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Chemical Profiling of Fatty Acids and Volatile Compounds in the Roots of *Chrysopogon nigritanus*

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Abstract

Background: *Chrysopogon nigritanus*, a medicinal plant rich in bioactive compounds, represents a valuable resource from both pharmacological and industrial perspectives. This species, widely used in traditional medicine, is characterized by its diverse biological properties, which are of particular interesting the pharmaceutical and cosmetic industries. **Objective:** This study aimed to characterize the volatile organic compounds (VOCs) and fatty acid composition of *C. nigritanus* roots in order to assess their biological potential and potential applications. **Methods:** Volatile organic compounds (VOCs) were identified and quantified using solid-phase microextraction coupled with gas chromatography-mass spectrometry (SPME-GC-MS). Fatty acids were converted to their corresponding methyl esters and subsequently analyzed by gas chromatography coupled with flame ionization detection (GC-FID). **Results:** The analysis revealed a diverse profile of volatile organic compounds, with terpenes clearly predominating. The volatile fraction consisted mainly of sesquiterpene hydrocarbons and oxygenated sesquiterpenoids. In addition to terpenes, the analysis revealed trace amounts of aromatic compounds, aldehydes, and alkanes were detected. Analysis of the fatty acid profile revealed a marked predominance of heptadecenoic acid (65.352% ± 1.135%), followed by eicosadienoic acid, linoleic acid and eicosadienoic acid (4.382% ± 3.079%, 4.266% ± 3.360%, 4.171% ± 4.433%, respectively). Each the other fatty acids identified accounted for less than 4% of the total area. **Conclusion:** The roots of *C. nigritanus* exhibit a chemical profile rich characterized by a high abundance for terpenoid compounds and predominance for heptadecenoic acid. These findings provide chemical evidence supporting the traditional use and highlight its potential for further investigation in pharmaceutical, cosmetic, and food industries.

Keywords

Chrysopogon nigritanus, Volatile Organic Compounds, Fatty Acids, SPME-GC-MS, GC-FID

1. Introduction

Plants are a major source of bioactive compounds that play important roles in the fields of pharmacology, cosmetics, agriculture, and the food industry. Among these compounds are fatty acids and volatile organic compounds (VOCs). Despite their biological functions and therapeutic properties, fatty acid and VOCs exhibit diverse biological functions and therapeutic prosperities.

Volatile plant compounds are chemical substances composed of at least one carbon atom and one or more other elements, such as alcohols, hydrocarbons and aldehydes. They are highly volatile and can evaporate under normal atmospheric conditions [1]. They are generally characterized by their lipophilic nature and high vapor pressure. These molecules can pass through cell membranes and diffuse freely into the atmosphere or soil, provided that no factors limited their mobility [2]. They are constituents of essential oils, which are renowned for their therapeutic properties particularly their anti-infective effects and are often used in non-pharmaceutical products [3]. They play important roles in plan defense against insects, chemical communication, and antimicrobial activity.

As for fatty acids, they perform essential functions in the body; they are components of all cell membranes and constitute the body's primary long-term energy reserve. In addition, they contribute to the physicochemical integrity of membranes. Their role also extends to growth, various metabolic, regulatory processes and cosmetics application, including enzyme synthesis, prostaglandin production, hormone receptor function, and cell adhesion [4]-[7]. They may have a protective effect against insulin resistance, which is associated with a wide range of conditions, such as obesity, type 2 diabetes, metabolic syndrome, gestational diabetes, and polycystic ovary syndrome (PCOS). Preventing or reducing insulin resistance may help lower the risk of developing these conditions and improve their prognosis [8].

In this context, we assessed the volatile organic compound (VOC) content and fatty acid composition of *C. nigritanus* roots. This species has a wide range of traditional uses, particularly in traditional medicine, where it is valued for its diverse prosperities of considerable interest to pharmaceutical and cosmetic industries. However, from a scientific perspective, this plant species has not yet been extensively investigation, particularly with regard to its pharmacological properties. Current knowledge remains limited, and systematic studies characterizing its bioactive compounds, potential mechanisms of action, and therapeutic or cosmetic applications are still lacking. This gap in scientific knowledge contrasts with the importance of this plant in traditional medicine, highlighting the need for further research to validate or refute its purported properties.

2. Materials and Methods

2.1. Plant Material

The *C. nigritanus* sample was collected as a single batch in October in the Dakar region, specifically in Hann Bel-Air. This locality is located at 14˚45'N latitude and 17˚20'W longitude and covers an area of 42 km^2. It is part of the Grand Dakar district in the Dakar region of Senegal. It is home to the Hann Forest and Zoological Park, with includes an ethnobotanical garden containing hundreds of identified plant species from diverse origins.

The harvested roots were cleaned and dried in the absence of light for several days and then ground into a powder using an electric grinder.

2.2. Methodologies

2.2.1. Method for Determining VOCs

The method used to identify volatile compounds was solid-phase microextraction coupled with gas chromatography-mass spectrometry (SPME-GC-MS), using a GC 7890A equipped with an HP-5MS capillary column (30 m × 250 µm × 0.25 µm, Agilent Technologies, USA), using helium as the carrier gas, and an Agilent 5975C mass detector (GC-MS) [9].

