

Mineral composition and secondary metabolites in the leaves of *Lophira lanceolata* (Ochnaceae) from Bondo City in the Democratic Republic of the Congo

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ABSTRACT

Introduction

Many nutrient-rich plants remain underutilised in the diets of sub-Saharan populations, particularly in the Bondo area of northern Democratic Republic of Congo (DRC). It is therefore necessary to valorise them through appropriate laboratory investigations.

Purpose

This study focused on *Lophira lanceolata* to investigate the phytochemical composition and mineral content of its leaves.

Method

Standard chemical screening and atomic absorption spectrometry were employed to assess phytochemical composition and mineral content, respectively.

Results

Leaves were collected approximately 54 km from Bondo City. Phytochemical screening revealed flavonoids (flavones) at $12.7 \pm 0.31\%$, terpenes at $2.49 \pm 0.23\%$, saponins at $0.65 \pm 0.02\%$, and sterols at $0.60 \pm 0.05\%$. Gallic tannins and alkaloids were detected but not quantified. The loss on drying was $10.70 \pm 0.35\%$ and the total ash content was $5.90 \pm 0.11\%$. Mineral analysis indicated high concentrations of iron ($15.63 \pm 0.15\%$), sulfur ($13.85 \pm 0.11\%$), and silicon ($5.25 \pm 0.02\%$), along with moderate levels of zinc ($3.47 \pm 0.56\%$), calcium ($2.68 \pm 0.01\%$), potassium ($1.89 \pm 0.04\%$), phosphorus ($0.80 \pm 0.001\%$), copper ($0.61 \pm 0.02\%$), and trace titanium ($<0.24\%$). The calcium-to-phosphorus ratio (3.35) suggests potential use in livestock nutrition, particularly during the dry season.

Conclusion

Our findings demonstrate that *Lophira lanceolata* leaves from Bondo are a rich source of bioactive compounds and essential minerals, supporting their traditional use against anaemia, infections, hypertension, and inflammatory conditions. The presence of silicon and sulfur suggests additional benefits for bone health, dermatological conditions, and pest resistance. These results highlight the plant's potential applications in phytotherapy, veterinary medicine, and agro-nutrition.

INTRODUCTION

Natural products represent a major source for the discovery of new therapeutic molecules. Thanks to advances in biotechnology, a wide diversity of secondary metabolites – small organic molecules with unique structures – has been identified. These compounds often play a crucial role in the defence mechanisms of living organisms (N'Guessan et al., 2017). In parallel, mineral elements found in various foods such as leafy vegetables, legumes, fish, nuts, and dairy products are essential for numerous physiological functions, including oxygen transport, neuromuscular regulation, and bone development (Novidzro et al., 2019).

Standardised methods for mineral determination, particularly atomic absorption spectrometry, were proposed as early as the Second Colloquium on Cultivated Plant Nutrition in 1968 and have since been consolidated by several researchers (Khelifa & Benfedila, 2013). Sub-Saharan Africa, and especially the Democratic Republic of Congo (DRC), is rich in medicinal plants with diverse traditional uses, yet their scientific potential remains largely underexplored.

Among these is *Lophira lanceolata*, a species widespread in the Sudano-Guinean savannah, traditionally used to treat ailments such as parasitic infections, anaemia, abdominal pain, and hypertension (PROTA, 2007; Nonviho, 2015). It is also used as fodder during the dry season.

Despite these empirical uses, few studies have been conducted on this species within the Congolese context. The present study aims to fill this gap by analysing the phytochemical and mineral composition of *Lophira lanceolata* leaves collected in the Bondo region. Through standard chemical screening (Folo, 2014; N'Guessan et al., 2014) and atomic absorption spectrometry (Genin, 2004), we seek to highlight the secondary metabolites and mineral elements present, in order to better understand the nutritional and therapeutic properties of this plant.

