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Valorization of angolan native plants: Nutritional composition, phenolic profile and bioactive potential of *Commelina africana, Dombeya rotundifolia* and *Lablab purpureus* leaves

Claudete Bastos [a,b], Ângela Liberal [a], Tayse F.F. da Silveira [a,*], Isabel C.F.R. Ferreira [a], Carla Pereira [a], Tânia S.S.P. Pires [a], Filipa Mandim [a], Margarida Moldão [c], Luís Catarino [d], Lillian Barros [a]

[a] CIMO, LA SusTEC, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
[b] ISPCS - Instituto Superior Politécnico do Cuanza Sul, Rua 12 de Novembro (P. O. Box 82), Sumbe, Angola
[c] LEAF - Linkink Landscape Environment Agriculture and Food, Associated Laboratory TERRA, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal
[d] cE3c - Centre for Ecology, Evolution and Environmental Changes & CHANGE - Global Change and Sustainability Institute, Faculty of Sciences, University of Lisbon, 1749-016 Lisboa, Portugal

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ABSTRACT

Commelina africana L., *Dombeya rotundifolia* (Hochst.) Planch. and *Lablab purpureus* (L.) Sweet are wild edible plants (WEPs) native to Africa, traditionally used in rural Angolan communities. This study characterizes their nutritional, chemical, and bioactive properties, with carbohydrates and proteins predominating as macronutrients across all species. Monounsaturated and polyunsaturated fatty acids were most abundant in *D. rotundifolia* and *C. africana*. Phenolic profiling revealed that *C. africana* was mainly characterized by *p*-coumaroyl malic acid and caffeoyl shikimic acid, whereas *D. rotundifolia* contained majorly flavan-3-ols, including epicatechin and B-type procyanidin oligomers. In contrast, *L. purpureus* exhibited the highest total phenolic content overall. The hydroethanolic extract of *D. rotundifolia* exhibited the highest efficacy against foodborne and clinical bacteria and inhibition of cancer cell proliferation. This integrated characterization demonstrates that these underutilized WEPs offer substantial dual nutritional and bioactive value, supporting their traditional use and potential for nutraceuticals and food applications.

1. Introduction

Exploring natural matrices rich in nutrients and bioactive compounds remains a topic of paramount scientific relevance, as their comprehensive profiling can benefit rural communities facing food insecurity and contribute to global health strategies. Native wild edible plants (WEPs) in Angola represent a sustainable resource, particularly amid projected population growth and nutritional vulnerabilities in sub-Saharan Africa (Catarino et al., 2019; Heinze et al., 2019a; Kissanga et al., 2021; Urso et al., 2016). These underutilized WEPs are particularly valuable for food security in rural Angolan communities, where they provide nutrient-dense, locally abundant alternatives during periods of crop scarcity and food shortages.

In this context, *Commelina africana* L., *Dombeya rotundifolia* (Hochst.) Planch. and *Lablab purpureus* (L.) Sweet are native African species whose leaves are commonly consumed as vegetables by communities living near the Cumbira Forest Reserve, in Cuanza Sul Province. They are typically boiled or braised, either alone or mixed with other ingredients, and served as accompaniments to staple foods (African Plant Database, 2024; *POWO - Plants of the World Online*, 2022). In addition to their dietary use, the leaves are also used as animal fodder, while other parts of these plants are widely employed in traditional African medicine (Kibungu Kembelo et al., 2023; Maroyi, 2018; Sulaiman and Lawal, 2018).

C. africana (Fig. 1**A**) is a widely distributed herb that has long been used in traditional medicine, particularly for the treatment of skin ailments (Kudumela and Masoko, 2018). Recent phytochemical studies have identified several bioactive compounds, including flavonoids,

* Corresponding author.
E-mail address: tayse.silveira@ipb.pt (T.F.F. da Silveira).