To do this, we placed 1 g of *C. nigritanus* root powder in a hermetically sealed 10-mL glass vial. A solid phase microextraction (SPME) fiber (65 µm PDMS/DVB, Supelco, Sigma Aldrich) was used to concentrate the volatile compounds for 15 minutes. We then performed a temperature program starting at 40˚C for 2 minutes, followed by a ramp of 4˚C/min to 200˚C, and then a ramp of 20˚C/min to 300˚C for 5 minutes to analyze the volatile compounds using a GC 7890A and a mass detector.

The GC-MS system interface was heated to 280˚C; the actual temperatures in the MS source and at the quadrupole were 250˚C and 200˚C, respectively. The electron impact energy was set to 70 eV, and data were collected in a range from 25 to 550 atomic mass units.

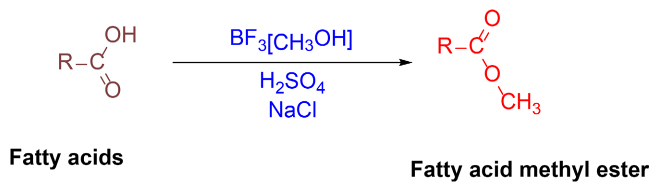
We used MassHunter software with the NIST17L library to identify the volatile compounds. The Kovats index was used to confirm the results following data processing.

2.2.2. Method for Analyzing Fatty Acids

Quantitative analysis of fatty acids, in the form of fatty acid methyl esters (FAMEs), is performed using the GC-FID reference method. This technique allows for precise characterization of these compounds according to the protocol described by Tchinda *et al.* (2021) [10].

Lipid extraction was performed on 15 g of dry *C. nigritanus* root powder by maceration in n-hexane for six hours. The resulting extract, after drying, was stored away from light and oxygen for subsequent analysis.

To prepare the derivatives (see Scheme 1), 10 mg of this extract were dissolved in 0.2 mL of *n*-hexane. To this solution, 0.5 mL of 14% BF_3-methanol was added, and the mixture was then heated to 70˚C in a water bath for 90 minutes to carry out the transesterification of the fatty acids. After cooling, 0.5 mL of a saturated sodium chloride solution and 0.2 mL of 10% sulfuric acid were added. The methylated fatty acids were then extracted by adding 8 mL of *n*-hexane.



Scheme 1. Esterification reaction of fatty acids.

After decantation, the upper hexane phase, containing the fatty acid methyl esters, was collected for analysis. The analysis was performed by gas chromatography with flame ionization detection (GC-FID). A volume of 0.5 µL of the hexane phase was injected in split mode. Nitrogen was used as the carrier gas at a flow rate of 1.234 mL/min. The injector and detector temperatures were maintained at 250˚C.

The oven temperature program was as follows: held at 55˚C for 0.5 minutes, then ramped up at 30˚C/min to 150˚C, followed by a ramp at 5˚C/min to 250˚C, with a final hold of 15 minutes. The total analysis time was 38.67 minutes. The gas flow rates for the FID detector were 30 mL/min for hydrogen and 400 mL/min for air. Fatty acids were identified by comparing their retention times with those of a standard mixture of fatty acid methyl esters (FAMEs). The results, expressed as relative percentages of peak areas, were used to determine the fatty acid profile of the analyzed sample.

3. Results and Discussion

3.1. Volatile Organic Compounds

The analysis of the volatile organic compound (VOC) composition of *C. nigritanus* roots, performed by SPME-GC-MS, revealed a rich and diverse chemical profile dominated by terpenoid compounds, as shown in Figures 1-3 and Table 1. A total of 63 compounds were identified, including 29 sesquiterpene hydrocarbons, 21 oxygenated sesquiterpenoids, 5 monoterpenes, 3 aromatic compounds, 2 alkanes, 2 aldehydes, and 1 ketone. Sesquiterpenes, particularly sesquiterpene hydrocarbons and oxygenated sesquiterpenoids, constituted the major classes of compounds identified. Monoterpenes (C10) were also detected, but in lower proportions. Among the major sesquiterpene subgroups, methanoazulene derivatives, characterized by a hydroazulene skeleton, were predominant, followed by naphthalene derivatives. Spiro compounds, sesquiterpene ketones, and bicyclic

