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CHEMICAL CHARACTERIZATION AND ANALYTICAL REPRODUCIBILITY OF THE ESSENTIAL OIL FROM THE TRUNK BARK OF *IRVINGIA GABONENSIS* (AUBRY-LECOMPTE EX O'RORKE) BAILL. FROM CÔTE D'IVOIRE

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ABSTRACT

Irvingia gabonensis is a fruit tree native to West Africa. In Côte d'Ivoire, its trunk bark, leaves, and seeds are commonly used in traditional medicine and as food. While the fatty acid composition of the kernel has been studied extensively, the essential oil extracted from the trunk bark remains poorly documented.

This study had two objectives: to characterize the chemical composition of this essential oil and to verify the reproducibility of the measurements. The oil was obtained by hydrodistillation and then analyzed by gas chromatography-mass spectrometry (GC/MS). The concentrations are expressed as mean ± standard deviation over several analytical replicates.

Ten compounds were identified, representing 100.0% of the quantified constituents. The profile is dominated by hydrocarbon monoterpenes (94.7%). Sabinene is by far the most abundant (65.2 ± 1.26%), followed by p-cymene (8.7 ± 0.34%), γ-terpinene (7.8 ± 0.23%), and then α-pinene and α-terpinene (4.3% each). Oxygenated monoterpenes (4-carvomenthenol, 2.0%) and hydrocarbon sesquiterpenes (β-bisabolene, 3.3%) are present in smaller quantities. No oxygenated sesquiterpenes were detected.

Standard deviations are low from one replicate to the next: the measurements show little dispersion under the experimental conditions used. A compound that alone exceeds 65% of the total suggests a sabinene a sabinene-dominant chemical profile for this bark, a profile comparable to those described in other West African organs and species rich in monoterpenes.

These results provide an initial reference characterization of the essential oil from the bark of *I. gabonensis* from Côte d'Ivoire. They pave the way for broader studies on intraspecific variability: organs, localities, seasons.

Keywords: *Irvingia gabonensis*; Trunk bark; Essential oil; Sabinene; GC/MS

1 INTRODUCTION

The genus *Irvingia* includes plant species widespread in Africa and Southeast Asia. Three of them are commonly used in traditional medicine, especially in Africa: *Irvingia gabonensis* , *Irvingia malayana* , and *Irvingia grandifolia* . Recorded uses include treating fever, scabies, toothaches, inflammation, as well as liver and gastrointestinal disorders.

Irvingia gabonensis is a fruit tree that grows to a height of 15 to 40 m, with gray, slightly scaly bark. It is found in the humid forest areas of West and Central Africa [1]. The species plays an important role in agroforestry systems and in the West African village economy, particularly in Côte d'Ivoire. Its trunk bark is reputed to be very effective against skin bruises, toothaches, dysentery, and hernias [2]. Several authors have also reported its hepatoprotective action [3,4]. The plant is also recognized for its potential in the fight against obesity [5].

All parts of the plant are used. The kernels, rich in lipids, are processed into a paste ("odika", "dika bread") which serves as a thickener for sauces. The bark, leaves, and roots are used in traditional medicine to treat diabetes, pain, digestive disorders, and various infections. Studies of almond oil have shown that *I. gabonensis* is composed of 98.4% triglycerides, mainly consisting of lauric acid (38.5 ± 0.1%) and myristic acid (51.9 ± 0.2%) [6].

From a phytochemical standpoint, the plant is described as rich in polyphenols [7] and volatile compounds. The latter, particularly those in the bark, remain significantly less documented than the lipid fraction of the kernel, which is widely characterized by its high lauric and myristic acid content. Essential oils, however, constitute chemotaxonomic markers and potential sources of bioactive molecules (antibacterial, antifungal, antioxidant). In several West African woody species, trunk or root bark produces volatile profiles dominated by monoterpenes, the composition of which varies according to the organ, geographic origin, or chemotype of the individual sampled. In *Irvingia gabonensis* , the limited data available on the volatile fraction mainly concern the seed, particularly fermented seeds, some major constituents of which have been reported alongside oxygenated and sesquiterpene compounds. To our knowledge, no data exist on the essential oil of the trunk bark of *I. gabonensis* from Côte d'Ivoire.

This study therefore has two objectives: to characterize, using GC/MS, the chemical composition of the essential oil from the trunk bark of *I. gabonensis* harvested in Côte d'Ivoire, and to evaluate the reproducibility of this composition through analytical replicates (mean ± standard deviation). This is a first step before considering a broader intraspecific variability study focusing on plant parts, harvest locations, and harvest periods.

2 MATERIALS AND METHODS

2.1 Plant material

Bark samples of *Irvingia gabonensis* were collected in Abidjan in June 2018 from previously identified adult trees. The botanical identification was confirmed at the National Floristic Center in Abidjan. A control specimen was deposited under herbarium number IG 2018-B.

The barks were then washed with water, dried at 25°C, ground, then placed in hermetically sealed jars and kept in the refrigerator.

