Asian Journal of Research in Biochemistry

7(1): 19-27, 2020; Article no.AJRB.55304
ISSN: 2582-0516

Essential Oil Compositions of *Aframomum danielli* Seed (Ataiko)

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Authors' contributions

This work was carried out in collaboration among all authors. Author PDE designed the study, wrote the protocol, read and approved the final manuscript. Author KS performed the statistical analysis and wrote the first draft of the manuscript. Author BMOO read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRB/2020/v7i130130
Editor(s):
(1) Dr. Khadiga Mohamed Abu-Zied, National Research Centre, Egypt.
Reviewers:
(1) S. Danish Kadir, University of Rajshahi, Bangladesh.
(2) Catherine Ukponmwan, University of Benin, Nigeria.
(3) Daniela Benedec, "Iuliu Hatieganu" University of Medicine and Pharmacy Cluj-Napoca, Romania.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55304

Original Research Article

Received 12 January 2020
Accepted 19 March 2020
Published 30 July 2020

ABSTRACT

Background: Differentiation in oil quality and the volatile component of essential oils (EOs) is associated with climatic conditions, the geographical location of collection sites and other ecological and genetic factors defining its chemotypes.
Objective: Hence this study was aimed at characterizing volatile constituents of *Aframomum danielli* seed collected in Choba, Port Harcourt in Rivers State, South-South region of Nigeria.
Methods: Essential oils (EOs) were analyzed using gas chromatography–flame ionization detector (GC-FID).
Results: A total of forty-two EO (99.96%) constituents were identified, monoterpenes were 32 (99.93%) and sesquiterpenes: 10 (0.03%) No oxygenated sesquiterpenes were detected. Oxygenated monoterpene was higher consisting of 18 EO compounds; 66.94% while monoterpene hydrocarbons comprised of 14 EO compounds; 32.99%. Chemical constituents in the EO include: 1,8- cineole (50.95%), β-pinene (11.79%) α–terpineol (9.15%), γ –terpinene (7.45%), Sabinene (6.03%), α- pinene (3.41%), α –terpinenly acetate (3.38%), terpinene-4-of(2.44%) and α-thujene (2.11%).
Conclusion: *Aframomum danielli* from this geographical location could serve as a rich source of 1,8- cineole.

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Keywords: Aframomum danielli; essential oil; monoterpenes; sesquiterpenes; 1,8- cineole.

1. INTRODUCTION

Plant-derived natural products are promising sources for the discovery and development of novel herbal pharmaceutical agents in the treatment of different human ailments [1]. Since 1981, almost 71% of new drugs approved are derived directly or indirectly from natural products [2].

Approximately 80% of the people in the world depend on traditional plant-based medicines for primary health care while the rest 20% of the population relies on plant products for health care [3]. Therefore, traditional medicinal plants greatly contribute to the development of modern medicines [4]. The genus *Aframomum*, is widely used for medicinal, ethno-dietary, cultural and spiritual purposes [5].

The genus *Aframomum, a* perennial plant *belongs* to the Zingiberaceae family, consisting of approximately fifty species are widespread in humid forest regions of West and Central Africa [6]. When any part of the plant is pulverized an aromatic flavour exudes [7]. More than 23 species have been identified in Cameroon in South-West, South, North-West, West and Central regions [6].

Aframomum species are well known in several countries for their odoriferous leaves and fruits with aromatic seeds which produce essential oils [5,8]. Different species are recognized of *Aframomum* family which includes *Aframomum danelli, Aframomum melegueta, Aframomum zambesiacum, Aframomum corrorima, Aframomum elegans* etc.

Among them, *Aframomum danielli,* (Hook, F) K. Schum is a large robust perennial plant 3-4 m tall which grows in central and west African countries [9]. The seeds of this plant are used for flavouring traditional dishes and the essential oil is used in perfumery, flavouring and dye preparations.

Aframomum danielli is a herb with a creeping rhizome found in the region of Niger Delta, the plant is used as spices in traditional dishes. It is commonly known as Ataiko, a local spice commonly used to enhance flavour, aroma and palatability in 'Banga' soup in the southern part of Nigeria, particularly by the Urhobos, Itsekiris and Isoko of Delta State.