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phenolic acids, and hydroxycinnamic acids, which show promising antioxidant and antimicrobial properties (Dagne et al., 2024). *Dombeya rotundifolia* (Fig. 1**B**), a small tree from Malvaceae family, is also widely used across tropical Africa, where its leaves are traditionally employed to treat conditions such as headaches, pneumonia, and hypertension. Previous phytochemical screenings of *Dombeya* spp. have identified phenolics, flavonoids cardiac glycosides, fatty acids, flavonoids, iridoids, phenolic acids, saponins, steroids, tannins, and terpenoids in bark and roots, linked to antioxidant and antimicrobial effects (Kudumela and Masoko, 2018; Maroyi, 2018; Reid et al., 2005). Additionally, pharmacological studies of leaves extracts have demonstrated several biological properties, including anthelmintic, antihypertensive, acetylcholinesterase inhibitory, anti-inflammatory, antimicrobial, antioxidant, and cytotoxic activities (Amoo et al., 2012; Kudumela, 2017; Mkhize et al., 2018). *Lablab purpureus* (Fig. 1**C**), a nutrient-rich legume from Fabaceae family, is valued for its nutritional profile, especially its edible pods and seeds (Kankwatsa and Muzira, 2018). Although primarily cultivated for its edible grain, its aerial parts are also widely used as animal feed due to their richness in essential nutrients and minerals. In addition to their nutritional value, studies have shown that crude extracts from the aerial parts contain numerous bioactive secondary metabolites, such as saponins, flavonoids, tannins, steroids, alkaloids, coumarins, phenolic acids, and terpenoids. These extracts have shown to possess a range of biological activities, including antimicrobial, anti-inflammatory, antioxidant, and cytotoxic effects (Adeleke et al., 2012; Al-Snafi, 2017; Sulaiman and Lawal, 2018). More recently, a study by Bhat et al. (2025) highlighted the presence of flavonoids such as luteolin and apigenin, as well as the potential anticancer activity of compounds identified in the seeds.

Despite these advances, a comprehensive study on the nutritional, phytochemical profile and bioactive assessment of these species, particularly from Angolan varieties, remain unexplored. Therefore, to valorize these underutilized WEPs and their contribution to Angolan food security, this study aimed to perform the first integrated characterization of the leaves of *Commelina africana, Dombeya rotundifolia*, and *Lablab purpureus* collected in the Cumbira Forest Reserve, Angola (Fig. 2), by assessing their (i) proximate composition, free sugars, tocopherols, fatty acid profiles, (ii) detailed phenolic composition through LC-HRMS, and (iii) *in vitro* antioxidant, antimicrobial, and antiproliferative activities. By focusing on these three co-occurring edible species of local importance, this work seeks to generate baseline data to support their sustainable use, traditional relevance, and potential development as functional food or bioactive resources.

2. Materials and methods

2.1. Plant material

Leaves of *Commelina africana* L. (collected in the understory of forest near walkways, 11°12′45″S/14°20′08″E, Bastos 11), *Dombeya rotundifolia* (Hochst.) Planch. (collected in forest, 11°13′37″S/14°22′43″E, Bastos 10), and *Lablab purpureus* (L.) Sweet (collected in an old fallow, 11°10′34″S/14°16′46″E, Bastos 9) were harvested in December 2021 in the Cumbira Forest Reserve, Conda, Cuanza Sul, Angola, at approximately 1000 m a.s.l. Voucher specimens were identified by the authors CB and LC at the LISC herbarium of the University of Lisbon, and duplicates were deposited at LISC, as well as at the KZ herbarium of the Instituto Superior Politécnico do Cuanza Sul, Sumbe, Angola, and at LUBA, the herbarium of the Instituto Superior de Ciências da Educação da Huíla, Lubango, Angola. The leaf samples were cleaned, dehydrated at 45°C, ground, and stored protected from light until further analysis.

2.2. Proximate composition and energetic value

Proximate composition (proteins, fat, ash, carbohydrates and energy), expressed on a dry weight basis (dw) was determined using AOAC (2016) methods: crude protein by the macro-Kjeldahl method (N × 6.25), crude fat by Soxhlet extraction with petroleum ether, ash by incineration at 600 ± 15 °C, carbohydrates by difference, and energy as.

Energy (kcal) = 4 (g protein + g carbohydrate) + 9 (g fat).

2.3. Chemical composition

2.3.1. Free sugars

Free soluble sugars were quantified by HPLC with refractive index detection after ethanolic extraction (80%, 80 °C), concentration, defatting with ethyl ether and filtration, using melezitose as internal standard (Barros et al., 2013). Identification was performed using Clarity 2.4 software (DataApex, Prague, Czech Republic) by comparison of the retention times with commercial standards. For quantification, peak areas were compared with the calibration curves of the commercial standards. Melezitose was used as the internal standard (IS) and the obtained results were expressed in g per 100 g of dry weight.

