



Chemical Profiles and Antioxidant Potential of Extracts from *Nauclea diderichii* (De Wild. & T. Durand) Merr., Collected in the Republic of the Congo

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Abstract

The chemical profiles of methanolic extract from the leaves, trunk, and roots of *Nauclea diderichii* were determined by liquid chromatography coupled with mass spectrometry (LC-MS). Total polyphenol content was determined using the Folin-Ciocalteu reagent method, and total flavonoid content using the aluminum trichloride method. Antioxidant potential was evaluated via DPPH free radical scavenging, ferric reducing antioxidant power (FRAP), and HPTLC bioautography. Extraction yields were highest for the roots (13.17%) and leaves (12.68%). Total polyphenol content was highest in the leaves (270.68 mg GAE/g), followed by the roots (244.26 ± 0.01 mg GAE/g). Total flavonoid content followed the same trend as total polyphenol content; specifically, the leaves (142.27 mg QE/g) contained higher levels than the roots (29.03 ± 0.01 mg QE/g). Quinic, chlorogenic, protocatechuic, and caffeic acids were identified in the leaves. In contrast, the trunk and roots were rich in triterpene compounds such as quinovic, quafrinoic, and emmolic acids. Antioxidant potential was most pronounced in the leaves (DPPH (IC₅₀) = 90.90 ± 0.03 µg/mL; FRAP = 814.25 ± 0.08 mg BHA-E/g) and roots (DPPH (IC₅₀) = 92.16 ± 0.04 µg/mL; FRAP = 723.36 ± 0.03 mg BHA-E/g).

Subject Areas

Analytical Chemistry

Keywords

Nauclea diderrichii, LC-MS, HPTLC Bioautography, Polyphenol, Flavonoid, Antioxidant Potential

1. Introduction

The genus *Nauclea* (Rubiaceae) comprises seven species distinguished by the shape of their placentas, stipules, and fruit type [1], as well as leaf shape, seed margins, petiole length, calyx and corolla pubescence, flowering head diameter, and leaf pubescence [2]. The best-known species are *Nauclea latifolia* Smith, *Nauclea pobeguinii* (Hua ex Pobég.) Merr. and *Nauclea diderrichii* (De Wild.) Merr. These species are distributed across the tropical and subtropical zones of Central Africa (Republic of the Congo, DRC, Gabon, Angola, and the Central African Republic) and West Africa (Benin, Senegal, and Côte d'Ivoire). Other species, such as *Nauclea vanderguchtii* (De Wild.) Petit, *Nauclea gillettii* (De Wild.) Merr., and *Nauclea xanthoxylon* (Chev.) Aubr., are less well known [3]. One species, *Nauclea nyasica*, is found in East Africa, in countries such as Tanzania, Mozambique, and Malawi. Among these species, *N. latifolia* has been the most extensively studied [4]-[7]. *Nauclea* species are used in traditional African medicine to treat various ailments, as evidenced by the development of three improved traditional antimalarial medicines based on *N. latifolia* [8], *N. latifolia* combined with *Cassia occidentalis* [9] [10], and *N. pobeguinii* [11]-[13].

Given the interest surrounding *Nauclea* species, we focused our attention on *Nauclea diderrichii*, which is known by several vernacular names such as “bilinga”, “aloma”, “badi”, and “kusia”. This species can reach heights of 30 to 40 m, with a trunk diameter ranging from 0.9 to 1.5 m. Its fruit is edible [14]. *N. diderrichii* is used as a medicinal plant within its distribution range to treat various conditions [15]-[19]. In Nigeria, a decoction of the stem bark is used to treat anemia, stomach aches, and indigestion, while a leave decoction is used as a lotion for measles [20]. The leaves are used to treat gastrointestinal [21] and skin infections [22]. In Benin, Cameroon, and Côte d'Ivoire, the species is used to treat malaria [23] [24].

N. diderrichii extracts are also used in traditional medicine to treat microbial and respiratory ailments [25]. The literature cites several phytochemical and pharmacological studies conducted on *N. diderrichii*. Nwodo and Agbo [20] demonstrated the antitrypanosomal activity of the stem bark; this extract contained alkaloids, tannins, saponins, and flavonoids. Aderibigbe *et al.* [26] confirmed the anthelmintic activity of the leaves. *N. diderrichii* specimens acclimatized in the Republic of the Congo have not yet been the subject of phytochemical or pharmacological studies. The aim of this study is to determine the phytochemical profiles and evaluate the antioxidant potential of *Nauclea diderrichii* extracts.

2. Materials and Methods

2.1. Plant Material

The plant material was collected in the Patte d'Oie forest (04° 16' 12.85" South and 015° 14' 58.92" East) in Brazzaville in April 2025. The species was authenticated by botanists from the National Herbarium, and a specimen was preserved under reference ND-01. The various parts of the same plant, namely the leaves, trunk bark, and root bark were dried separately for two weeks, away from sunlight. The samples were then ground into a very fine powder.

2.2. Extraction

50 g of powder (consisting of leaves, trunk bark, or root bark) was macerated in 300 mL of methanol under magnetic stirring for 24 hours. The mixture was filtered, and the resulting filtrate was evaporated to dryness under vacuum using a Heidolph rotary evaporator.

2.3. Determination of the Chemical Profiles

The phytochemical profiles of the extracts were obtained using the method described by Boungou-Tsona *et al.* [27]. This method is based on liquid chromatography coupled with mass spectrometry. Analyses were performed on an Ultimate 3000 RSLC UHPLC system (Thermo Fisher Scientific Inc., Waltham, MA, USA) coupled with a quaternary rapid separation pump (Ultimate autosampler) and a diode array detector (DAD). The UHPLC system was connected to an Orbitrap mass spectrometer (Thermo Fisher Scientific Inc., Waltham, MA, USA) with electrospray ionization in positive (ESI+) or negative (ESI-) mode. Compounds were eluted on an Uptisphere Strategy C18 column (250 × 4.6 mm, 5 µm; Interchim, Montluçon, France). The mobile phase consisted of a mixture of water and 0.1% (v/v) formic acid (phase A) and a mixture of acetonitrile and 0.1% (v/v) formic acid (phase B). The phase A gradient was programmed as follows: 100% (0 min), 80% (10 min), 73% (35 min), 0% (40 - 50 min), and 100% (51 - 60 min). The flow rate was 0.8 mL/min, and the injection volume was 5 µL. The spray voltage was set to 3 kV, the capillary temperature to 320°C, and the auxiliary gas temperature to 400°C, with flow rates (in arbitrary units) of 2, 50 (for nitrogen), and 10 (for sheath gas). Collision energy ranged from 10 to 50 eV. Full-scan spectra were acquired at a resolution of 70,000, and MS² spectra at a resolution of 17,500. Xcalibur software version 4.6 (Thermo Fisher Scientific Inc., MA, USA) was used for spectral processing.