2.2 Extraction of the essential oil

The essential oils were obtained by hydrodistillation using a Clevenger-type apparatus, following method 2.8.12 of the European Pharmacopoeia (10th edition). For the trunk bark, 500 g of material was distilled. The oily phase was then collected, dried over anhydrous sodium sulfate, and stored at −20 °C in hermetically sealed amber bottles until analysis. Each extraction was repeated three times to verify reproducibility.

2.3 GC/MS Analysis

The analysis was conducted by GC/MS, following the protocol described by Soilhi et al. [8] and Sidali et al. [9]. Ten milligrams of essential oil were dissolved in 100 mL of n-hexane, yielding a 0.01% (w/v) solution, and then analyzed by GC/MS (Agilent, Santa Clara, CA, USA). Each essential oil was replicated three times.

The system used was an Agilent 7890B GC (Agilent, Santa Clara, CA, USA) equipped with a split-splitless injector and coupled to an Agilent MSD 5977B detector. One microliter of 0.01% solution was injected. The analytical conditions were as follows:

- injection in splitless mode at 300 °C, on HP-5SM capillary column (Agilent, Santa Clara, CA, USA) (30 m, 0.25 mm, df = 0.25 µm);
- temperature program: from 50 °C (1 min) to 300 °C (5 min), at 5 °C/min.

Helium was used as the carrier gas, at a flow rate of 1.2 mL/min. Mass spectra were recorded in electron impact ionization mode at 70 eV, The mass spectra were recorded over an m/z range of 40-400. The source and the quadrupole were heated to 230 °C and 150 °C, respectively.

Compound identification was based on their chromatographic retention indices (RIs), by comparing mass spectra with those available in the PAL 600K® spectral library, and, when possible, by comparison with reference standards [10]. RI values were measured on an HP-5SM column (Agilent, Santa Clara, CA, USA) and calculated in temperature-programmed mode according to Babushok et al. [11] and Benini et al. [12]. A mixture of n-alkane homologs (C7–C30) was injected under the same chromatographic conditions. When pure standards were commercially available (Sigma, Darmstadt, Germany), the main compounds were confirmed by co-injection, comparing retention times and mass spectra.

2.4 Statistical Analysis

All values are expressed as mean ± standard deviation, calculated from three independent replicates (n = 3).

3 RESULTS

3.1 Chemical composition of bark essential oil

GC/MS analysis of the essential oil extracted from the trunk bark of *I. gabonensis* identified ten compounds, representing 100% of the total composition (Table 1). The profile is dominated by a single constituent: sabinene, at 65.2 ± 1.26%. Far behind are p-cymene (8.7 ± 0.34%) and γ-terpinene (7.8 ± 0.23%). α-Pinene and α-terpinene follow, at 4.3% each (standard deviations of 1.01% and 0.16%), then β-bisabolene (3.3 ± 0.29%), α-thujene (2.6 ± 0.14%), and 4-carvomenthenol (2.0 ± 0.19%). β-Myrcene and α-Phellandrene close the list, both at 0.9% (standard deviations of 0.27% and 0.14% respectively).

Table 1: Chemical composition (retention time, mean content, and standard deviation) of the essential oil from the trunk bark of Irvingia gabonensis. Compounds in bold represent a mean content ≥ 4%. TR: retention time

No.	TR (min)	Compound	Average (%)	Standard deviation (%)
1	6,423	*α-thujene*	2.6	0.14
2	6,597	*α-pinene*	4.3	1.01
3	7,616	*Sabine*	65.2	1.26
4	8,072	*β-Myrcene*	0.9	0.27
5	8,444	*α-phellandrene*	0.9	0.14
6	8,779	*α-terpinene*	4.3	0.16
7	8,994	*p-cymene*	8.7	0.34
8	9,958	*γ-terpinene*	7.8	0.23
9	13,333	4-carvomenthenol	2.0	0.19
10	22,048	β-bisabolene	3.3	0.29
Total identified			100.0	0.01

3.2 Distribution by chemical classes

Grouping by biosynthetic class reveals a marked dominance of hydrocarbon monoterpenes: 94.7% of the essential oil (Table 2). Oxygenated monoterpenes, reduced to 4-carvomenthenol alone, represent 2.0%. Sesquiterpenes reach 3.3%, all hydrocarbon (β-bisabolene). No oxygenated sesquiterpenes were detected in this sample.

Table 2: Distribution of the essential oil of Irvingia gabonensis bark by major chemical classes

Chemical class	Representative compounds	Total (%)
Hydrocarbon monoterpenes (MH)	α-thujene, α-pinene, sabinene, β-myrcene, α-phellandrene, α-terpinene, p-cymene, γ-terpinene	94.7
Oxygenated monoterpenes (MO)	4-carvomenthenol	2.0
Sesquiterpene hydrocarbons (SH)	β-bisabolene	3.3
Oxygenated sesquiterpenes (SO)	not detected	0.0

3.3 Analytical Reproducibility

The standard deviations of the mean concentrations remain generally low: from 0.14% for α-thujene and α-phellandrene to 1.26% for sabinene. When compared to the corresponding means, the coefficients of variation (CVs) remain below 25% for all compounds except β-myrcene: a standard deviation of 0.27% for a mean of 0.9%, resulting in a CV of approximately 30%. α-Pinene shows a standard deviation of 1.01% for a mean of 4.3%, therefore a CV close to 23%. It remains below the 25% threshold, but this is the second highest value, after that of β-myrcene.