2.3.2. Tocopherols

Tocopherols were extracted (500 mg) by repeated homogenization

Fig. 1. Edible wild species studied in this work: A) *Commelina africana*; B) *Dombeya rotundifolia*; C) *Lablab purpureus*.

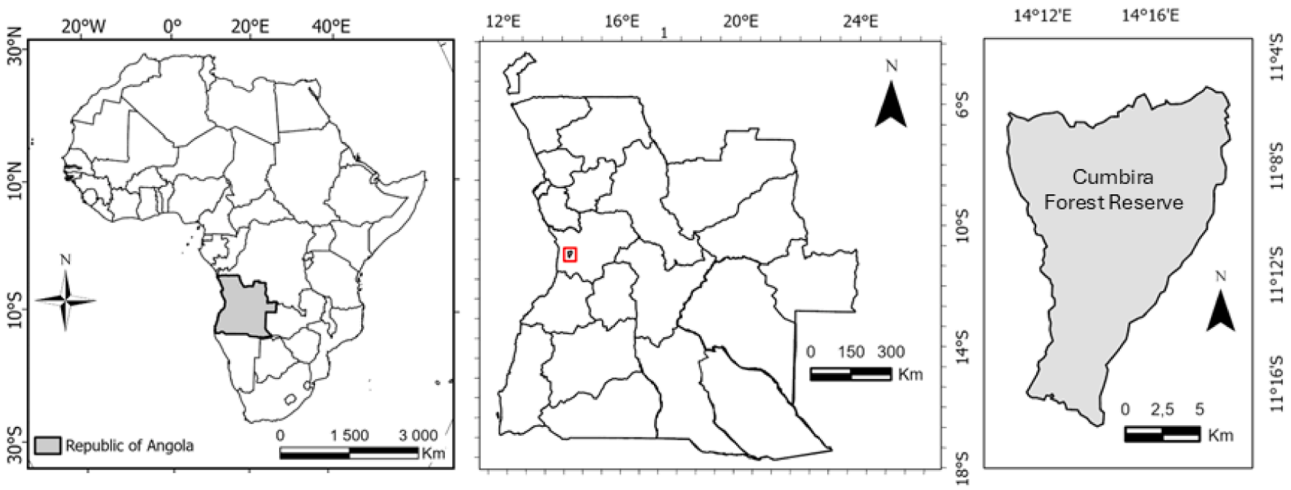

Fig. 2. Location of the Cumbira Forest Reserve in the Province of Cuanza Sul, Angola.

and centrifugation with methanol and hexane, the organic phase was evaporated, redissolved in hexane and analysed by HPLC with a fluorescence detector (FP-2020, Jasco, Easton, USA) (Albuquerque et al., 2023). Compounds were identified and quantified using the internal standard method and by comparing their chromatographic characteristics with tocopherol standards (i.e., α-, β-, γ-, and δ-isoforms, Sigma, St Louis, MO, USA) (Matreya, Pleasant Gap, USA). Data processing was carried out using Clarity 2.4 software (DataApex, Podohradska, Czech Republic), and the results expressed as milligrams per 100 grams of dry weight.

2.3.3. Fatty acids

The fatty acid methyl ester (FAME) profile was obtained through transesterification of the lipid fraction extracted by the Soxhlet method, followed by gas–liquid chromatography coupled with a flame ionization detector (FID), using a YOUNG IN ChroMass 6500 GC system equipped with a split/splitless injector set at 250°C and a split ratio of 1:50 (Heleno et al., 2009). Fatty acids were identified and quantified by comparing the relative retention times of sample FAME peaks with those of a standard mixture (47885-U, Sigma, St. Louis, USA). Data acquisition and processing were performed using Clarity DataApex 4.0 software (Prague, Czech Republic), and results were expressed as the relative percentage of each fatty acid.