2.4. Total Polyphenol Content (TPC)

Total polyphenol content was determined using the method described by Sokmen *et al.* [28], with minor modifications. 0.1 g sample of each material (leaves, trunk bark, and root bark) was dissolved in 50 mL of distilled water. A 300 µL aliquot of this solution was mixed with 1.5 mL of Folin-Ciocalteu reagent (diluted 1:10 v/v); four to five minutes later, 1.2 mL of a 7.5% (w/v) sodium carbonate solution was added. After 2 hours of incubation in the dark, absorbance was measured at 760

nm against a blank using a Jenway spectrophotometer. Experiments were performed in triplicate. A gallic acid calibration curve was used to determine total polyphenol content, expressed as milligrams of gallic acid equivalent per gram of dry matter (mg GAE/g).

2.5. Total Flavonoid Content (TFC)

Total flavonoid content was determined according to the method described by Arvouet-Grand *et al.*, with minor modifications [29]. 0.1 g sample of plant extract was dissolved in 100 mL of distilled water. Four milliliters of distilled water were added to a 1 mL aliquot of this solution. Several solutions were then added successively to the resulting mixture: at $t = 0$ minutes, 0.3 mL of sodium nitrite solution (NaNO_2 ; 5%); and after 5 minutes, 0.3 mL of aluminum chloride solution (AlCl_3 ; 10%). After 6 minutes, 2 mL of sodium hydroxide solution (NaOH ; 1 N) and, finally, 2.4 mL of distilled water were added. The mixture was then incubated for 30 minutes. Absorbance was measured at 510 nm against a blank using a Jenway UV-visible spectrophotometer. The experiments were performed in triplicate. Total flavonoid content was determined using a quercetin calibration curve and is expressed as mg quercetin equivalents per gram of dry matter (mg QE/g).

2.6. Antioxidant Activity Assay

- DPPH free radical scavenging assay

The quantitative evaluation of anti-radical activity was performed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method described by Brand-Williams *et al.* [30] and Meda *et al.* [31], with minor modifications. 300 μL of methanolic extract solutions at various concentrations (25, 50, 75, and 100 $\mu\text{g/mL}$) were mixed with 3 mL of a methanolic DPPH solution (0.18 mM, Sigma-Aldrich). Reaction kinetics were monitored for 45 minutes at 517 nm using a Jenway UV-visible spectrophotometer. Measurements were taken against a methanol blank. Ascorbic acid, used as a reference, was treated in the same manner as the extracts. Inhibition percentages (I%) were calculated using the following equation:

$$I\% = \frac{\text{Abs C} - \text{Abs E}}{\text{Abs C}} \times 100$$

The 50% inhibitory concentration was calculated based on the percentage of inhibition using the formula:

$$\text{IC}_{50} = \frac{\text{Concentration} \times 50}{I\%}$$

The experiments were repeated three times, and the results are presented as the mean $\pm$ SEM.

- Ferric Reducing antioxidant Power assay (FRAP)

The iron-reducing antioxidant power was determined using the method described by several authors, with minor modifications [32]. This method is based on the reduction of ferric iron (Fe^{3+}) in the potassium hexacyanoferrate complex

[K₃Fe(CN)₆] to ferrous iron (Fe²⁺), resulting in a color change of the solution from yellow to blue. To 0.4 mL of each sample (at 200 µg/mL), 1 mL of phosphate buffer (0.2 M; pH 6.6) and 1 mL of potassium hexacyanoferrate ([K₃Fe(CN)₆], 1%) were added. After a 30-minute incubation at 50°C in a water bath, 1 mL of trichloroacetic acid (10%) was added. The resulting mixture was centrifuged at 3000 rpm for 10 minutes; the supernatant was collected and then mixed with 0.2 mL of ferric chloride (FeCl₃, 0.1%). The resulting mixture was left to stand in the dark for 30 minutes. A blank was prepared in the same manner but without the extract. Absorbance was measured at 700 nm using a Jenway UV-visible spectrophotometer. A calibration curve for butylated hydroxyanisole (BHA) was used to determine the antioxidant power of the extracts. Experiments were performed in triplicate. Results are expressed as mg BHA equivalent/g dry matter (mg EBHA/g).

2.7. Analysis of Extracts by HPTLC-Bioautography

Analyses were performed on 20 x 10 cm glass plates coated with 0.20 mm silica gel 60 (Merck, Darmstadt, Germany). The equipment used included a CAMAG HPTLC system (Muttens, Switzerland) equipped with an automatic TLC sampler (ATS4), an automatic developing chamber (ADC2) with humidity control, a TLC visualizer, a CID III plate immersion device (for derivatization), and a heating plate. Vision CATS software was used for data processing. Extract solutions were prepared in HPLC-grade methanol at a concentration of 5 mg/mL. The elution system consisted of: dichloromethane/ethyl acetate/formic acid/acetic acid/water (25:100:10:10:11 v/v/v/v/v). After elution, the plates were immersed in solutions of the derivatizing agents NP (1 g in 150 mL of ethyl acetate) and PEG 400 (5 g in 150 mL of ethyl acetate), then dried at 120°C and visualized under UV light at 254 nm and 366 nm. A separate plate was prepared using the same procedure but was derivatized with a DPPH· solution (50 mg of DPPH· in 150 mL of methanol).

3. Results and Discussion

3.1. Yield

The extracts were obtained by maceration of the plant material in methanol. The extraction yields obtained were 12.68 ± 0.07 , 4.46 ± 0.02 , and 13.17 ± 0.06 for the leaves, trunk, and roots, respectively (Table 1). The roots yielded the highest return compared to the other plant parts. Other authors reported a yield of 21.0% for the trunk, which is significantly higher than our results [33]. Similarly, Isa *et al.* [34] obtained a much lower yield for the leaves (3.47%) compared to our study.