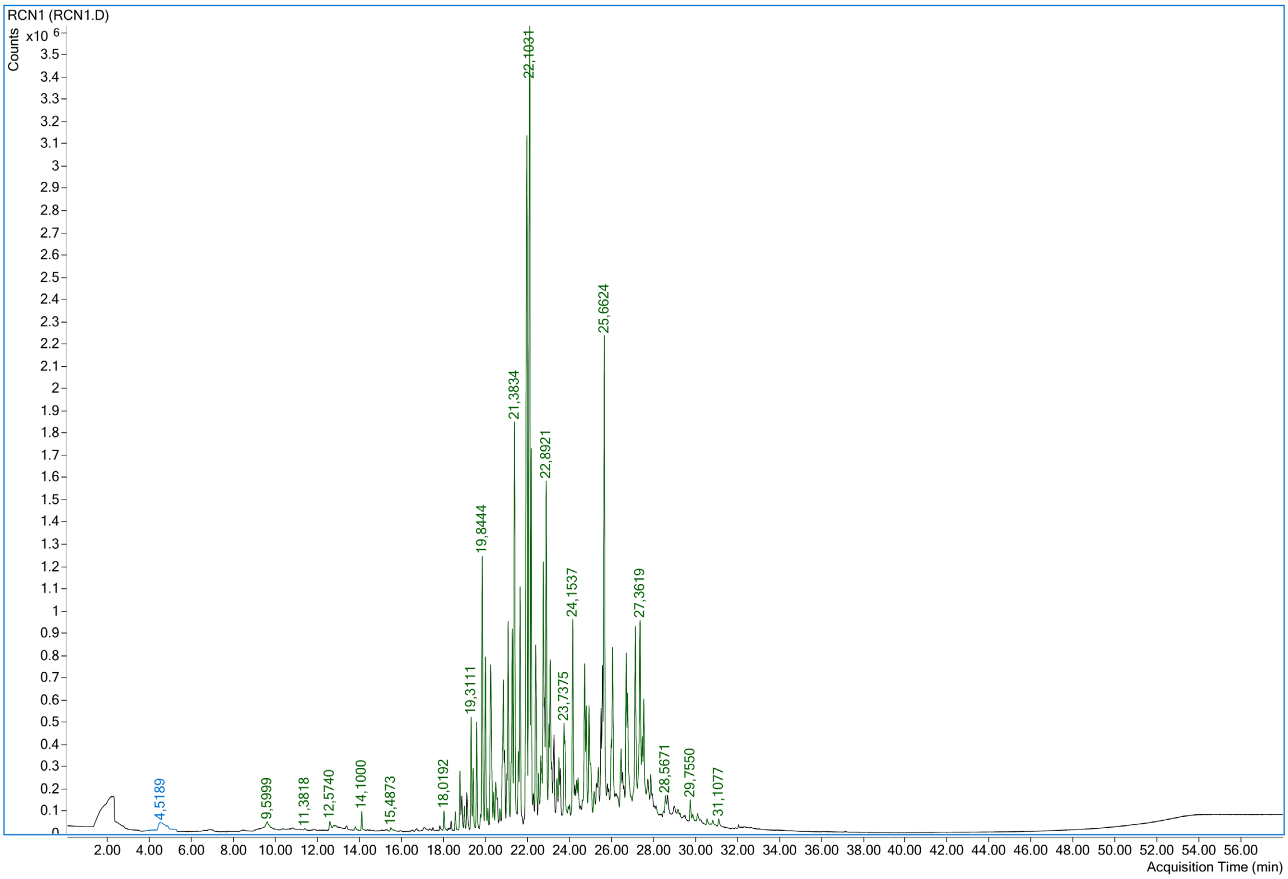


Figure 1. The SPME-GC-MS chromatogram of *C. nigritanus* root volatiles organic compound.

Table 1. SPME-GC-MS analysis of the volatiles organic compound profile of *C. nigritanus* roots.

No.	Retention time	compound Name	match factor	CAS number	Exp RI	Theo RI	ref	Relative peak area (%) (mean ± SD, n = 3)
1	20.8459	(−)-Aristolene	88.9	6831-16-9	1406	1428.3	[11]	2.21 ± 0.14
2	21.5655	(+)-epi-Bicyclosesquiphellandrene	91.4	54274-73-6	1434	1498	[11]	0.68 ± 0.01
3	19.7577	Cyprotene	85	193695-14-6	1364	1327	[11]	0.12 ± 0.04
4	21.0106	Acora-3(7),14-diene	96.8	55732-78-0	1412	1412	[12]	0.38 ± 0.06
5	22.8921	Selina-5,11-diene	89.2	52026-55-8	1488	1446.5	[11]	3.92 ± 0.24
6	22.1031	Ziza-6(13)-ene	96.4	18444-94-5	1456	1452	[12]	11.39 ± 0.36
7	20.1133	Copaene	89.6	3856-25-5	1476	1452	[11]	0.15 ± 0.06
8	24.0064	Cubenene	88.4	29837-12-5	1605	1532	[11]	0.05 ± 0.04
9	18.5656	Cycloocta-1,3,6-triene, 2,3,5,5,8,8-hexamethyl-	86.6	1000161-97-9	1318	1328	[11]	0.20 ± 0.01
10	19.3199	Cyclopentane-3'-spirotricyclo[3.1.0.0(2,4)] hexane-6'-spirocyclopentane	85.9	78578-93-5	1448			1.17 ± 0.07