2.4. Phenolic compounds

2.4.1. Extracts preparation

Hydroethanolic extraction were prepared using a standardized laboratory method from 2 g of dried sample using 80% aqueous ethanol (v/v). This approach was selected for its optimal extraction of phenolic compounds as widely reported in phytochemical studies of plant matrices. Although it may not reflect the traditional utilization of the studied plants, it promotes an exhaustive extraction of phenolic compounds, allowing a comprehensive characterization of their profile. Briefly, the mixture underwent magnetic stirring for 1h at room temperature, followed by filtration (filter paper Whatman N.° 4). This process was repeated once (two extraction cycles total), the filtrates were combined, evaporated (rotary evaporator Büchi R-210, Flawil, Switzerland) at 40°C and 100 mbar, and freeze-dried (FreeZone4.5, Labconco, Kansas City, MO, USA), yielding 20.64%, 15.38%, and 19.62% for *C. africana, D. rotundifolia,* and *L. purpureus,* respectively.

2.4.2. Phenolic compounds composition

Phenolic compounds were analyzed by high-performance liquid chromatography coupled to a diode array detector and a mass spectrometer (HPLC-DAD-ESI-MS/MS) operating under the conditions described by Bessada et al. (2016). For that purpose, the freeze-dried hydroethanolic extracts were redissolved in ethanol/water (20:80, *v/v*) to a final concentration of 10 mg/mL and filtered using a 0.22 μm disposable filter disc.

The LC system was coupled to an Orbitrap Exploris 120 mass spectrometer (Thermo Scientific, Hemel Hempstead, UK), equipped with a heated electrospray ionization source (H-ESI) operating in negative mode, with a spray voltage of -2.5 kV. Nitrogen was used as the nebulizing gas at a flow rate of 50 arbitrary units, while auxiliary and sweep gas flows were set at 10 and 1 arbitrary units, respectively. The ion transfer tube and vaporizer temperatures were maintained at 325°C and 350°C, respectively. Full-scan mass spectra were acquired over an *m/z* range of 110–1100, with a resolving power of 60,000 for MS and 17,000 for MS/MS analyses. Acquisition was carried out in data-dependent mode (DDA), employing a normalized collision energy of 30%. The identification of compounds was achieved by comparing the obtained retention times, the UV-Vis, MS and MS/MS spectra with those of the available standards. When standards were not available, the compounds were annotated based on chromatographic behavior, UV-Vis spectra, accurate mass, molecular formula, comparison of fragmentation pattern with data available in literature and online mass database (e.g. ChemSpider, PubChem), and evaluation of diagnostic neutral losses. The identified compounds were quantified using external calibration, and the results were expressed in mg per g of extract. The following calibration curves, prepared in the range between 1 and 80 mg/L, were used: caffeic acid (y = 50042x – 27910, R^2=0.9985; LOD=0.77 mg/L; LOQ=2.32 mg/L), *p*-hydroxybenzoic acid (y = 15103x - 1869.1 R^2=0.9998; LOD=0.51 mg/L; LOQ=1.55 mg/L), ferulic acid (y = 51383x - 3199.7, R^2=0.9999; LOD=0.31 mg/L; LOD=0.94 mg/L), *p*-coumaric acid (y = 15103x - 1869.1, R^2=0.9999; LOD=0.52 mg/L; LOQ=1.60 mg/L), quercetin-3-*O*-glucoside (y = 12714x - 13698, R^2=0.9970; LOD=0.92 mg/L; LOQ=2.78 mg/L), epicatechin (y = 6384.7x - 2195.8, R^2=0.9980; LOD=1.10 mg/L; LOQ=3.32 mg/L).

2.5. In vitro bioactive properties

2.5.1. Antioxidant activity

The antioxidant potential of the studied extracts was assessed using two *in vitro* cellular assays: lipidic peroxidation and oxidative haemolysis inhibition (TBARS and OxHLIA, respectively), each performed in three independent experiments with three replicates per concentration (n=3).