3.2. Total Polyphenol and Total Flavonoid Contents

Phenolic compounds, particularly flavonoids, are considered an important class of phytochemicals. They are widely distributed in plants. Flavonoids are known for their numerous pharmacological properties [35]. Indeed, they can neutralize free radicals, thereby exhibiting antioxidant activity [36]. Figure 1 presents the total polyphenol and total flavonoid contents of the various parts of *Nauclea di-*

derichii. The assay results are summarized in **Table 1**. Regarding total polyphenols, the content obtained were 270.68 ± 0.04 mg GAE/g, 131.95 ± 0.08 mg GAE/g, and 244.26 ± 0.01 mg GAE/g for the leaves, stem, and roots, respectively. The leaves were richest in total polyphenols, followed by the roots. Regarding flavonoids, the contents obtained were 142.27 ± 0.05 mg QE/g, 46.3 ± 0.04 mg QE/g, and 120.72 ± 0.01 mg QE/g for the leaves, stem, and roots, respectively. As with the total polyphenol assay, the leaves were rich in total flavonoids.

Table 1. Extraction yields from different parts of *Nauclea diderichii*.

Organs	Yield (%)	TPC ^a	TFC ^b	DPPH ^c	FRAP ^d
Leave	12.68 ± 0.07	270.68 ± 0.04	142.27 ± 0.05	90.90 ± 0.03	814.25 ± 0.08
Trunk	4.46 ± 0.02	131.95 ± 0.08	46.3 ± 0.04	-	-
Roots	13.17 ± 0.06	244.26 ± 0.01	120.72 ± 0.01	92.16 ± 0.04	723.36 ± 0.03
Ascorbic acid= 51.65 ± 0.01				-	-

^aExpressed as mg gallic acid equivalents/g of dry plant material (mg GAEs/g); ^bExpressed as mg quercetin equivalents/g of dry plant material (mg QEs/g); ^cExpressed as $\mu\text{g/mL}$; ^dExpressed as mg butylhydroxyanisole equivalents/g of dry plant material (mg BHAs/g).

3.3. Chemical Profiles

LC-MS analysis in negative ESI mode of the leaves, trunk, and roots of *Nauclea diderichii* enabled the detection of several phytochemical compounds. All identified compounds are listed in **Table 2**. The compounds were identified based on experimentally obtained fragment ions by comparing them with fragment ions from laboratory and online databases. The chemical profile of the leaves (**Figure 1(A)**) shows the following compounds: chlorogenic acid, protocatechuic acid, glucose, mannitol, quinic acid, citric acid, and lophirone A. In the stem (**Figure 1(B)**), glucose, glucuronic acid, galactonic acid, quinic acid, caffeic acid, quinovic acid, emmolic acid, and quafrinoic acid were found. In the root extract, glucose, quinic acid, rhyncoside B, quinovic acid, and emmolic acid were identified (**Figure 1(C)**).

Table 2. Phytochemical composition of methanolic extracts from the leave, trunk, and roots of *Nauclea diderichii*.

N°	Rt (min)	Compound	Formula	M-H _{exp} (m/z)	MS ² experimental (m/z)	MS ² theoric (m/z)	Leave	Trunk	Root	Reference
1	3.19	Glucose	C ₆ H ₁₂ O ₆	179.0556	-	-	+	+	+	Standard
2	3.22	Mannitol	C ₆ H ₁₄ O ₆	181.0712	181/101/89/59/71/163	58/181/101/89/59/163/71	+	-	-	[48]
3	3.32	Gluconic acid	C ₆ H ₁₂ O ₇	195.0505	195/75/129/89/87	129/89/87/85/75	-	+	-	MassBank
4	3.45	Glucuronic acid	C ₆ H ₁₀ O ₇	193.0348	103/59/193/71/89	113/89/59/103/193	-	+	-	MassBank
5	3.81	Quinic acid	C ₇ H ₁₂ O ₆	191.0556	191/173/155/127/85	191/127/93/85	+	+	+	Standard
6	7.02	Citric acid	C ₆ H ₈ O ₇	191.0192	191/155/131/129	191/129/111/87/85	+	-	-	Standard
7	11.4	Protocatechuic acid	C ₇ H ₆ O ₄	153.0188	109/153/135	109/153/110	+	-	-	[27]

Continued

8	12.94	Chlorogenic acid	C ₁₆ H ₁₈ O ₉	353.0873	191/353/274	191/353/85/161	+	-	-	Standard
9	14.28	Rhyncoside B	C ₁₉ H ₂₈ O ₁₃	463.1452	59/89/241/127/179	-	-	-	+	[49]
10	14.68	Caffeic acid	C ₉ H ₈ O ₄	179.0344	135/179/134/107/117	161/135	-	+	-	[50]
11	39.45	Lophirone A	C ₂₄ H ₁₆ O ₉	447.0716	447/295/251/151	447/295	+	-	-	[37]
12	40.56	Quinovic acid	C ₄₂ H ₆₆ O ₁₄	793.4374	587/793/455/749/441	-	-	+	+	[15]
13	41.32	NI	C ₃₉ H ₅₄ O ₆ N	631.3873	587/631/341/160	-	-	-	+	-
14	42.12	Emmolic acid	C ₃₀ H ₄₆ O ₅	485.3267	441/485/340/136	467/423/60	-	+	+	[43]
15	42.53	Quafrinoic acid	C ₃₀ H ₄₄ O ₅	483.3110	439/483/393/285	483	-	+	-	[51]

+: presence of the compound in the extract; -: absence of the compound in the extract.