METHODS

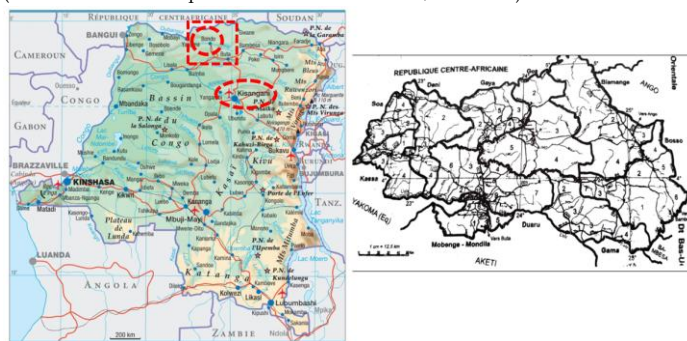
Study sites

We conducted an experimental study focused on the exploratory identification of phytochemical and mineral compounds of *Lophira lanceolata* and their quantification whenever technically possible. The study material, i.e.,

plant leaves, was collected in Gangumbili locality (latitude 34° North, altitude 499 m, GPS: North-West 4°16.991 and East-West 23°35.950). The site is located about 54 km from Bondo centre in the Bas-Uele Province, northern Democratic Republic of the Congo (see Figure 1). The phytochemistry analyses were conducted at the Drug Analysis Laboratory of Kisangani (LAMEKIS) of the University of Kisangani, while the mineral analyses were carried out at the Congolese Control Office (OCC) Laboratory in Bukavu.

Figure 1:

Map of the Bondo territory located in the north of Democratic Republic of the Congo (Source: National Independent Election Committee, 2023 DRC).



Plant authentication requirement

Each specimen of the collected plant was compared with a herbarium specimen from the Yangambi National Botanical Garden near Kisangani in December 2023. A second specimen was deposited on 7 September 2024 for future analyses.

Phytochemical analysis

Chemicals and reagents

Absolute ethanol (95°) and hydrochloric acid (HCl, 99%) were obtained from Prolabo (Paris, France); n-butanol (98%), ethyl acetate (99%), and n-hexane (99%) were obtained from Loba Chimie (Mumbai, India); while petroleum ether was purchased from Pallav Chemicals & Solvents Pvt. Ltd (Mumbai, India).

Materials

Phytochemical contents were measured using UV-Visible spectrometry (Jeanway, SP-400, Dunmow, United Kingdom).

Detection of phytochemical groups

Preliminary phytochemical screening was carried out following the classical protocol described by Folo (2014),

which aimed to identify flavonoids, terpenes, saponins, sterols, tannins, coumarins, and alkaloids.

Extraction of secondary metabolites

The dried leaves were ground into a fine powder and used for extraction. Different classes of secondary metabolites were isolated according to the methodologies proposed by Bouchalt et al. (2005), N'Guessan et al. (2014), and Musaka et al. (2014). Extract yields were expressed as grams of pure compound per 100 g of dry matter. The test was repeated four times (n = 4).

Moisture content

Moisture content was determined using the methods of Sanon et al. (2005), N'Guessan et al. (2014), and Folo (2014). An amount of 2 g was placed in a calibrated crucible and dried in an oven at 105°C for 24 h. The crucibles were cooled in a desiccator and weighed. The assay was performed three times (n = 3).

Ash content

Ash content was analysed based on the method of Novidzro et al. (2019), N'Guessan et al. (2014), and Folo (2014). The dried powder used to determine the water content was reduced to ash in an oven at 600°C for 6 h. After cooling in a desiccator, the ash was weighed. The masses obtained were used to calculate the total ash content in percent.

Determination of mineral content

Qualitative and quantitative analyses of the mineral concentrations were determined using atomic absorption spectrometry (AAS) according to the protocol described by Genin (2004). Ten grams of sample were reduced to ash and then cooled in a desiccator. Then, 5 g of the obtained ash was placed in a container covered with transparent adhesive on a primed support and attached to the AAS slide. All the material was introduced into the AAS-RFX chamber for microanalysis. The test was performed three times (n = 3).