Continued

11	20.252	Di-epi-*α*-cedrene	90.3	50894-66-1	1481	1482	[11]	2.82 ± 0.09
12	20.0006	*α*-Ylangene	97.5	14912-44-8	1373	1372	[11]	1.82 ± 0.06
13	19.5799	Silphiperfol-5-ene	86.5	138752-24-6	1457	1485		1.09 ± 0.0
14	18.0192	Tricyclo[4.2.2.0(2,5)]dec-7-ene, 7-butyl-	85	1000164-31-1	1298	1330.7	[11]	0.21 ± 0.02
15	20.3863	*β*-Ylangene	93.3	20479-06-5	1388	1380	[11]	0.32 ± 0.07
16	21.9687	Preziza-7(15)-ene	96.5	31145-21-8	1539	1669	[11]	10.41 ± 0.33
17	22.1769	*α*-Gurjunene	94.3	489-40-7	1459	1408	[12]	3.84 ± 0.16
18	20.4905	*β*-Gurjenene	92.7	17334-55-3	1392	1408	[11]	0.59 ± 0.07
19	19.4109	*α*-Cubebene	93.4	17699-14-8	1351	1354	[11]	0.71 ± 0.08
20	22.7534	*α*-Muurolene	97.1	31983-22-9	1482	1482	[12]	2.73 ± 0.12
21	28.5671	*γ*-HIMACHALENE	88.5	1000140-08-0	1737	1515	[11]	0.27 ± 0.0
22	23.0829	*γ*-Muurolene	91.2	30021-74-0	1495	1485	[11]	1.97 ± 0.14
23	25.6624	1,1,4a-Trimethyl-5,6-dimethylenedecahydronaphthalene	92.4	1000193-60-8	1605			6.34 ± 0.24
24	19.8444	(+)-Cyclosativene	97.7	22469-52-9	1367	1362	[11]	3.23 ± 0.04
25	23.7375	10s,11s-Himachala-3(12),4-diene	92.7	60909-28-6	1523	1399	[11]	1.32 ± 0.28
26	21.3834	1,5,9,9-Tetramethyl-2-methylene-spiro[3.5]non-5-ene	86.4	1000186-71-7	1427	1491	[11]	5.03 ± 0.11
27	21.2751	Cedr-8(15)-ene	96	546-28-1	1423	1424	[11]	2.63 ± 0.18
28	23.4038	Cadina-1(10),4-diene	87.6	483-76-1	1509	1508	[11]	0.51 ± 0.34
29	23.0266	*β*-cadinène	94	5951-61-1	1493	1491	[11]	0.87 ± 0.13
30	24.3402	*α*-Agarofuran	86.6	07/12/5956	1549	1556.1	[11]	0.37 ± 0.13
31	27.1365	Epizizanone	94.5	28624-27-3	1671	1452	[11]	2.89 ± 0.51
32	26.7029	Prezizaan-7-ol	90.3	312296-11-0	1652	1628	[12]	1.90 ± 0.17
33	24.1537	11,12,13-tris-nor-trans-Eudesm-5-en-7-one	94.7	69460-62-4	1541	1566	[12]	2.44 ± 0.11
34	22.3892	11,12,13-tris-nor-Eremofil-1(10)-en-7-one	86.3	39850-88-9	1468	1440	[11]	2.36 ± 0.12
35	29.755	(E)-Eremophila-1(10),7(11)-dien-12-yl acetate	91	352461-71-3	1793	1831.4	[11]	0.26 ± 0.01
36	27.3619	Junicedranone	88.8	465-26-9	1681			3.50 ± 0.4
37	24.7997	15-nor-Prezizaan-7-one	91.9	114299-44-4	1568	1581.1	[11]	1.24 ± 0.15
38	28.4718	Methyl 2-epi-ziza-6(13)-en-12-oate	84	18444-89-8	1732	1738.7	[11]	0.03 ± 0.01
39	25.992	Spatulenol	80.6	6750-60-3	1668	1622	[11]	0.61 ± 0.03
40	24.7218	cis-Eudesm-6-en-11-ol	93.4	194607-96-0	1628	1613.2	[11]	2.02 ± 0.22

Continued

41	30.8216	*α*-Vetivone	86.8	15764-04-2	1821	1836	[12]	0.06 ± 0.01
42	23.4992	8-Isopropenyl-1,3,3,7-tetramethyl-bicyclo[5.1.0]oct-5-en-2-one	81.8	1000189-25-8	1589			0.49 ± 0.12
43	27.8736	(3-hydroxy-4,8a-dimethyl-6-prop-1-en-2-yl-2,3,5,6,7,8-hexahydro-1H-naphthalen-2-yl) acetate	88	1000185-44-8	1728			0.38 ± 0.32
44	26.7681	Acorenone B	84.5	21653-33-8	1693	1700	[11]	1.84 ± 0.54
45	26.0527	Junenol	82.9	472-07-1	1623	1627.5	[11]	2.04 ± 0.47
46	29.1698	trans-Valerenyl acetate	82	101527-74-6	1765	1831.8	[11]	0.09 ± 0.05
47	21.648	Tricyclo[6.3.0.0(1,5)]undec-2-en-4-one, 5,9-dimethyl-	86.7	1000153-99-7	1528			2.61 ± 0.04
48	18.7822	Spiro[3.6]deca-5,7-dien-1-one,5,9,9-trimethyl	80.8	81532-19-6	1327			0.62 ± 0.03
49	30.1063	Nootkatone	92.1	4674-50-4	1809	1819	[11]	0.13 ± 0.04
50	23.2651	*β*-Dihydroagarofurane	83.2	02/09/5956	1581	1501	[11]	1.03 ± 0.05
51	22.5281	*γ*-Cadinene	91.2	39029-41-9	1557	1514	[11]	0.32 ± 0.01
52	25.3807	4*β*H,5*α*-Eremophila-1(10),11-diene	80.2	03/07/4630	1593	1496	[11]	0.61 ± 0.27
53	10.3804	D-Limonene	86	5989-27-5	1028	1028	[12]	0.02 ± 0.01
54	25.177	2-Butenal, 2-methyl-4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-	83.5	3155-71-3	1584	1584.2	[11]	0.25 ± 0.15
55	30.5527	(E)-Eremophila-1(10),7(11)-dien-12-al	90.9	137695-18-2	1832	1812	[12]	0.08 ± 0.01
56	24.9342	2-Hydroxy-5-methoxybenzaldehyde, 3-methylbutyl ether	80.4	1000395-39-7	1635			2.08 ± 0.34
57	28.1294	Benzene, 1,3,5-tris(1-methylethyl)	81.6	717-74-8	1716	1328	[11]	0.07 ± 0.04
58	27.5441	Phenol, 2,4-bis(1,1-dimethylpropyl)	80.7	120-95-6	1717			1.51 ± 0.26
59	4.6317	Hexanal	93.2	66-25-1	819	800	[11]	0.63 ± 0.38
60	12.6695	Nonanal	81.6	124-19-6	1105	1105	[11]	0.07 ± 0.03
61	13.7922	(R,S)-5-Ethyl-6-methyl-3E-hepten-2-one	93.5	57283-79-1	1147	1143.9	[11]	0.05 ± 0.0
62	23.1567	Pentadecane	93	629-62-9	1498	1500	[12]	0.32 ± 0.02
63	20.6854	Tetradecane	87.2	629-59-4	1399	1399	[13]	0.08 ± 0.01