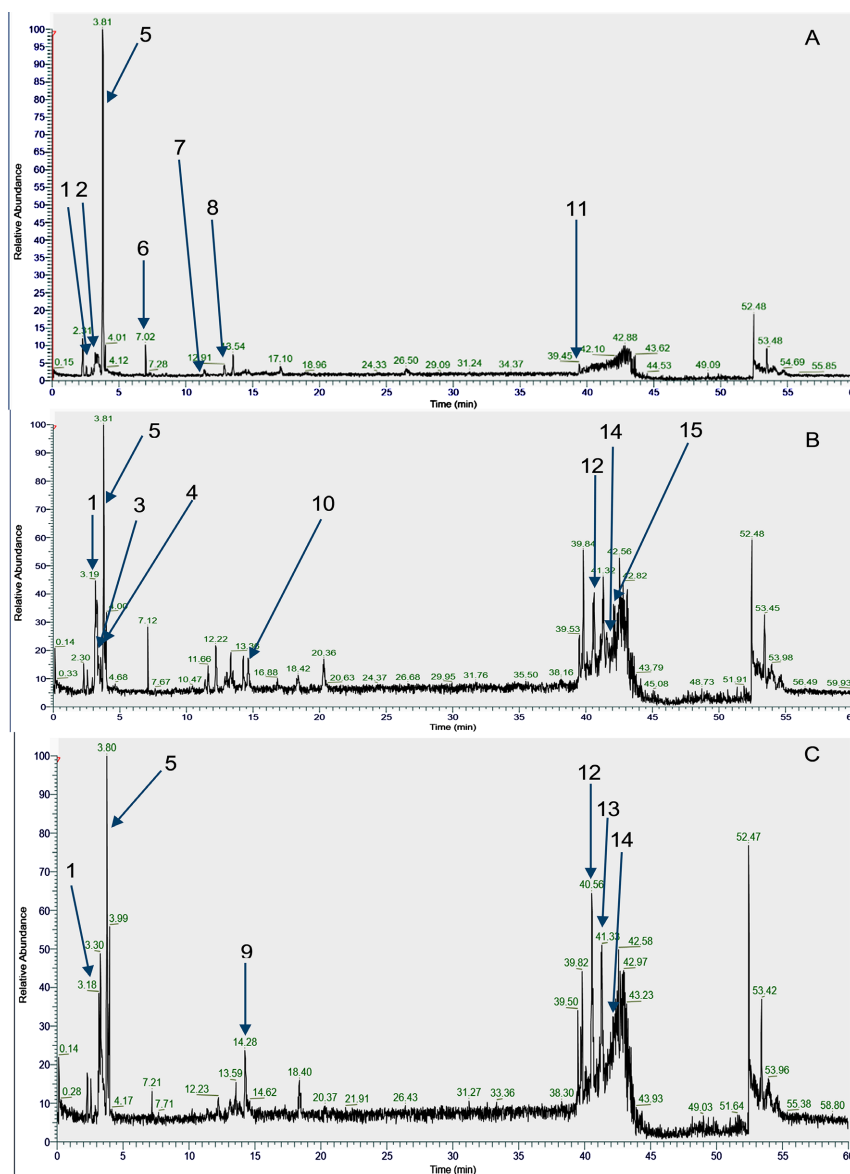


Figure 1. Chemical profiles of *Nauclea diderichii* extracts, Leaves (A), trunk (B), Root (C).

Analysis of the results shows that the leaves extract is rich in constituents commonly found in plant extracts, except for lophirone A, a biflavonoid isolated from the species *Lophira lanceolata* [37]. Regarding the stem and root extracts, triterpenoid compounds predominate (See **Table 2**). These compounds have previously been identified in extracts of *N. diderrichii* and other *Nauclea* species [18] [38]. Indeed, quinovic acid and quafrinoic acid have been identified in the trunk bark of *N. diderrichii* acclimatized in Gabon and Nigeria [16] [17] [39]. Quinovic acid has also been identified in the root bark of *N. pobeguinii* acclimatized in the Democratic Republic of the Congo [40]. Emmolic acid has been identified in extracts of *Ziziphus jujuba* var. *spinosa* [41] and *Emmenospermum alphonoides* [42]. Quafrinoic acid has been isolated from *N. pobeguinii* [43], *N. xanthoxylon* [44], and *Quassia africana* [45]. Several alkaloids have been isolated and identified in extracts of *N. diderrichii* [46] [47]. The phytochemical diversity observed in *Nauclea* species, particularly *N. diderrichii*, may explain their multiple pharmacological properties. The structures of the main compounds identified in the various extracts are shown in **Figure 2**.

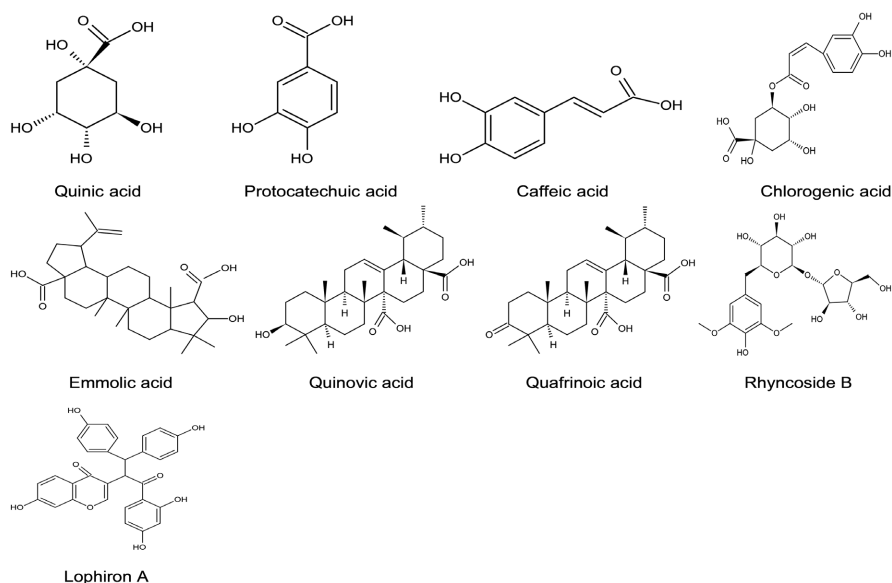


Figure 2. Main compounds identified in the methanolic extracts of organs of *Nauclea diderrichii*.