4 DISCUSSION

4.1 A sabinene-dominated profile: towards a trunk bark chemotype

Sabinene is by far the dominant compound (65.2%), accompanied by p-cymene and γ-terpinene in significant quantities. These two compounds originate from the same biogenetic pathway, that of p-menthane. Together, they form a profile rich in hydrocarbon monoterpenes, already described in several tropical woody species.

This imbalance in favor of a single major compound is classically interpreted, in the chemistry of essential oils, as the mark of a chemotype: an intraspecific chemical variant linked to the individual, the population or the edaphic-climatic conditions of origin, without any link with any visible morphological variation.

This polarization around sabinene, α-terpinene, or limonene has been observed in several tropical woody species. In these species, the bark exhibits a distinct volatile profile, often dominated by a single compound, regardless of the chemotype identified in the leaves. The bark thus has its own biosynthetic logic, separate from that of other organs.

Boswellia species from West Africa show the same marked interindividual variability for their major hydrocarbon monoterpenes: α-pinene ranges from 21.7 to 76.6% depending on the individual, with secondary chemotypes dominated by myrcene.

This range, documented in phylogenetically distant but ecologically comparable species, places the value of 65.2% of sabinene measured here in a perfectly plausible range of dominance for a bark of a tropical woody species.

4.2 Comparison with available data for *Irvingia gabonensis*

Published data on the volatile fraction of *I. gabonensis* remain scarce. They mainly concern the seed, with very little on the trunk bark. Gas chromatography (GC) analysis of the methyl esters of fatty acids in the oil shows a clear predominance of saturated fatty acids (90%), particularly myristic acid (C14:0) and lauric acid (C12:0). After oil extraction, the press cake contains high levels of nitrogen, phosphorus, potassium, magnesium, and total protein (20%). Once defatted, this press cake could be used to season sauces in Benin, with good nutritional value [13]. The oil is the main component of the seed, composed primarily of myristic and lauric acids. The defatted extracts are characterized by flavonoid glycosides and ellagic acid derivatives [1].

In other species of the genus, 31 compounds have been identified in Irvingia malayana, representing 97.4% of the total composition. Oxygenated monoterpenes dominate, at 45.1%. Hydrocarbon and oxygenated sesquiterpenes are also well represented, at 29.4% and 20.3%, respectively. The most abundant compounds are β-ionone (20.2%), α-ionone (16.2%), β-caryophyllene (15.2%), δ-cadinene (6.2%), β-eudesmol (5.8%), and (E)-nerolidol (5.4%). The essential oil was shown to be active in the lipoxygenase assay, with an IC50 of 60.5 µg/mL (quercetin, IC50 10.5 µg/mL) [14]. In the leaves of Irvingia barteri Hook. f. (Irvingiaceae), the main compounds are β-caryophyllene (17.0%), (E)-α-ionone (10.0%), geranial (7.6%), (E)-β-ionone (6.6%) and β-gurjunene (5.1%) [15].

5 CONCLUSION

This study presents the first chemical characterization by GC/MS of the essential oil extracted from the bark of *Irvingia gabonensis* in Côte d'Ivoire. Ten compounds were identified. The profile is dominated by hydrocarbon monoterpenes (94.7%), and especially by sabinene (65.2%), alongside p-cymene and γ-terpinene. The standard deviations remain low, indicating good analytical reproducibility. The resulting profile can therefore serve as a first chemical reference for the studied bark sample and is considered a sabinene chemotype.

These results are based on a single sample. They need to be confirmed by studies involving more individuals, locations, and harvest periods, as well as other plant parts (leaves, seeds). The objective is to create a comprehensive map of the intraspecific chemical variability of *I. gabonensis* in Côte d'Ivoire and to evaluate the bioactive potential (antimicrobial, antioxidant) of this sabinene-rich essential oil.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

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Disclosure of conflict of interest

The authors declare that they have no conflicts of interest related to the publication of this article.

Statement of ethical approval

This study focuses exclusively on the chemical characterization of plant material (trunk bark of *Irvingia gabonensis*) and does not involve human subjects or experimental animals; therefore, no approval from an ethics committee was required for its execution.

Data availability statement

The data used to establish the results of this study are available from the corresponding author upon reasonable request.

Authors' Contribution

- KABLAN Richmond Jean-François: participation in hydrodistillation extractions, statistical analysis of data, contribution to the interpretation of results, proofreading of the manuscript.
- KABLAN Ahmont Landry Claude: conceptualization and methodology of the study, execution of GC/MS extractions and analyses, data processing, writing of the original manuscript, correspondence with the journal.
- ADIKO N'dri Marcelline: collection and preparation of plant material, critical review of the manuscript.
- KABRAN Aka Faustin: scientific supervision, methodological validation, critical review of the manuscript.
- ATTIOUA Koffi Barthélemy: general supervision of the project, final validation, critical review of the manuscript.

All authors have read and approved the final version of the manuscript.

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