hydrocarbons also accounted for substantial proportions of the sesquiterpene profile. Finally, low amounts of aromatic compounds, aldehydes, and alkanes were detected, further contributing to the overall chemical diversity of the volatile profile of *C. nigritanus* roots [11]-[13] (see **Table 1**).

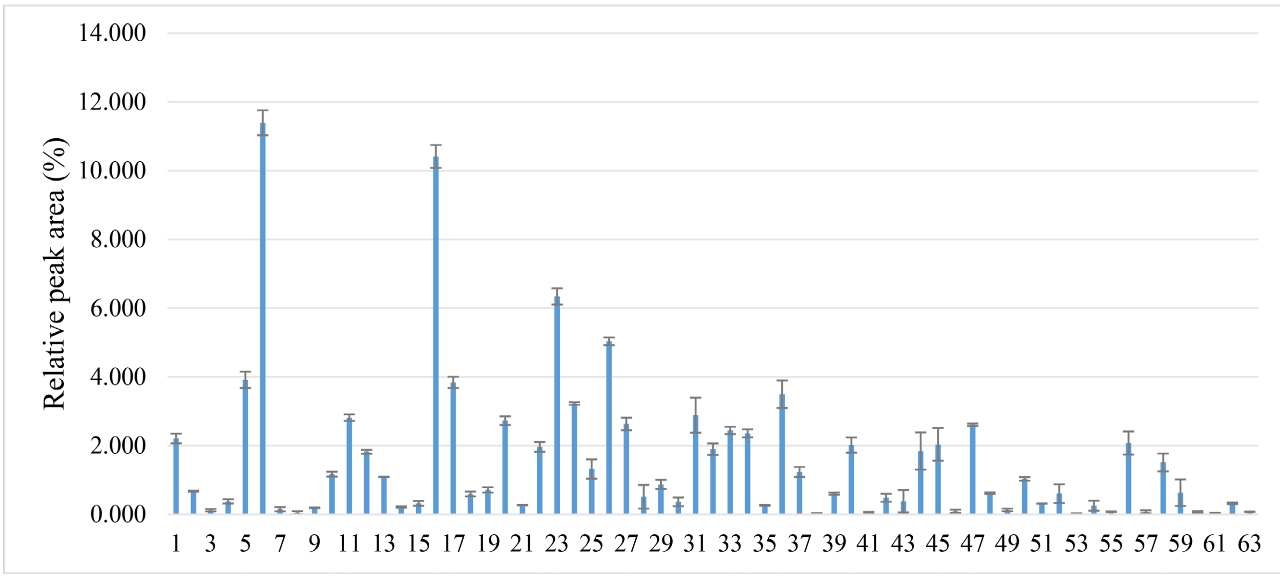


Figure 2. Distribution of VOCs according to their mean relative peak area (%).

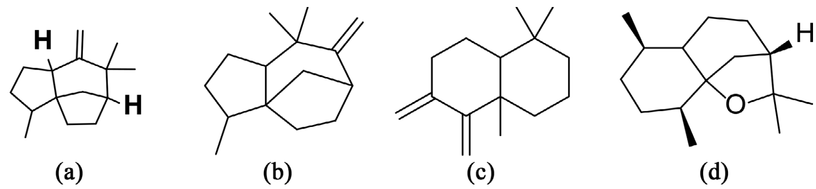


Figure 3. Structures of 3S.3aS.6R.8aS-3.7.7-trimethyl-8-methyleneoctahydro-1H-3a.6-methanoazulene (a), 3S.3aS.6R.8aS-3.8.8-trimethyl-7-methyleneoctahydro-1H-3a.6-methanoazulene (b), 1.1.4a-trimethyl-5.6-dimethylenedecahydronaphthalene (c) and β-Dihydroagarofurane (d).

The analyses revealed that the roots of *C. nigritanus* contain terpenoid metabolites, many of which have documented biological activity. These activities include anticancer, anti-inflammatory, anti-allergic, analgesic, antibacterial, antimalarial, insecticidal, and immunomodulatory effects, as well as anti-aging and neuroprotective activities [14] [15]. These compounds have also been associated which gastroprotective, antiretroviral, antifungal, antidiabetic [16] [17], cytotoxic, antiplatelet, and antiprotozoal activities [18]. In addition, compounds such as α-muurolene, γ-muurolene, ylangene, copaene, and nootkatone has been identified as characterization constituents of essential oils with a woody or resinous character [19].