3.4. Antioxidant Activity

The antioxidant activity of the extracts was evaluated using two methods: DPPH free radical scavenging and iron reduction. Results were compared to those of ascorbic acid for the DPPH method. For the FRAP method, results were expressed based on a butylhydroxyanisole calibration curve. Analysis of the results shows that the leaf extract ($IC_{50} = 90.90 \pm 0.03 \mu\text{g/mL}$) is slightly more active than the root extract ($IC_{50} = 92.16 \pm 0.04 \mu\text{g/mL}$), regardless of the method used (**Table 1**). These results align with the total polyphenol and total flavonoid contents; indeed, the leaves and root extracts with higher total polyphenol and total flavonoid levels

exhibited the highest activity. Several studies have highlighted the antioxidant potential of *Nauclea diderrichii* extracts [52] [53]. The compounds present in the leaves, and root extracts are likely responsible for this antioxidant activity. Phenolic acids such as quinic, chlorogenic, protocatechuic, and caffeic acids, which predominate in the leaves extract are thought to contribute to the antioxidant potential of the various extracts [43] [54] [55]. The antioxidant potential observed with the root extract is likely attributable to the presence of triterpene acids, specifically quinovic acid [56] and emmolic acid [57].

3.5. HPTLC-Bioautography of the Extracts

The use of high-performance thin-layer chromatography (HPTLC) combined with NP/PEG and DPPH is an approach that enables the rapid determination of the phytochemical profile and the individual contribution of constituents to the biological potential of a plant matrix [58]. **Figure 3** presents the results obtained from the analysis of leaves, trunk bark, and root extracts of *N. diderrichii*. Analysis of **Figure 3(A)** shows that all extracts visualized at 366 nm exhibit nearly identical phytochemical profiles, characterized by the presence of light blue, dark blue, and brown, fluorescent bands typical of phenolic compounds, particularly flavonoids. Additionally, bright red, fluorescent bands are observed in the leaf extract, likely indicating the presence of plant pigments. Analysis of **Figure 3(B)**, following derivatization with DPPH, reveals stronger antioxidant potential in the leaf and root extracts, characterized by yellow bands against a purple background.

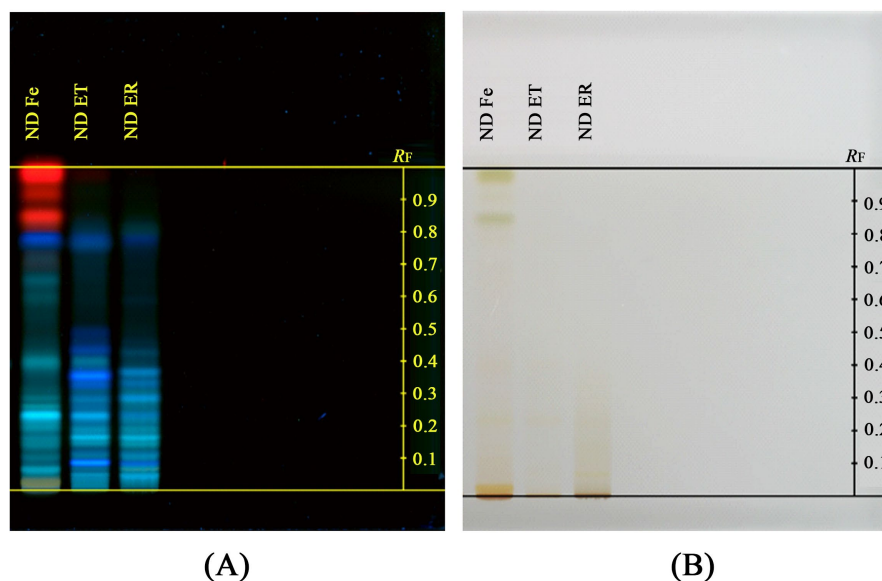


Figure 3. HPTLC analysis with derivatization using NP/PEG at 366 nm (A) and DPPH under white light (B).

4. Conclusion

The aim of this study was to determine the chemical profiles and evaluate the antioxidant potential of methanolic extracts from various parts of *Nauclea di-*

derrichii, a species endemic to Republic of the Congo. The results indicate higher yields for the leaves and roots. Both plant parts are also rich in total polyphenols and total flavonoids. Analysis of the chemical profiles reveals that the leaves are rich in phenolic acids, whereas the trunk and roots are rich in triterpene compounds, specifically emmolic, quafrinoic, and quinovic acids. Extracts from the leaves and roots demonstrated significant antioxidant potential, characterized by low inhibitory concentrations. These findings could substantiate the numerous uses of *Nauclea diderrichii* in traditional African phytotherapy. Consequently, it would be worthwhile investigating other pharmacological activities of these extracts, particularly their anti-inflammatory, anticancer, antidiabetic, and antimicrobial properties.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Ridsdale, C.E. (1975) A Synopsis of the African and Madagascan Rubiaceae—Naucleaeae. *Blumea*, **22**, 541-553.
- [2] Ridsdale, C.E. (1978) A Revision of the Tribe Naucleaeae s.s. (Rubiaceae). *Blumea*, **24**, 307-366.
- [3] Löfstrand, S.D., Krüger, Å., Razafimandimbison, S.G. and Bremer, B. (2014) Phylogeny and Generic Delimitations in the Sister Tribes Hymenodictyeae and Naucleaeae (Rubiaceae). *Systematic Botany*, **39**, 304-315.
<https://doi.org/10.1600/036364414x678116>
- [4] Badiaga, M. (2011) Etude ethnobotanique, phytochimique et activités biologiques de *Nauclea latifolia* Smith, une plante médicinale africaine récoltée au Mali, Université Blaise Pascal-Clermont-Ferrand II.
- [5] Gidado, A., Ameh, D.A., Atawodi, S.E. and Ibrahim, S. (2012) A Preliminary Study of the Mechanism of Hypoglycaemic Activity of *Nauclea latifolia* Leaf Ethanolic Extract. *Journal of Complementary and Integrative Medicine*, **9**, 1-9.
<https://doi.org/10.1515/1553-3840.1561>
- [6] Boucherle, B., Haudecoeur, R., Queiroz, E.F., De Waard, M., Wolfender, J., Robins, R.J., *et al.* (2016) *Nauclea latifolia*: Biological Activity and Alkaloid Phytochemistry of a West African Tree. *Natural Product Reports*, **33**, 1034-1043.
<https://doi.org/10.1039/c6np00039h>
- [7] Iheagwam, F.N., Israel, E.N., Kayode, K.O., DeCampos, O.C., Ogunlana, O.O. and Chinedu, S.N. (2020) *Nauclea latifolia* sm. Leaf Extracts Extenuates Free Radicals, Inflammation, and Diabetes-Linked Enzymes. *Oxidative Medicine and Cellular Longevity*, **2020**, 1-13. <https://doi.org/10.1155/2020/5612486>
- [8] Gamaniel, K. (2009) A Comparative Randomized Clinical Trial of NIPRD AM1 against a Chloroquine and Sulfadoxine/Pyrimethamine Combination in Symptomatic but Uncomplicated Malaria. *African Journal of Traditional, Complementary and Alternative Medicines*, **6**, 411-412.
- [9] Pousset, J.L. (2006) Place des médicaments traditionnels en Afrique. *Médecine Tropicale*, **66**, 606-609.
- [10] Memvanga, P.B., Tona, G.L., Mesia, G.K., Lusakibanza, M.M. and Cimanga, R.K.