The seed essential oil composition of *A. danielli* from Cameroon, Nigeria and S. Tome has been reported [10,11,12]. Similarly, volatile constituents of other *Aframomum* species grown in some regions of West and East Africa have been investigated [13,8,14,15,16,17,7]. There is a dearth of data on the volatile oil composition of *Aframomum danielli* seed from South-South region of Nigeria as only one study exists in the published literature on characterization and antioxidant activity of volatile constituents of the seed of *Aframomum danielli* from this region [18].

Studies have shown that differentiation in oil quality and volatile components is associated with climatic conditions, the geographical location of collection sites and other ecological and genetic factors. The influence of those factors on the accumulation of distinct volatile compounds defines its chemotype [19,20,21]. Hence this study was aimed at characterizing volatile constituents of the seed of *Aframomum danielli* collected at Choba in Obio Akpor Local Government Area of Rivers State in South-south region, Nigeria.

Essential oils are a complex volatile mixture of polar and non-polar compounds [22] from aromatic plant material, including leaves, rhizomes, flowers, roots, bark, seeds, peel, fruits, wood and whole plants [23]. Essential oils constituents can be divided into two major groups: terpene hydrocarbons and oxygenated compounds [24].

Essential oils from different plant parts exhibit different biological activities [25]. Biological activities of essential oils include antioxidant, antimicrobial, antiviral, antimutagenic and anticancer [26].

The overall activity cannot be attributed to only one of the major constituents [27]. The inactive compounds might influence resorption, the rate of reactions and biological activity of the active compounds. The combination of the major and minor constituents modifies the activity to exert significant synergistic or antagonistic effect [28].

2. MATERIALS AND METHODS

2.1 Sample Collection and Identification

Aframomum danielli (Ataiko) seed was bought from Choba market in Obio/Akpor Local

Government Area, Rivers State and was identified in the herbarium of Department of Plant Science and Biotechnology (PSB), the University of Port Harcourt, by Dr. Chimezie, Ekeke with the voucher specimen and herbarium number (UPH/V/1344) archived at the herbarium unit of PSB.

2.2 Isolation of Essential Oils

Some seeds of *Aframomum danielli* were placed in the mortar and pulverized to a fine powder.

A weight of 150 g of pulverized *Aframomum danielli* seed was carefully introduced into a 5L round bottom flask and de-ionized water was added until it covered the sample completely. The essential oil was extracted using a modified glass Clevenger-type distillation unit for 3 h at normal pressure and dried by passing over anhydrous sodium sulphate. The essential oil was stored in a 2 ml sealed Agilent vial protected from light at 4°C before GC analysis.

2.3 Gas Chromatography–Flame Ionization Detector (GC-FID) Analysis of Essential Oils

The Gas Chromatograph (GC) analysis was carried out using a Hewlett Packard G C (Model 6890 series powered with HP chemstation Rev A 09.01)) equipped with a flame ionization detector. The column dimension (30 meter × 0.25 milimeter× 0.24 micrometer) and a column type, DB-5MS capillary. The injection temperature was 250°C and in the split injection of sample. The carrier gas used was nitrogen at 28 psi hydrogen pressure. The initial oven temperature was 60°C for 5 minutes and the first ramping was 10°c/min for 20 minutes, then the second ramping was 15°C for 4 mins, while the FID detector temperature was 320°C at Hydrogen pressure: 22 psi and Compressed Air: 35 psi. The data were recorded and treated with the Chem-Station software. Each extraction and GC analysis was performed in duplicate (n = 2).

2.4 Identification of Oil Components

Essential oil components were identified by co-injection with the authentic standards available in our laboratory (purchased from Sigma-Aldrich) and comparison of the data and retention time of sample with those of authentic reference standards. Determination of the quantities of different essential oil components in percentages was carried out by the normalization procedure using peak areas obtained in GC-FID.

2.5 Statistical Analysis

GC analyses were repeated at least twice. An average of the duplicate determinations was added to the data making triplicate determinations to enable analyses by SPSS software. Data were analysed using Statistical Package for Social Sciences (SPSS) version 22. All data were represented as mean ± standard deviation (M±SD) using descriptive statistics.

