadi Sunusu of the Botany Department, Ahmadu Bello University, Zaria, where a voucher specimen (08145) was deposited at the herbarium. The leaves of *C. lobatus* were air dried under shade for 5-7 days and pulverized using an electric blender and stored in a polythene container until ready for use.

2.2. Sample preparation for essential oil

The air-dried leaf sample (500 g) was placed in a 5-L flask, and distilled water was added to cover the sample. Hydrodistillation was carried out for four hours in an all-glass Clevenger apparatus in accordance with the British Pharmacopoeia. The distillate was extracted with *n*-hexane, transferred to a pre-weighed amber sample vial, and dried with anhydrous sodium sulfate to remove any remaining water to give a light yellow essential oil. The oils were refrigerated at 4 °C until ready for analysis.

2.3. Gas chromatographic – mass spectral analysis

The chemical composition of the leaf essential oil from *C. lobatus* was determined using gas chromatography–mass spectrometry (GC–MS). This was achieved using a Shimadzu GCMS-QP2010 Ultra operated in electron impact (EI) mode (electron energy = 70 eV), scan range = 40–400 atomic mass units, with a scan rate of 3.0 scans per s, with GC–MS solution software. The GC column was a ZB-5 fused silica capillary column (30 m length × 0.25 mm inner diameter) with a 5% phenyl-polymethylsiloxane stationary phase and a film thickness of 0.25 μm. Helium gas was used as the carrier gas with a column head pressure of 552 kPa at a flow rate of 1.37 mL/min. The injector and ion source temperatures were 250 °C and 200 °C, respectively. The oven temperature of 50 °C was initially programmed for the GC and gradually increased at 2 °C/min to 260 °C. The sample (5% w/v) was dissolved in dichloromethane, and 0.1 μL of the solution was injected using a split-injection technique (30:1). Each constituent of the essential oils was identified by injection of pure

Table 1. Chemical composition of the leaf essential oil of *Croton lobatus* L. (Euphorbiaceae).

RT	RI_{calc}	RI_{db}	Compounds	Composition(%)
39.83	1377	1375	α-Copaene	2.3
42.23	1414	1416	*cis*-α-Bergamotene	4.0
42.58	1419	1418	α-Santalene	6.0
42.82	1423	1421	(*E*)-α-Ionone	0.4
43.47	1434	1432	*trans*-α-Bergamotene	56.9
44.35	1448	1446	*epi*-β-Santalene	0.6
44.83	1456	1454	α-Humulene	1.1
45.10	1460	1457	β-Santalene	0.7
46.62	1484	1483	*trans*-β-Bergamotene	12.9
46.91	1489	1492	β-Selinene	0.6
47.36	1496	1497	α-Selinene	0.6
48.17	1509	1508	β-Bisabolene	0.9
48.42	1514	1514	Sesquicineole	0.7
48.72	1519	1518	δ-Cadinene	2.0
48.91	1522	1519	*trans*-Calamenene	6.4
49.57	1533	1536	*trans*-Cadina-1,4-diene	0.8
52.44	1582	1587	Caryophyllene oxide	0.7
			Compound classes	
			Sesquiterpene hydrocarbons	93.0
			Oxygenated sesquiterpenoids	1.4
			Others	0.4
			Total identified	***94.8***

RT = Retention time (min). RI_{calc} = Retention index determined with respect to a homologous series of *n*-alkanes on a ZB-5ms column [20]. RI_{db} = Reference retention index values from the databases [21-24].

samples and by comparison of the retention index values, through calibration using a series of *n*-alkanes [20], in addition to MS fragmentation comparisons with those found in databases [21-24].

3. Results and discussion

3.1. Essential oil profiles

The essential oil from the leaves of *C. lobatus* was obtained as a pale-yellow oil with a percentage yield of 0.45% (v/w) calculated on the basis of the weight of air-dried plant material to the volume of EO obtained. The total oil composition revealed 17 chemical constituents with a percentage composition of 94.8% (Table 1).

C. lobatus essential oil was dominated by sesquiterpene hydrocarbons (93.0%), predominantly *trans*-α-bergamotene (56.9%), *trans*-β-bergamotene (12.9%), *trans*-calamenene (6.4%), α-santalene (6.0%), *cis*-α-bergamotene (4.0%), α-copaene (2.3%) and δ-cadinene (2.0%), with trace amount of oxygenated sesquiterpenoids. These findings differ from the essential oil compositions of other *Croton* species (Table 2). The chemical profiles of other *Croton* essential oils, when compared with our sample, were also dominated by varying amounts and types of sesquiterpene hydrocarbons, as shown in Table 2.