- (2015) Antimalarial Activity of Medicinal Plants from the Democratic Republic of Congo: A Review. *Journal of Ethnopharmacology*, **169**, 76-98.
<https://doi.org/10.1016/j.jep.2015.03.075>
- [11] Mesia, K., Cimanga, K., Tona, L., Mampunza, M., Ntamabyaliro, N., Muanda, T., *et al.* (2011) Assessment of the Short-Term Safety and Tolerability of a Quantified 80% Ethanol Extract from the Stem Bark of *Nauclea pobeguinii* (PR 259 CT1) in Healthy Volunteers: A Clinical Phase I Study. *Planta Medica*, **77**, 111-116.
<https://doi.org/10.1055/s-0030-1250134>
- [12] Mesia, K., Tona, L., Mampunza, M., Ntamabyaliro, N., Muanda, T., Muyembe, T., *et al.* (2012) Antimalarial Efficacy of a Quantified Extract of *Nauclea pobeguinii* Stem Bark in Human Adult Volunteers with Diagnosed Uncomplicated *Falciparum Malaria*. Part 1: A Clinical Phase IIA Trial. *Planta Medica*, **78**, 211-218.
<https://doi.org/10.1055/s-0031-1280359>
- [13] Mesia, K., Tona, L., Mampunza, M., Ntamabyaliro, N., Muanda, T., Muyembe, T., *et al.* (2012) Antimalarial Efficacy of a Quantified Extract of *Nauclea pobeguinii* Stem Bark in Human Adult Volunteers with Diagnosed Uncomplicated *Falciparum Malaria*. Part 2: A Clinical Phase IIB Trial. *Planta Medica*, **78**, 853-860.
<https://doi.org/10.1055/s-0031-1298488>
- [14] Opuni-Frimpong, N.Y. and Opuni-Frimpong, E. (2012) *Nauclea diderrichii* (De Wild. Et T. Durang) Merr. Prot. (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Pays Bas.
- [15] Lamidi, M., Ollivier, E., Faure, R., Debrauwer, L., Nze-Ekekang, L. and Balansard, G. (1995) Quinovic Acid Glycosides from *Nauclea diderrichii*. *Phytochemistry*, **38**, 209-212. [https://doi.org/10.1016/0031-9422\(94\)00566-c](https://doi.org/10.1016/0031-9422(94)00566-c)
- [16] Lamidi, M., Gasquet, M., Ollivier, E., Nze-Ekekang, L., Balansard, G. and Boudon, G. (1996) Antiparasitic Studies of *Nauclea diderrichii* Bark. *Pharmaceutical and Pharmacological Letters*, **6**, 31-33.
- [17] Di Giorgio, C., Lamidi, M., Delmas, F., Balansard, G. and Ollivier, E. (2006) Antileishmanial Activity of Quinovic Acid Glycosides and Cadambine Acid Isolated from *Nauclea diderrichii*. *Planta Medica*, **72**, 1396-1402.
<https://doi.org/10.1055/s-2006-951726>
- [18] Mbuta, K., Mwima, K., Bitengeli, M., Y'okolo, I., Kavuna, M., Mandanga, M., Kalam-bayi, M., Izamajole, N., Kazembe, K., *et al.* (2012) Plantes médicinales de traditions Province de l'Equateur—R.D.C. Institut de Recherche en Sciences de la Santé.
- [19] Mbiantcha, M., Djami, M.B., Ateufack, G., Atsamo, D.A., Tsafack, G.E., Yousseu, W.N., *et al.* (2020) Anti-Inflammatory and Anti-Arthritic Properties of Aqueous Extract of *Nauclea diderrichii* (Rubiaceae) Stem Bark in Rats. *Advances in Traditional Medicine*, **20**, 199-212. <https://doi.org/10.1007/s13596-020-00446-6>
- [20] Nwodo, N. and Agbo, M. (2010) Antitrypanosomal Effects of Methanolic Extracts of *Nauclea diderrichii* (Merr.) and *Spathodea campanulata* Stem Bark. *Journal of Pharmaceutical and Allied Sciences*, **7**, 1219-1227.
<https://doi.org/10.4314/jophas.v7i5.63466>
- [21] Alqasim, A.M., Gabriel, O. and Is-Haq, I.U. (2013) Plant Remedies Practiced by Keffi People in the Management of Dermatitis. *Journal of Medicinal Plants Studies*, **1**, 112-118.
- [22] Haudecoeur, R., Peuchmaur, M., Pérès, B., Rome, M., Taiwe, G.S., Boumendjel, A., *et al.* (2018) Traditional Uses, Phytochemistry and Pharmacological Properties of African *Nauclea* Species: A Review. *Journal of Ethnopharmacology*, **212**, 106-136.
<https://doi.org/10.1016/j.jep.2017.10.011>