3. RESULTS AND DISCUSSION

In the present study, a total of forty-two (42) essential oil constituents were identified representing 99.96% of the total composition Tables 1 & 2. The oil was characterized by two major chemical groups: Monoterpenes and sesquiterpenes, no diterpene hydrocarbons were detected in the EO seed of *Aframomum danelli*. Monoterpenes were 32 EO compounds accounting for 99.93% and sesquiterpenes consisting of 10 EO compounds representing 0.03% of which only 8 were detected in trace amount (≤ 0.01%). Monoterpenes consisting of oxygenated monoterpene and monoterpene hydrocarbons of which oxygenated monoterpene was higher consisting of 18 EO compounds constituting 66.94% while monoterpene hydrocarbons comprised 14 compounds accounting for 32.99%. The compositional pattern of EOs seed of *Aframomum danelli* in the present study was similar to previous reports of EOs seed of *Aframomum danelli* from Nigeria [11,29,18]. However, *A. melegueta* seed essential oil (a different Afranomom specie from Cameroon) showed a similar compositional pattern irrespective of the difference in geographic origin and genetic characteristics of the samples [30]. No oxygenated sesquiterpenes were detected. Spathulenol an oxygenated sesquiterpenes and geranyl acetate an oxygenated monoterpene were absent or not detected represented as (-) and 25 compounds referred to as trace was detected at <0.01%.

Among the chemical constituents in the EO obtained from the seed, 1,8- cineole (50.95%), β-pinene (11.79%) α – terpineol (9.15%), γ–terpinene (7.45%), Sabinene (6.03%), α-pinene (3.41%), α–terpinenly acetate (3.38%), Terpinen-4-of (2.44%) and α-thujene (2.11%) were the most abundant compounds (Table 1). A similar trend of 1,8-cineole (59.8%), β-pinene (13.2%),

α-terpineol (9.3%), α-pinene (4.3%), and α-terpinyl acetate (3.2%) was reported by Adegoke et al. [11] of individual EO constituents of *Aframomum danelli* seed collected from Southwestern Nigeria.

According to the data obtained from this study, the most and more abundant EO components in *Aframomum danelli* seed are 1,8- cineole (50.95%) and β-pinene (11.79%) respectively classifying it as cineole-rich chemotype.

Table 1. Qualitative and quantitative compositions of essential oil of *Aframomum danelli* seed (Ataiko)

S/N	Compound	RT(min)	Concentration (%)
1	Cymene[m,h]	6.347	T
2	α- Phellandrene[m,h]	6.795	T
3	α-terpinene[m,h].	7.269	T
4	Camphene[m,h]	8.100	T
5	Terpinolene[m,h]	8.308	T
6	Sabinene[m,h]	8.768	6.03±0.21
7	Limonene [m,h]	9.370	0.92±0.04
8	α- pinene[m,h]	9.698	3.41±0.13
9	Benzylalcohol[m,o]	10.799	T
10	β-pinene[m,h]	11.377	11.79±0.46
11	Cis- ocimene[m,h]	12.261	1.28±0.05
12	Myrcene[m,h]	12.777	T
13	Allo ocimene[m,h]	13.201	T
14	Pinene-2--ol[m,o]	13.836	0.93±0.04
15	α-thujene[m,h]	14.221	2.11±0.09
16	γ –terpinene[m,h]	14.886	7.45±0.29
17	Citral[m,o]	15.123	T
18	Geranial (neral)[m,o]	15.400	0.01±0.00
19	Linalool[m,o]	16.552	T
20	Borneol[m,o]	17.210	T
21	1,8- cineole[m,o]	17.714	50.95±1.89
22	Citronellal[m,o]	18.206	0.04±0.00
23	Nerol[m,o]	18.549	T
24	α –terpineol[m,o]	18.691	9.15±0.36
25	Terpinen-4-ol[m,o]	18.788	2.44±0.10
26	Citronellol[m,o]	19.266	0.03±0.00
27	Eugenol[m,o]	19.608	T
28	Linalyl acetate[m,o]	20.534	T
29	α –terpinenly acetate[m,o]	21.103	3.38±0.13
30	Ethyl cinnamate[m,o]	21.419	T
31	Borneol acetate[m,o]	21.623	T
32	Neryl acetate[m,o]	21.724	0.01±0.00
33	Geranyl acetate[m,o]	21.814	T
34	Germacrene B[s,h]	22.091	T
35	β --caryophyllene[s,h]	22.585	T
36	β --caryophyllene[s,h]	22.585	T
37	α -copane[s,h]	24.727	T
38	α-gurjunene[s,h]	24.792	T
39	α - bergamotene[s,h]	26.054	T
40	Humulene[s,h]	27.775	0.03±0.00
41	α -selinene[s,h]	28.318	T
42	β -selinene[s,h]	28.511	T
43	Aromadendrene[s,h]	29.783	T
44	Spathulenol[s,o]	29.504	-