For the OxHLIA assay, extracts were dissolved in phosphate-buffered saline (PBS). Oxidative hemolysis of sheep red blood cells was induced

by AAPH using fresh erythrocyte (Lockowandt et al., 2019). The inhibition of hemolysis was measured spectrophotometrically at 690 nm and expressed as EC_{50} values (μg/mL), corresponding to the extract concentration required to prevent 50% of erythrocyte haemolysis. For the TBARS assay, freeze-dried hydroethanolic extracts were dissolved in water to obtain a 10 mg/mL stock solution, from which the tested concentrations were prepared. Lipid peroxidation inhibition in pig brain homogenates (*Sus scrofa*) was evaluated by measuring the formation of the malondialdehyde (MDA)–thiobarbituric acid (TBA) complex (Roriz et al., 2014) measured spectrophotometrically at 532 nm. The inhibition ratio (%) was calculated as $[(A - B)/A] \times 100$, where *A* and *B* correspond to the absorbance of the control blank and sample solutions in different concentrations, respectively. Results were expressed as EC_{50} values (μg/mL), representing the extract concentration providing 50% antioxidant activity. Trolox (Sigma-Aldrich, St. Louis, MO, USA) was used as the positive control.

2.5.2. Antiproliferative activity

The antiproliferative and hepatotoxic activities of the extracts were evaluated in five human tumor cell lines (Caco-2, AGS, MCF-7, HeLa, and NCI-H460) and in a non-tumor Vero cell line. Cells were cultured in RPMI 1640 medium, except Vero cells, which were maintained in DMEM, both supplemented with 10% fetal bovine serum and antibiotics. Extract concentrations ranging from 400 to 6.25 μg/mL were tested, and cell proliferation was assessed using the sulforhodamine B (SRB) assay (Mandim et al., 2022). Results were expressed as GI_{50} values (μg/mL), representing the concentration of the extracts required to inhibit cell proliferation by 50%.

2.5.3. Antimicrobial activity

The antimicrobial activity was assessed using the broth microdilution method following the guidelines of the Clinical and Laboratory Standards Institute (CLSI), with minor adaptations (Pires et al., 2018), with extracts being serially diluted twofold (20–0.15 mg/mL). The inoculum size was standardized to a 0.5 McFarland turbidity standard, corresponding to approximately 5×10^5 CFU/mL, in accordance with CLSI recommendations. Extract stock solutions were prepared using 5% (*v/v*) DWSO as a solubilizing agent. Although a dedicated solvent control was not included, the DWSO concentration used ($\leq$5%) is widely recognized in the literature as non-inhibitory to microbial growth and is routinely employed in broth microdilution assays for antimicrobial evaluation. At this low concentration, DWSO is not expected to interfere with bacterial or fungal viability or to influence MIC or MBC/MFC determinations. Clinical isolates from hospitalized patients were tested, including five Gram-negative (*E. coli, P. mirabilis, K. pneumoniae, P. aeruginosa*, and *M. morganii*) and four Gram-positive bacteria (*E. faecalis, L. monocytogenes*, MSSA, and MRSA). Microorganisms were standardized to a 0.5 McFarland turbidity equivalent ($\sim 5 \times 10^5$ CFU/mL inoculum size) and incubated at 37°C for 24 h. Results were expressed as minimum inhibitory (MIC) and bactericidal (MBC) concentrations. Ampicillin, imipenem, and vancomycin were used as positive controls.

For antifungal activity, *Aspergillus brasiliensis* and *Aspergillus fumigatus* were tested, and results were expressed as MIC and minimum fungicidal concentrations (MFC). Ketoconazole (Sigma-Aldrich, St. Louis, MO, USA) was used as the positive control.

2.6. Statistical analysis

All analyses were performed in triplicate, and results (except antibacterial activity) were expressed as mean ± standard deviation. The differences between samples were analyzed using a one-way analysis of variance (ANOVA) followed by Tukey's HSD significant difference post hoc test. Samples were considered different when $p < 0.05$. The different phenolic compounds were correlated with the antioxidant, antiproliferative, and antimicrobial activities by Pearson 2-tailed significance correlation (95% confidence level). Both analyses were carried out using the SPSS v. 27.0 program.