(*E*)-β-Caryophyllene and bicyclogermacrene were common in most *Croton* species reported, but these constituents were not found in our sample. In contrast, our sample predominantly contained *trans*-α-bergamotene and *trans*-β-bergamotene. To the best of our knowledge, this is the first report on the chemical profile of *C. lobatus.*

Moreover, studies have shown that bicyclogermacrene, a sesquiterpene essential oil constituent, that exhibited antibacterial, antioxidant, antispasmodic, antiviral, and

Table 2. Comparison of the major (> 5 %) sesquiterpene hydrocarbons in the leaf essential oils of *Croton* species.

Croton species	Collection site	Major sesquiterpene hydrocarbon components	Ref.
C. argyrophylloides Müll. Arg.	Fortaleza, CE, Brazil	*trans*-β-Elemene (7.9%)	[25]
C. argyrophylloides Müll. Arg.	Viçosa do Ceará, CE, Brazil	Bicyclogermacrene (30.6%), *trans*-β-elemene (8.52%),	[26]
C. argyrophyllus Kunth	Alagoas, Maceió, AL, Brazil	Bicyclogermacrene (27.8%), δ-elemene (8.7%), *trans*-β-elemene (8.5%), prenopsan-8-ol (8.5%), (*E*)-β-caryophyllene (6.3%), *trans*-dauca-4(11),7-diene (6.0%)	[27]
C. bonplandianus Baill.	Belgaum, Karnataka, India	(*E*)-β-Caryophyllene (16.7%), germacrene D (14.7%), (*Z*)-β-damascenone (6.9%), α-humulene (6.1%), germacrene A (5.2%)	[28]
C. campestris A. St.-Hil.	Crato, CE, Brazil	(*E*)-β-Caryophyllene (17.0%), bicyclogermacrene (16.2%)	[29]
C. campestris A. St.-Hil.	Belém, PA, Brazil	(*E*)-β-Caryophyllene (23.0%), γ-elemene (13.9%), germacrene D (13.7%), *trans*-β-elemene (7.1 %), δ-elemene (6.0%), bicyclogermacrene (4.7%)	[30]
C. campestris A. St.-Hil.	São Paulo, Brazil	(*E*)-β-Caryophyllene (43.0%), α-cubebene (15.8%)	[31]
C. chaetocalyx Müll. Arg.	Belém, PA, Brazil	Bicyclogermacrene (13.9%), δ-elemene (13.5%), germacrene D (9.3%), spathulenol (9.0%), δ-cadinene (8.0%), (*E*)-β-caryophyllene (7.1%)	[30]
C. doctoris S. Moore	Dourados, MS, Brasil	(*E*)-β-caryophyllene (39.6%), α-humulene (13.2%)	[32]
C. draconoides Müll. Arg.	Belém, PA, Brazil	Curzerene (12.8%), germacrene D (9.0%)	[33]
C. eriocladus Müll. Arg	Belém, PA, Brazil	(*E*)-β-Caryophyllene (24.1%), germacrene D (17.9%), α-humulene (6.2%), bicyclogermacrene (5.2%) and δ-elemene (5.0%)	[30]
C. flavens L.	Chicoutimi, Quebec, Canada	Viridiflorene (12.2%), (*E*)-γ-bisabolene (5.3%) and (*E*)-β-caryophyllene (5.0%)	[34]
C. glandulosus Vell.	São Paulo, Brazil	(*E*)-β-Caryophyllene (18.9%)	[31]
C. glandulosus Vell	Belém, PA, Brazil	Bicyclogermacrene (9.6%), (*E*)-β-caryophyllene (8.9%), δ-elemene (8.8%)	[30]
C. heliotropiifolius Kunth	Caatinga biome, Pernambuco-Brazil	(*E*)-β-Caryophyllene (20.8%), spathulenol (16.4%), germacrene B (9.3%)	[35]
C. heliotropiifolius Kunth	Semi-arid region, northeast Brazil	(*E*)-β-Caryophyllene (35.8%), bicyclogermacrene (20.0%), germacrene D (11.9%)	[36]
C. heliotropiifolius Kunth	São Francisco, Petrolina, PE, Brazil	(*E*)-β-Caryophyllene (28.6-47.0%), bicyclogermacrene (22.6%), germacrene D (7.8%)	[37]
C. heliotropiifolius Kunth	São Paulo, Brazil	(*E*)-β-Caryophyllene (23.9%), γ-muurolene (10.5%), viridiflorene (8.1%)	[38]
C. jacobinensis Müll. Arg**.**	Fortaleza, CE, Brazil	Germacrene B (7.6%),	[25]
C. jacobinensis Müll. Arg.	Viçosa do Ceará, CE, Brazil	Bicyclogermacrene (30.1%), β-elemene (22.3%), δ-elemene (12.9%), (*E*)-β-caryophyllene (10.9%), α-humulene (7.6%)	[26]
C. jacobinensis Müll. Arg**.**	Caatinga biome, Pernambuco, Brazil	No major sesquiterpene hydrocarbons	[39]
C. lobatus L.	Northwest Nigeria	*trans*-α-Bergamotene (56.9%), *trans*-β-bergamotene (12.9%), *trans*-calamenene (6.4%), α-santalene (6.0%)	This study
C. lundianus Müll. Arg.	São Paulo, Brazil	γ-Elemene (19.0%), α-cubebene (17.1 %), (*E*)-β-caryophyllene (11.1%)	[31]
C. matourensis Aubl.	Caracas, Venezuela	Valencene (5.8%)	[40]
C. micans Sw.	Caatinga biome, Pernambuco, Brazil	α-Bulnesene (32.9%), germacrene B (21.4%), (*E*)-β-caryophyllene (12.3%)	[39]
C. micans Sw.	Caracas, Venezuela	α-Humulene (12.6%), (*E*)-β-caryophyllene (5.5%), β-cubebene (5.0%), α-cubebene (5.3%)	[40]
C. muscicapa Müll.Arg.	Caatinga biome, Pernambuco, Brazil	(*E*)-β-caryophyllene (7.0%)	[39]
C. nepetifolius Baill.	Fortaleza, CE, Brazil	(*E*)-β-Caryophyllene (21.2%), germacrene B (5.8%)	[25]