This predominance of terpenes is also observed in the roots of the related species, *C. zizanoides*, whose volatile fractions were dominated by sesquiterpene [20]. However, comparison of the two species indicates that some compounds detected in *C. nigritanus* appear to be less frequently reported in the studies of the other species. Among the compounds identified in our study, 15-nor-prezizan-7-one is of particular interest because it belongs to the prezizane structural family. It has also been reported in a study on roots of *C. nigritanus* from Burkina Faso accounting for 1.17% of the oil, supporting the hypothesis that it may be a characteristic compound of this species [21]. Other compounds, such as silphiperfol-5-ene, acorenone B, junenol, trans-valerenyl acetate, and β-dihydroagafurane may also be characteristic of *C. nigritanus*. However, their potential as chemotaxonomic markers will need to be confirmed though further analyses of a larger number of *C. nigritanus* samples. Conversely, several compounds identified in *C. nigritanus* are also common to both species; and may therefore be considered characteristic compounds of the genus Chrysopogon [20]. These findings suggest a degree of chemical similarity between the two species will also indicating qualitative differences in their volatile profiles.

This hypothesis is consistent with the findings of Kossouoh *et al.* (2008), who isolated and characterized four new compounds from the root oil of *C. nigritanus* collected in Mali [22]. These compounds may contribute to the chemical differentiation of *C. nigritanus* from *C. zizanoic*. However, the chemical composition of different *Chrysopogon* species can vary considerably depending on several factors, including geographical origin, cultivation condition, the age of the harvested roots, and, in particular the methods used for compounds extraction and analysis [20].

3.2. Fatty Acid Composition of *C. nigritanus* Roots

The analysis of the fatty acids presents in the roots of *C. nigritanus* revealed carbon chain lengths ranging from C13 to C22 (see **Figure 4** and **Table 2**), which can be classified into three main categories: saturated, monounsaturated, and polyunsaturated fatty acid. The profile was characterized by a marked predominance of heptadecenoic acid (ω-7), a relatively uncommon fatty acid, followed by eicosenoic acid (C20:1n-9), linoleic acid (C18:2n-6) and eicosadienoic acid (C20:2n-6). Each of the other identified fatty acids account for less than 4% of the total.

A total of 21 fatty acids were identified, including 9 saturated fatty acids, 7 monounsaturated fatty acids, and 5 polyunsaturated fatty acids.

The fatty acid profile revealed a contrasting distribution, characterized by the marked predominance of heptadecenoic acid, which accounts for 65.352% of the total area. This represents an unusual fatty acid profile compared which those reported in previous studies on the related species *C. zizanoide*. This observation may be of taxonomic interest for *C. nigritanus*. In addition to the marked

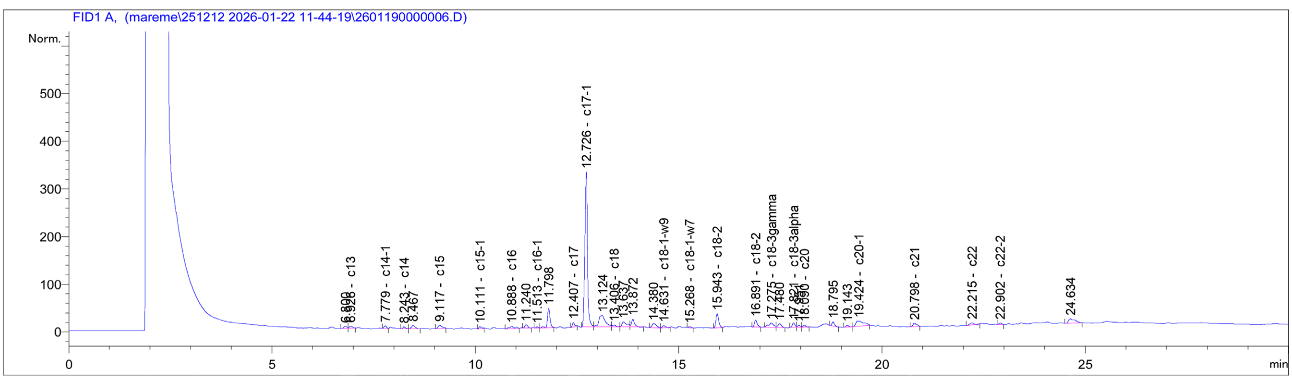


Figure 4. GC-FID chromatogram of the fatty acid profile of *C. nigritanus* roots.

Table 2. Fatty acid composition of *C. nigritanus* roots.