3. Results and discussion

3.1. Proximate composition and energetic value

The results regarding the proximate composition of *C. africana, D. rotundifolia*, and *L. purpureus* leaves are shown in Table 1. Carbohydrates dominated as the main macronutrient (73.55–88.30 g/100g dw), followed by proteins (11.21–23.39 g/100g dw) and lipids (1.60–2.47 g/100g dw), with *L. purpureus* exhibiting the highest protein and fat contents. The protein content of *L. purpureus* aligns with Murphy and Colucci (1999) findings (24.7 ± 3.92%) for Honduran leaves, while Chemutai (2016) reported 16.05% protein and 1.72% fat in Kenyan *C. africana*, values slightly differing from our study. *C. africana* showed the highest ash content, consistent with prior analyses of *C. africana* and *L. purpureus* (Chemutai, 2016; Sulaiman and Lawal, 2018). Comparisons with other studies reveal variations, as Washaya et al. (2018) reported 11.45% ash, 19% protein, and 2.41% fat in South African *L. purpureus*, while Sulaiman and Lawal 2018) found higher protein, fat, and ash contents in Nigerian aerial parts of *L. purpureus* harvested in Kargi. Overall, these findings suggest that *L. purpureus* nutritional profile is influenced by plant growth stage, soil type, and regional edaphoclimatic factors (Liberal et al., 2023; Washaya et al., 2018). Other studies validate *L. purpureus* as a high-value legume, recommending it as a dietary vegetable and animal feed supplement (Cui et al., 2016; Hossain et al., 2016; Kankwatsa and Muzira, 2018). Additional reports confirm the nutritional quality of other *Commelina* species, such as *C. benghalensis, C. diffusa* and *C. ereta* (Cavichi et al., 2023; Ezeabara et al., 2019). Developing high-value food products incorporating functional ingredients represents a strategy to promote nutrient-rich, healthy diets while minimizing industrial waste and enhancing resource sustainability.

3.2. Chemical composition

3.2.1. Free sugars

The free sugar content in *C. africana, D. rotundifolia*, and *L. purpureus* leaves was determined and the results are shown in Table 1. Fructose, glucose, and sucrose were detected in all species, whereas trehalose was present only in *C. africana* and *L. purpureus*, and raffinose was exclusive to *L. purpureus*. Total free sugars were lowest in *D. rotundifolia* (1.36 g/100g dw), compared to *C. africana* (4.39 g/100g dw) and *L. purpureus* (6.0 g/100g dw). Sucrose predominated in *L. purpureus* (5.1 g/100g dw) and *D. rotundifolia* (0.72 g/100g dw), whereas fructose was most abundant in *C. africana* (2.76 g/100g dw). No previous studies have reported free sugars in *C. africana* leaves; however, related *Commelina* species such as *C. ereta* exhibited lower fructose (0.212 g/100g fw) and sucrose (0.014 g/100g fw) (Cavichi et al., 2023) levels, which vary according to plant maturity, geographical origin, soil conditions, climate, and altitude (Liberal et al., 2023). To the best of our knowledge, the free sugar profile of *D. rotundifolia* leaves remain unreported in the literature.

3.2.2. Fatty acids

The fatty acid composition of *C. africana, D. rotundifolia* and *L. purpureus* leaves is presented in Table 1. Saturated fatty acids (SFA) predominated in *L. purpureus* and *D. rotundifolia*, primarily due to palmitic acid (27.6% and 37.2%, respectively; C16:0). In contrast, polyunsaturated fatty acids (PUFA) were most abundant in *C. africana*, driven by linolenic (31.9%; C18:3n3) and linoleic (16.1%; C18:2n6c) acids. This PUFA profile yielded a ω6/ω3 of 1:2, which is within the ratio between 1:1 and 4:1 considered the most balanced for cardiovascular health (Simopoulos, 2003). Although presenting lower PUFA levels, both *L. purpureus* and *D. rotundifolia* also showed significant amounts of linoleic and linolenic acids, with a ω6/ω3 within the recommended ratio (1:1.1 and 1.3:1, respectively). Despite the leaves contained low fat concentrations, the results evidence their potential to contribute with

Table 1
Proximate and chemical composition of the studied *Commelina africana, Dombeya rotundifolia*, and *Lablab purpureus* leaves (mean±SD; n=3).