Statistical methods

Data processed using descriptive statistics to assess variability and reliability were expressed as mean \pm standard deviation (n = 4 for secondary metabolites; n = 3 for mineral content).

RESULTS

Plant authentication

Figure 2:

Lophira lanceolata in its natural environment at Gangumbili near Bondo (left picture) and the herbarium specimen deposited at the Yangambi National Herbarium (right picture) under the accession number 1, 07/09/2024.



Table 1:

Phytochemical screening of *Lophira lanceolata* leaves and content of secondary metabolites expressed in dry matter.

Secondary metabolites	Presence	Content (mean \pm standard deviation; n = 4)
Flavonoids	++	12.7 \pm 0.31%
Terpenes	++	2.49 \pm 0.23%
Saponins	+	0.65 \pm 0.02%
Sterols	++	0.60 \pm 0.05%
Coumarins	++	Not quantified
Gallotannins	++	Not quantified
Alkaloids	+	Not quantified

Table 2:

Results of mineral element analysis of *Lophira lanceolata* leaves (mean \pm standard deviation; n = 3) expressed in dry matter

Mineral	Content (%)
Fe	15.64 \pm 0.15
S	13.85 \pm 0.11
Si	5.25 \pm 0.02
Zn	3.47 \pm 0.56
Ca	2.68 \pm 0.01
K	1.89 \pm 0.04
P	0.80 \pm 0.01
Cu	0.61 \pm 0.02
Ti	0.24 \pm 0.00

DISCUSSION

Plant authentication

Botanical authentication confirmed that our plant was indeed *Lophira lanceolata*, belonging to the order Malpighiales and the family Ochnaceae. This confirmation was critical to avoid confusion or error during collection.

Phytochemical screening of Lophira lanceolata

The presence of several secondary metabolites was revealed, namely flavonoids, gallotannins, terpenes, sterols, alkaloids, coumarins, and saponins (Table 1). These findings are consistent with the results reported by Ngoua et al. (2018). Flavonoids constituted the most abundant class. This high yield exceeds that observed in several other medicinal plant species. For example, *Ziziphus mauritiana* leaves contain a total flavonoid content of 5.94 ± 0.23 mg EQ/g dry matter (N'Guessan et al., 2017), which, although therapeutically relevant, remains markedly lower than the flavonoid content in *Lophira lanceolata*.

Terpenes ranked second in abundance. Although moderate, this content remains biologically meaningful, as terpenes are known for their insect-repellent activity at low concentrations, as well as antimicrobial and anti-inflammatory effects. Saponins and sterols, though present in smaller quantities, are significant due to their high bioactivity per unit mass. Saponins are recognised for their immunomodulatory, haemolytic, and hypocholesterolemic properties, while sterols may contribute to cytotoxic and membrane-stabilising effects. These values are comparable to those reported by Aubert et al. (1989) in eggplant (*Solanum melongena*) pericarp, which ranged from 0.5 to 1% using TLC methods.

Our findings also align with several authors who have reported the therapeutic potential of flavonoids in antioxidant, vasculoprotective, antitumour, antidiabetic, and anti-inflammatory applications (Emeraux, 2019; Kabre, 2023). *Lophira lanceolata* could therefore be promoted in the management of multiple diseases, including tropical neglected diseases such as sickle cell disease, which has one of the highest prevalences in the DRC. Its pathophysiological consequences involve red blood cell polymerisation, oxidative stress, and inflammatory responses leading to anaemia (Borive et al., 2025).