Name	Retention Time	Relative peak area (%) (mean ± SD, n = 3)
Heptadecenoic acid (C17:1n-7)	12.726	65.352 ± 1.135
Eicosenoic acid (C20:1n-9)	19.424	4.382 ± 3.079
Linoleic acid (C18:2n-6)	15.943	4.266 ± 3.360
Eicosadienoic acid (C20:2n-6)	19.158	4.171 ± 4.433
γ-Linolenic acid (C18:3n-6)	17.275	3.126 ± 0.398
Pentadecanoic acid (C15)	9.117	2.161 ± 0.074
α-Linolenic acid (c18:3n-3)	17.821	2.079 ± 0.106
Heneicosanoic acid (C21)	20.798	2.006 ± 0.026
Octadecanoic acid (C18)	13.406	1.948 ± 1.518
Hexadecanoic acid (C16)	10.888	1.786 ± 0.061
Heptadecanoic acid (C17)	12.407	1.587 ± 0.054
docosanoic acid (C22)	22.215	1.189 ± 0.120
Tridecanoic acid (C13)	6.926	0.995 ± 0.048
Myristoleic acid (C14:1n-5)	21.35241	0.785 ± 0.272
Cis-10-pentadecenoic acid (C15:1n-5)	10.111	0.771 ± 0.038
Oleic acid (C18:1n-9)	14.631	0.767 ± 0.065
Arachidic acid (C20)	18.090	0.734 ± 0.054
Tetradecanoic acid (C14)	8.243	0.709 ± 0.016
Docosadienoic acid (C22:2n-6)	22.902	0.493 ± 0.003
Vaccenic acid (C18:1n-7)	15.268	0.386 ± 0.031
Palmitoleic acid (C16:1n-7)	11.513	0.309 ± 0.052

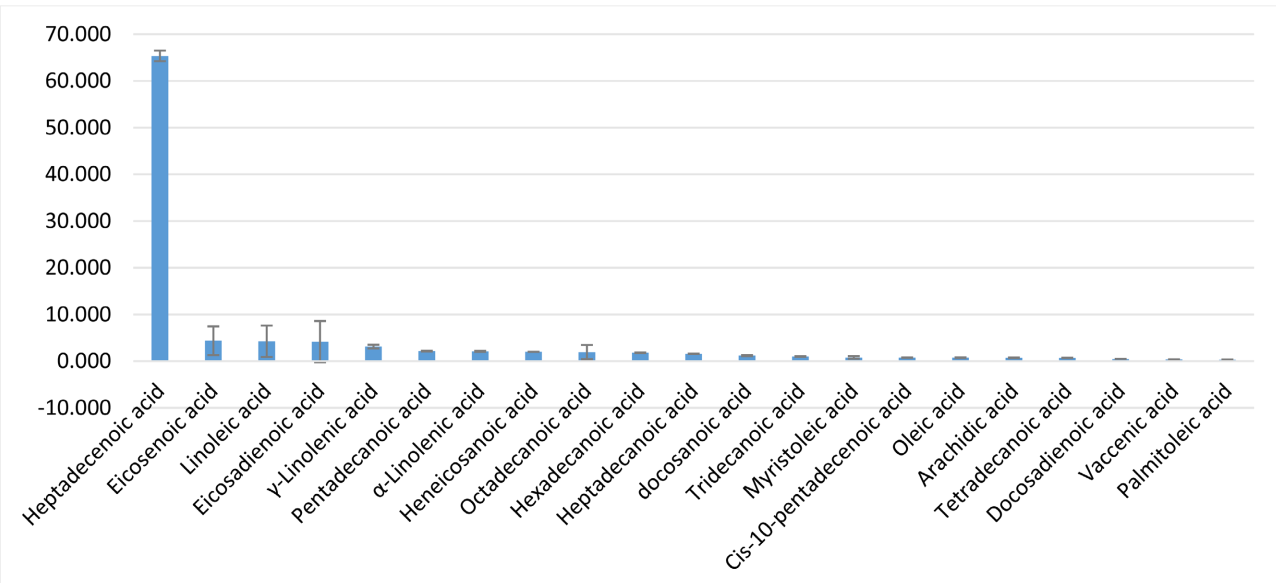


Figure 5. Distribution of fatty acids according to their mean relative peak area (%).

predominance of heptadecenoic acid, the species also contains notable proportion of fatty acids that have been associated with various biological activities in previous studies, particularly linoleic acid and α-linolenic acid, both of which are essential fatty acids (see Figure 5 and Figure 6). These fatty acids are particularly important because they are essential for the human body and cannot synthesize endogenously. They serve as precursor for the two main families of polyunsaturated the ω-6 and ω-3 fatty acid families.

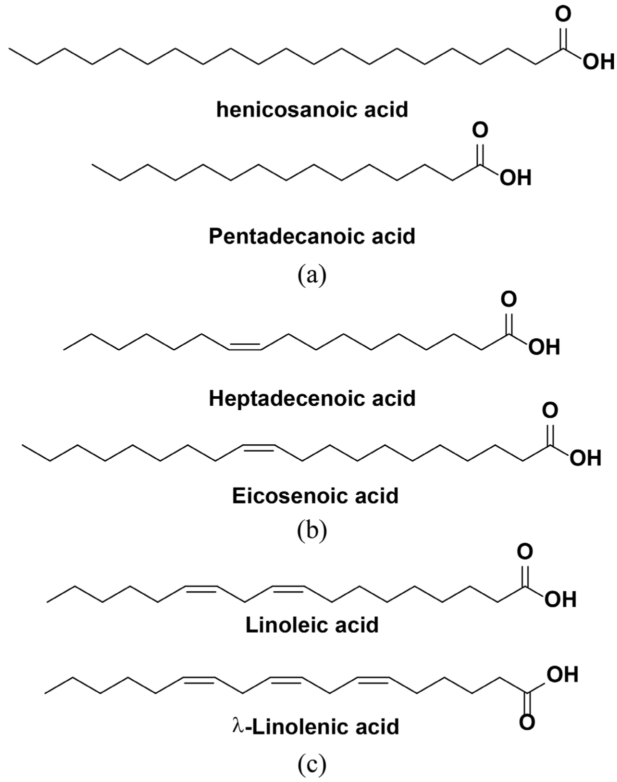


Figure 6. Major fatty acid structures (a) Saturated fatty acids, (b) Structures of monounsaturated fatty acids, (c) Structures of polyunsaturated fatty acids.