Data represented in mean ±standard deviation (M±SD) of triplicate determinations (n=3), [T] traces (≤ 0.01%), [m] Monoterpenes, [s] Sesquiterpenes, [n] Non-terpenes, [h] Hydrocarbons, [o] Oxygenetad and (-) absence or not detected

Table 2. Chemical groups in essential oils of *Aframomum danelli* seed (Ataiko) (mean ± standard deviation, n=3)

Chemical groups	No of EO in chemical groups	% Conc. of EO in chemical groups
Hydrocarbon monoterpenes[m,h]	14	32.99±1.27
Oxygenated monoterpenes [m,o]	18	66.94±2.62
Monoterpenes[m]	32	99.93±3.89
Hydrocarbon sesquiterpenes [s,h]	10	0.03±0.00
Oxygenated sesquiterpenes[s,o]	nil	0.00±0.00
Sesquiterpenes[s]	10	0.03±0.00
Total oxygenated constituents	18	66.94±2.62
Total hydrocarbon constituents	24	33.02±1.27
Total	42	99.96±3.89

Data represented in mean ±standard deviation (M±SD) of triplicate determinations (n=3), [T]races (≤ 0.01%)

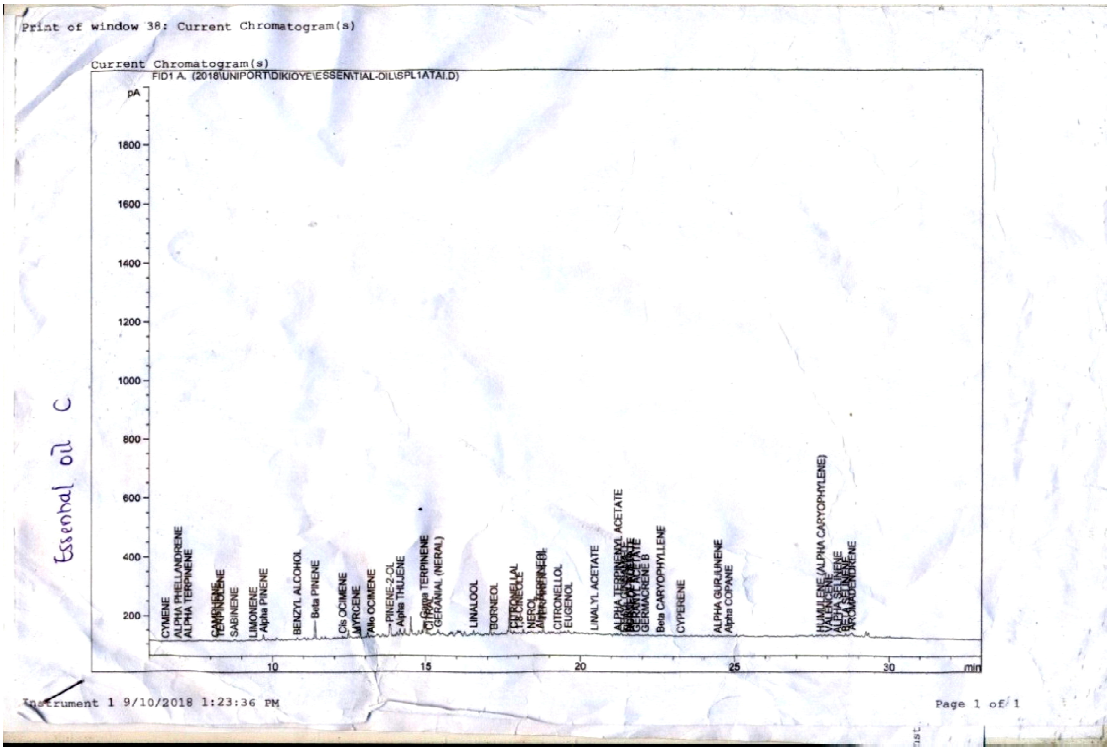

Fig. 1. A gas chromatographic data of essential oil constituents of *Aframomum daniellii* seed on the chromatogram, the *x-axis* is retention time (RT) in minutes and on the *y-axis* is abundance in arbitrary units

This is in contrast to the seed oil content of 1,8-cineole (53.44%) and α-Terpineol (12.23%) reported by Essien et al. [18] and 1,8-cineole (37.2%) and linalool (31.3%) reported by Lawal et al. [29] as major compounds of the Nigerian specie while the similar compositional pattern of the two major EO constituents in this work has been previously reported [10,11,12,31].

EO composition characterized by two or three major components at fairly high concentrations (20–70%) compared to other components

present in trace amounts is referred to as major components. Generally, these major components determine the biological properties of the essential oils. The components include two groups of distinct biosynthetic origin [32,33,34,35]. Since 1,8-Cineole (50.95%) was the only constituent that was within this concentration in this study it may likely determine the biological properties of the essential oils of *Aframomum danelli* seed. However, the overall activity cannot be attributed to only one of the major constituents [27]. The inactive compounds might influence resorption, the rate of reactions and biological activity of the active compounds. The combination of the major and minor constituents modifies the activity to exert significant synergistic or antagonistic effect [28].