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Table 2. *(Continued)*

Croton species	Collection site	Major sesquiterpene hydrocarbon components	Ref.
C. rhamnifolius Kunth	Caatinga biome, Pernambuco, Brazil	(*E*)-β-Caryophyllene (7.3%)	[39]
C. sincorensis Mart. ex Müll. Arg.	Viçosa do Ceará, CE, Brazil	(*E*)-β-Caryophyllene (25.3%), bicyclogermacrene (23.9%), germacrene D (9.1%), *trans*-β-elemene (5.6%),	[26]
C. sincorensis Mart. ex Müll. Arg.	Fortaleza, CE, Brazil	No major sesquiterpene hydrocarbons	[25]
C. triqueter Lam.	Belém, PA, Brazil	(*E*)-β-caryophyllene (16.3%), β-phellandrene (10.2%),	[33]
C. urucurana Baill.	Belém, PA, Brazil	Sesquicineole (23.0%), dehydro-sesquicineole (13.8%), (*E*)-β-caryophyllene (7.9%),	[33]
C. zambesicus Muell. Arg.	Southwestern Nigeria:	(*E*)-β-Caryophyllene (8.8%)	[41]

analgesic activities [42-44]. In addition, the non-volatile phytochemical constituents of *Croton* species containing diterpenoids have been reported to treat various ailments and diseases [45].

4. Conclusions

This is the first report on the essential oil composition of *Croton lobatus*. The essential oil was dominated by sesquiterpene hydrocarbons, including *trans*-α-bergamotene (56.9%), *trans*-β-bergamotene (12.9%), *trans*-calamenene (6.4%), and α-santalene (6.0%). However, the sesquiterpene hydrocarbon composition was remarkably different from previous reports on the leaf essential oils of *Croton* species, which are often dominated by (*E*)-β-caryophyllene and bicyclogermacrene. Thus, this study complements previous investigations on the *Croton* essential oils and adds to our knowledge of the phytochemical characterization of this genus. The high concentration of *trans*-α-bergamotene may make *C. lobatus* an attractive source of this sesquiterpene.

Authors' contributions

Conceptualization, M.S.O; Methodology, D.S.R.O., E.A.O., M.S.O., P.S., W.N.S.; Software, P.S.; Validation, A.L.O., W.N.S., Formal Analysis, A.P., W.N.S.; Investigation, D.S.R.O., E.A.O., B.S.R., M.S.O., P.S., A.P., W.N.S.; Resources, D.S.R.O., M.S.O. A.R.A.., P.S., W.N.S.; Data curation, W.N.S.; Writing – original draft preparation, D.S.R.O. B.S.A., A.R.A., M.S.O; Writing – review & editing, M.S.O., W.N.S.; Project administration, D.S.R.O., M.S.O.

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Availability of data and materials

All data will be made available on request according to the journal policy.

Conflicts of interest

The authors declare no conflict of interest.

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