In an unpublished survey conducted in Bondo on local knowledge of *Lophira lanceolata* use, 15 of 81 respondents reported using the plant for rheumatism, 13 for malaria, 9 for flu, and 9 for anaemia (Baka et al., 2025). Another potential application involves insecticidal and anophelotic properties, as reported by Korankye et al. (2017). This is supported by the presence of sulphur, which exhibits antibacterial and antifungal properties. Nagnan (1998) highlighted the role of volatile terpenes in termite toxicity and attraction, while Alzogaray et al. (2013) demonstrated their repellent effect on *Blattella germanica* (cockroaches), suggesting possible use in natural insect control.

Loss on drying and total ash

The moisture loss of *Lophira lanceolata* leaves was $10.70 \pm 0.35\%$ dry matter, indicating low water content likely related to the dry soil conditions in the Bondo area. This confirms sufficient drying to preserve active constituents and minimise microbial growth. The crude ash content was $5.90 \pm 0.11\%$ dry matter, reflecting a good concentration of mineral elements, consistent with the dryness of the soil. After eliminating organic matter through incineration, this value represents the total inorganic material present.

Content of mineral elements

Atomic absorption spectrometry revealed that the leaves are particularly rich in nine minerals of high nutritional and therapeutic value (Table 2). Minerals are fundamental to human physiology, contributing to bone mineralisation, hormone synthesis (particularly thyroid hormones), haemoglobin production, and the proper functioning of the nervous, muscular, and immune systems. They are generally classified into macronutrients (e.g., calcium, phosphorus, potassium, and magnesium) and trace elements (e.g., iron, zinc, copper, silicon), both of which are essential. Imbalances in these elements can cause serious disorders.

Given their biological roles, evaluating the mineral composition of *Lophira lanceolata* leaves is vital to understanding their nutritional and therapeutic potential. The high iron content may contribute synergistically to haemoglobin synthesis against anaemia. Our findings echo those reported for various antihyperglycaemic plants (N'Guessan et al., 2017).

However, this study has limitations. Geographical sampling was restricted to Gangumbili near Bondo, limiting representativeness for the entire DRC. Moreover, some compounds (alkaloids, coumarins, gallotannins) were detected but not quantified, preventing a complete assessment of their therapeutic value.

A comparative study in Côte d'Ivoire revealed sterols, flavonoids, and saponins in aqueous extracts of *Lophira lanceolata*, but also reported intraperitoneal toxicity (LD₅₀ ≈ 375 mg/kg) (Koffi, 2025), underscoring the importance of toxicological studies not covered in this work. Similarly, Lohlum (2010) analysed *Lophira lanceolata* seeds in Cameroon, revealing minerals (Fe, Zn, Ca), confirming the nutritional richness of the plant and supporting our results.

CONCLUSION

This study evaluated the secondary metabolite and mineral content of *Lophira lanceolata* leaves. Results revealed significant levels of flavonoids, terpenoids, saponins, and sterols, as well as essential minerals such as iron, sulphur, calcium, zinc, and silicon. The synergy of bioactive compounds and nutrients highlights a wide therapeutic potential: antioxidant, anti-inflammatory, antimicrobial, glycaemic regulation, remineralisation, and natural insecticidal properties.

High iron, calcium, and phosphorus content supports its traditional use against anaemia, osteoarticular disorders, and nutritional deficiencies. Elevated silicon explains both leaf toughness and potential for connective tissue regeneration. The use of *Lophira lanceolata* as fodder during the dry season also presents promising agro-veterinary applications.

The findings provide scientific validation of the plant's nutritional and pharmacological value and support its broader use in phytotherapy and sustainable agro-nutritional strategies, particularly in rural communities such as those in Bas-Uélé Province, DRC.

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Ethical Approval: Ethical approval was obtained under reference N°UNIKIS/CER/009/2024 from the Ethical Committee of the University

of Kisangani, Ministry of Higher and University Education, Democratic Republic of the Congo.

Conflicts of Interest: None declared.

ORCID iDs:

Baka, A.Z. ^{1,2} :	Nil identified.
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Mbinze, J. K. ⁵ :	Nil identified.
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