1,8-Cineole, a monoterpene cyclic ether is extensively used in cosmetics, for cough treatment, muscular pain, neurosis, rheumatism, asthma and urinary stones [36]. Several studies have shown that pure 1,8-cineole or from essential oils containing this oxide as a major component could benefit patients with a diverse range of respiratory conditions of varying complexities [37,38,39,40].

1,8-cineole act as an anti-infectious agent in synergy with other components of EO by causing leakage of bacterial cell membranes, permeabilizing their membranes and allowing these components into the cells [41,42].

Antiviral properties of 1,8-Cineole exceeded those of borneol, citral, geraniol, limonene, linalool, menthol, and thymol except for eugenol, however, it showed relatively low antiviral potential in comparison with the potent thujone [43,44].

Some studies have shown strong antioxidative activity of some plants containing 1,8-cineole and a-terpineol and 1,8-cineole and camphor as main components of the EO in some free radical scavenging assay models [45,46].

Artemisia lavandulaefolia EO and its major compound 1,8-cineole have been shown to induce apoptosis by mitochondrial and MAPKs pathways [47] via downregulation of antiapoptotic Bcl-2 protein on the cancer cells [48] resulting in apoptosis in the mouth cancer, KB cells [47].

4. CONCLUSION

In conclusion, a total of forty-two (42) essential oil constituents of Aframomum *danelli* seed from the South-south region of Nigeria were identified representing 99.96% of the total EOs composition. The oil was characterized by two major chemical groups: Monoterpenes and sesquiterpenes, Monoterpenes were 32 EO compounds accounting for 99.93% and sesquiterpenes consisting of 10 EO compounds representing 0.03%. The dominant EO chemical group was oxygenated monoterpene constituting 66.94%. The most abundant compounds were 1,8- cineole (50.95%), β-pinene (11.79%) α–terpineol (9.15%), γ –terpinene (7.45%), Sabinene (6.03%), α-pinene (3.41%), α–terpinenly acetate (3.38%), Terpinen-4-of (2.44%) and α-thujene (2.11%). A critical review of literature on phytotherapeutic potentials of 1,8-cineole the most abundant constituent of *A. danielli* in this study, suggests that *A. danielli* seed could be a rich source of 1,8- cineole oil and a promising spice in formulating next-generation herbal therapeutic agent in disease therapy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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