Fatty acids perform biological functions that are both distinct and varied.

Although the specific biological effects of heptadecenoic acid remain poorly understood, it belongs to the omega-7 fatty acid family. Omega-7 fatty acids are being investigated for their metabolic roles and their contribution to cell membranes structure, which may confer nutritional benefits, including potential effects on cardiovascular and mucosal health. Furthermore, its moisturizing, emollient, reparative, and anti-aging properties have contributed to its use in cosmetic formulations [22] [23].

Linoleic acid and related fatty acid, including γ-linolenic acid, eicosadienoic acid, and docosadienoic acid play important roles in maintaining the structure and barrier function of the stratum corneum. These fatty acids may help improve various skin conduction and contribute to maintaining cell membranes integrity. From a nutritional perspective, replacing saturated fatty acids with these fatty acids may help radius the risk of cardiovascular disease. In horses, these fatty acids are important for skin health and growth, when applied topically, may exert various biological effects, including anti-inflammatory activity, skin barrier repair, wound healing, skin lightening, photoprotection, and stimulation of hair growth [24]-[26].

α-Linolenic acid has potential medicinal and nutritional applications due to its reported antimicrobial, antidiabetic, and cardioprotective properties. It may contribute to the regulation of several physiological functions, including blood pressure and blood viscosity, and may therefore help reduce cardiovascular risk [27]. It may modulate the skin's immune through which receptors involved in various inflammatory skin conditions and immune-mediated, including atopic dermatitis, severe acne, skin cancer, and systemic lupus erythematosus [26]. They also offer benefits for symptoms and structural abnormalities associated with osteoarthritis [28].

Eicosenoic acid is a monounsaturated fatty acid (MUFA) that may contribute to maintaining membrane fluidity, serves as an energy reserve, and exerts metabolic effects, particularly on insulin sensitivity. As a member of ω-9 family it may contribute to a more favorable lipid profile when it replaces saturated fatty acids in the diet. Owing to its emollient, lubricating, nourishing, and protective properties, it is commonly incorporated into formulations for dry skin as well as in hair care products [29] [30].

Oleic acid has reported anti-inflammatory properties and may contribute to maintaining the fluidity of cell membranes; from a nutritional standpoint, it helps lower cholesterol levels and reduce the risk of cardiovascular disease when it replaces saturated fatty acids. In dermatological formulations, it is commonly used for its emollient properties and its ability to enhance the penetration of active ingredients through the stratum corneum. It may benefit dry skin, although high concentrations may compromise the skin barrier particularly in sensitive skin types [30]-[32].

Palmitoleic acid is recognized for its biological benefits, may act as a lipokine involved in lipid metabolism, improve insulin sensitivity, and modulate inflammatory responses. As a natural component of human sebum, it may contribute to maintaining skin hydration, supporting the epidermal barrier repair, promoting wound healing, and providing antibacterial protection [33] [34].

The various fatty acids identified in the roots of *C. nigritanus*, together with their biological, nutritional, and cosmetic properties, may partly explain some of the benefits attributed to this species, as well as their potential applications in traditional medicine, skincare, and nutrition. These results differ from those reported by P. Champagnat *et al.* (2006), who observed a predominance of zizanoic acid and isozizanoic acid, which lower proportion of conventional fatty acids [35].

4. Conclusion

The findings of this study provide additional insights into the chemical profile of

C. nigritanus. The analysis of volatile organic compounds extracted from the roots, carried out by gas chromatography-mass spectrometry (GC-MS), revealed a marked predominance of sesquiterpènols, particularly methanoazulene and naphthalene derivatives. Some of these compounds apart to be characteristic of the genus *Chrysopogon*, while others may represent potential markers specific to *C. nigritanus*. These compounds also show promising biological and pharmaceutical potential. At the same time, the study of the fatty acids in the root system reveals a distinctive profile, characterized by a marked dominance of heptadecenoic acid, an uncommon fatty acid in plan, which may be of potential interest as a chemotaxonomic criterion for this species. The roots also contain notable proportion of fatty acid associated various biological activities and documented nutritional benefits. Overall, these findings highlight the potential value of *C. nigritanus* roots for further investigation in pharmaceutic, cosmetic, and nutritional applications.

Author Contributions

Absa Diop: Validation, Formal Analysis, Data Curation, Writing—original draft preparation; Mareme Thiaw: Methodology, Validation, Formal Analysis, Data Curation, Writing—original draft preparation; Issa Samb: Methodology, Conceptualization, Validation, Resources, Writing—original draft preparation, Writing—review and editing, Supervision, Project Administration; Mohamed Lamine Gaye: Methodology, Conceptualization, Resources, Validation, Writing—original draft preparation, Writing-review and editing, Supervision, Project Administration.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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