- [23] Betti, J.L. (2004) Impact of Forest Logging in the Dja Biosphere Reserve, Cameroon. Ministry of Environment and Forestry, Cameroon. *Journal of Pharmaceutical and Allied Sciences*, 1219-1227.
- [24] Yetein, M.H., Houessou, L.G., Lougbégnon, T.O., Teka, O. and Tente, B. (2013) Ethnobotanical Study of Medicinal Plants Used for the Treatment of Malaria in Plateau of Allada, Benin (West Africa). *Journal of Ethnopharmacology*, **146**, 154-163. <https://doi.org/10.1016/j.jep.2012.12.022>
- [25] Ndenecho, E.N. (2009) Herbalism and Resources for the Development of Ethnopharmacology in Mount Cameroon Region. *African Journal of Pharmacy and Pharmacology*, **3**, 78-86.
- [26] Aderibigbe, S.A., Oyeniran, O.S. and Idowu, S.O. (2020) Anthelmintic Activity of *Nauclea diderrichii* Leaf Extracts and Fractions against Adult Haemonchus Placei. *Nigerian Journal of Pharmaceutical Research*, **16**, 81-86. <https://doi.org/10.4314/njpr.v16i1.9>
- [27] Bounvou-Tsona, G., Gainche, M., Decombat, C., Ripoché, I., Bikindou, K., Delort, L., et al. (2023) Chemical Profile, Antioxidant and Anti-Inflammatory Potency of Extracts of Vitex Madiensis Oliv. and Crossopteryx Febrifuga (afzel Ex G. Don). *Plants*, **12**, Article 386. <https://doi.org/10.3390/plants12020386>
- [28] Sokmen, M., Angelova, M., Krumova, E., Pashova, S., Ivancheva, S., Sokmen, A., et al. (2005) In Vitro Antioxidant Activity of Polyphenol Extracts with Antiviral Properties from *Geranium sanguineum* L. *Life Sciences*, **76**, 2981-2993. <https://doi.org/10.1016/j.lfs.2004.11.020>
- [29] Arvouet-Grand, A., Vennat, B., Pourrat, A. and Legret, P. (1994) Standardisation d'un extrait de propolis et identification des principaux constituants. *Journal de Pharmacie de Belgique*, **49**, 462-468.
- [30] Brand-Williams, W., Cuvelier, M.E. and Berset, C. (1995) Use of a Free Radical Method to Evaluate Antioxidant Activity. *LWT—Food Science and Technology*, **28**, 25-30. [https://doi.org/10.1016/s0023-6438\(95\)80008-5](https://doi.org/10.1016/s0023-6438(95)80008-5)
- [31] Meda, N.R., Fraisse, D., Gnoula, C., Vivier, M., Felgines, C. and Senejoux, F. (2017) Characterization of Antioxidants from Detarium Microcarpum Guill. et Perr. Leaves Using HPLC-DAD Coupled with Pre-Column DPPH Assay. *European Food Research and Technology*, **243**, 1659-1666. <https://doi.org/10.1007/s00217-017-2873-7>
- [32] Oyaizu, M. (1986) Studies on Products of Browning Reaction. Antioxidative Activities of Products of Browning Reaction Prepared from Glucosamine. *The Japanese Journal of Nutrition and Dietetics*, **44**, 307-315. <https://doi.org/10.5264/eiyogakuzashi.44.307>
- [33] Ipona, N.E., Kamalandua, M.B., Mawete, D.T., Mavinga, M.B., Ngbolua, K.P., Boloweti, B.D., Lituli, B.T., Nkongolo, K.C., Liyongo, I.C. and Kalulu, T. (2023) Screening phytochimique, activités anti-radicalaire et cytotoxique des extraits de quatre plantes utilisées dans la prise en charge de la dysfonction érectile à Mbandaka, République démocratique du Congo. *Journal of Applied Biosciences*, **185**, 19504-19523.
- [34] Isa, H., Katsayal, U.A., Agunu, A., Nuhu, A. and Abdulhamid, Z. (2017) Phytochemical Screening and Thin Layer Chromatographic Profile of *Nauclea diderrichii* Leaf Extracts. *Bayero Journal of Pure and Applied Sciences*, **10**, 281-284. <https://doi.org/10.4314/bajopas.v10i1.42>
- [35] Bruneton, J. (1999) Pharmacognosie, phytochimie, plantes médicinales. 3ème édition, Tec & Doc—Lavoisier, 915 p.
- [36] Tessema, F.B., Gonfa, Y.H., Asfaw, T.B., Tadesse, T.G., Tadesse, M.G., Bachheti, A.,

- et al.* (2023) Flavonoids and Phenolic Acids from Aerial Part of *Ajuga integrifolia* (Buch.-Ham. Ex D. Don): Anti-Shigellosis Activity and in Silico Molecular Docking Studies. *Molecules*, **28**, Article 1111. <https://doi.org/10.3390/molecules28031111>
- [37] Ghogomu, R., Sondengam, B.L., Martin, M.T. and Bodo, B. (1987) Lophirone A, a Biflavonoid with Unusual Skeleton from *Lophira lanceolata*. *Tetrahedron Letters*, **28**, 2967-2968. [https://doi.org/10.1016/s0040-4039\(00\)96256-7](https://doi.org/10.1016/s0040-4039(00)96256-7)
- [38] Agnani, H., Mbot, E.J., Keita, O., Fehrentz, J., Ankli, A., Gallud, A., *et al.* (2016) Antidiabetic Potential of Two Medicinal Plants Used in Gabonese Folk Medicine. *BMC Complementary and Alternative Medicine*, **16**, Article No. 71. <https://doi.org/10.1186/s12906-016-1052-x>
- [39] Adeoye, A.O. and Waigh, R.D. (1983) Secoiridoid and Triterpenic Acids from the Stems of *Nauclea diderrichii*. *Phytochemistry*, **22**, 975-978. [https://doi.org/10.1016/0031-9422\(83\)85034-1](https://doi.org/10.1016/0031-9422(83)85034-1)
- [40] Zeches, M., Richard, B., Gueye-M'Bahia, L., Le Men-Olivier, L. and Delaude, C. (1985) Constituents des Ecorces de Racine de *Nauclea pobeguinii*. *Journal of Natural Products*, **48**, 42-46. <https://doi.org/10.1021/np50037a007>
- [41] Song, X., Zhang, Y. and Zhang, L. (2025) Comprehensive Chemical Composition Evaluation of *Ziziphus Jujuba* Var. *Spinosa* Germplasm Resources and Selection of Elite Cultivars for Seed, Pulp, and Leaf Utilization. *Molecules*, **30**, Article 4470. <https://doi.org/10.3390/molecules30224470>
- [42] Boyer, J.P., Eade, R.A., Locksley, H. and Simes, J.J.H. (1957) Extractives of Australian Timbers. II. Emmolic Acid, a New Triterpene Acid from *Emmenospermum alphonoides* F. Muell. *Australian Journal of Chemistry*, **11**, 236-245. <https://doi.org/10.1071/ch9580236>
- [43] Bankeu, J.J.K., Madjouka, S., Feuya, G.R.T., Fongang, Y.S.F., Siddiqui, S., Ali, I., *et al.* (2018) Pobeguinine: A Monoterpene Indole Alkaloid and Other Bioactive Constituents from the Stem Bark of *Nauclea pobeguinii*. *Zeitschrift für Naturforschung C*, **73**, 335-344. <https://doi.org/10.1515/znc-2017-0127>
- [44] Nangmou, B.M.N., Djomkam, H.L.M., Tabekoueng, G.B., *et al.* (2023) Bioguided Fractionation and Isolation of an Antiplasmodial Saponin from the Roots of *Nauclea xanthoxylon* (A.Chev.) Aubrév. *Chem Biodivers*, **8**, e202200271.
- [45] Ajaiyeoba, E. and Krebs, H. (2003) Quafrinoic Acids: Two New Triterpenoids from *Quassia Africana* Stem Bark. *Nigerian Journal of Natural Products and Medicine*, **7**, 39-41. <https://doi.org/10.4314/njnp.v7i1.11704>
- [46] Dmitrienko, G.I., Szokolcai, A. and MC Lean, S. (1974) Constituents of *Nauclea diderrichii*: Naucleonine and Naucleonidine. *Tetrahedron Letters*, **15**, 2599-2602. [https://doi.org/10.1016/s0040-4039\(01\)92303-2](https://doi.org/10.1016/s0040-4039(01)92303-2)
- [47] Stewart, M.L. and Murray, D.G. (1972) The Constituents of *Nauclea diderrichii*. Part II. Isolation and Classification of Constituents; Simple β -Carboline and Pyridine Alkaloids. *Canadian Journal of Chemistry*, **50**, 1478-1485.
- [48] Rashwan, R.T., Moustafa, A.M.Y., Taie, H.A.A. and Marzouk, M. (2024) *Codiaeum variegatum* Zanzibar (Pictum Spot): LC-MS/MS Phytochemical Profile and *in Vitro* Antioxidant and Antitumor Activities. *Egyptian Journal of Chemistry*, **67**, 339-357.
- [49] Bao, S., Ding, Y., Deng, Z., Proksch, P. and Lin, W. (2007) Rhyncosides A-F, Phenolic Constituents from the Chinese Mangrove Plant *Bruguiera sexangula* var. *Rhynchopetala*. *Chemical & Pharmaceutical Bulletin*, **55**, 1175-1180. <https://doi.org/10.1248/cpb.55.1175>
- [50] Ali, A., Cottrell, J.J. and Dunshea, F.R. (2022) LC-MS/MS Characterization of Phe-

- nolic Metabolites and Their Antioxidant Activities from Australian Native Plants. *Metabolites*, **12**, Article 1016. <https://doi.org/10.3390/metabo12111016>
- [51] Bankeu Kezetas, J.J., Dietagoum Madjouka, S., Kumar, R., Ali, M.S., Lenta Njakou, B. and Yousuf, S. (2017) Crystal Structure and Hirshfeld Surface Analysis of 3-Oxours-12-Ene-27a,28-Dioic Acid (Quafrinoic Acid). *Acta Crystallographica Section E: Crystallographic Communications*, **73**, 763-766. <https://doi.org/10.1107/s2056989017006077>
- [52] Mensah, J.K., Sala, A. and Jibira, Y. (2022) Methanolic Extract of *Nauclea diderrichii* (Stem-Bark) Show Anti-Microbial, Anti-Oxidant and Anti-Inflammatory Bioactivities. *International Journal of Biological and Chemical Sciences*, **16**, 73-87. <https://doi.org/10.4314/ijbcs.v16i1.7>
- [53] Sidiq, L., Segun, P. and Ogbole, O. (2018) Total Phenolic Contents and Antioxidant Activity of Nine Medicinal Plants Used in Nigerian Traditional Medicine. *Tropical Journal of Natural Product Research*, **2**, 438-441. <https://doi.org/10.26538/tjnpr/v2i9.6>
- [54] Marinova, E.M., Toneva, A. and Yanishlieva, N. (2009) Comparison of the Antioxidative Properties of Caffeic and Chlorogenic Acids. *Food Chemistry*, **114**, 1498-1502. <https://doi.org/10.1016/j.foodchem.2008.11.045>
- [55] Bagues, M., Zaghdoud, C. and Nagaz, K. (2018) Composés phénoliques, activités antioxydantes et rendement en grains de l'orge (*Hordeum vulgare* L.) "Ardhaoui" sous irrigation déficitaire à l'eau salée dans le Sud tunisien. 6ème Meeting International sur l'Aridoculture et les Cultures Oasiennes, Zarzis, 19-21 December 2018, 1-10.
- [56] Khayam, A.U., Patel, H., Faiola, N.A., Figueroa Milla, A.E., Dilshad, E., Mirza, B., et al. (2020) Quinovic Acid Purified from Medicinal Plant *Fagonia indica* Mediates Anticancer Effects via Death Receptor 5. *Molecular and Cellular Biochemistry*, **474**, 159-169. <https://doi.org/10.1007/s11010-020-03841-4>
- [57] Tang, Y., Liu, J.X., Zhang, Q. and Zhang, J. (2024) Bioactivity, Pharmacological Research, and Application of Birch Fungus. *MOJ Food Processing & Technology*, **12**, 175-176. <https://doi.org/10.15406/mojfpt.2024.12.00316>
- [58] Islam, M.K., Sostaric, T., Lim, L.Y., Hammer, K. and Locher, C. (2021) Antioxidant HPTLC-DPPH Fingerprinting of Honeys and Tracking of Antioxidant Constituents Upon Thermal Exposure. *Foods*, **10**, Article 357. <https://doi.org/10.3390/foods10020357>