	Commelina africana	*Dombeya rotundifolia*	*Lablab purpureus*
Proximate Composition			
Lipids (g/100 g dw)	1.60±0.03^{c}	2.19±0.49^{b}	2.47±0.08^{a}
Proteins (g/100 g dw)	11.21±0.22^{b}	8.63±0.41^{c}	23.39±0.20^{a}
Ash (g/100 g dw)	1.60±0.20^{a}	0.88±0.04^{b}	0.59±0.02^{c}
Carbohydrates (g/100 g dw)	85.59±0.06^{b}	88.30±0.82^{a}	73.55±0.08^{c}
Energy (kcal/100 g dw)	404.4±2.30^{b}	404.21±2.90^{b}	407.5±2.01^{a}
Sugars (g/100 g dw)			
Fructose	2.76±0.06^{a}	0.35±0.01^{b}	0.28±0.02^{c}
Glucose	1.47±0.02^{a}	0.28±0.02^{c}	0.4±0.1^{b}
Sucrose	0.18±0.01^{c}	0.72±0.02^{b}	5.1±0.5^{a}
Trehalose	0.27±0.03^{a}	nd	0.18±0.04^{b}
Raffinose	Nd	nd	0.11±0.02
Total sugars	4.39±0.02^{b}	1.36±0.06^{c}	6.0±1.0^{a}
Fatty Acids (%)			
C8:0	Nd	0.05±0.01	nd
C10:0	0.06±0.01	0.14±0.01	2.78±0.02
C11:0	Nd	0.05±0.01	nd
C12:0	0.26±0.02	0.55±0.01	4.7±0.4
C13:0	Nd	0.05±0.01	nd
C14:0	0.50±0.01	2.1±0.1	2.0±0.2
C14:1	1.26±0.05	0.66±0.01	nd
C15:0	0.23±0.01	0.56±0.04	nd
C16:0	31.7±1.3	36.2±0.2	27.6±0.4
C16:1	3.01±0.10	2.9±0.1	1.45±0.04
C17:0	0.43±0.03	1.02±0.03	nd
C18:0	6.2±0.1	3.9±0.1	7.1±0.2
C18:1n9c	3.8±0.1	18.8±0.5	10.18±0.03
C18:2n6c	16.1±0.7	15.1±1.0	8.7±0.2
C18:3n3	31.9±0.4	11.4±0.5	10.6±0.5
C20:0	2.40±0.06	2.1±0.1	6.8±0.2
C20:1	0.22±0.01	0.72±0.01	nd
C20:2	Nd	0.61±0.1	nd
C21:0	0.11±0.01	0.44±0.02	0.89±0.05
C20:3n3	0.11±0.01	nd	nd
C22:0	1.00±0.01	1.5±0.1	5.31±0.05
C22:2	0.38±0.01	0.65±0.04	9.65±0.04
C23:0	0.23±0.01	0.57±0.03	2.27±0.07
SFA	43.1±1.2^{c}	49.2±0.1^{b}	59.4±0.6^{a}
MUFA	8.3±0.1^{c}	23.0±0.6^{a}	11.6±0.1^{b}
PUFA	48.5±1.1^{a}	27.7±0.5^{c}	29.0±0.7^{b}
ω6/ ω3	2:1	1.3:1	1:1.1
Tocopherols (mg/100 g dw)			
α-tocopherol	6.99±0.01^{b}	8.2±0.1^{a}	5.72±0.04^{c}
β-tocopherol	0.4±0.2^{b}	0.5±0.1^{a}	nd
γ-tocopherol	3.3±0.7^{a}	0.13±0.08^{c}	0.9±0.2^{b}
δ-tocopherol	1.0±0.1^{a}	0.4±0.1^{b}	nd
Total tocopherols	11.7±0.9^{a}	9.2±0.6^{b}	6.8±0.5^{c}

Different letters in the same row correspond to significant differences ($p < 0.05$). Free sugars calibration curves: fructose (y=1.04 ×, *R*2=0.999; LOD=0.05 mg/mL; LOQ=0.18 mg/mL), glucose (y=0.935 ×, *R*2=0.999; LOD=0.08 mg/mL; LOQ=0.25 mg/mL) and trehalose (y=0.991 ×, *R*2=0.999; LOD=0.07 mg/mL, LOQ=0.24 mg/mL).
Fatty acids are presented as relative percentage of each fatty acid. caprylic acid (C8:0); capric acid (C10:0); undecanoic acid (C11:0); lauric acid (C12:0); tridecanoic acid (C13:0); myristic acid (C14: 0); myristoleic acid (C14: 1); pentadecanoic acid (C15:0); palmitic acid (C16:0); palmitoleic acid (C16:1); heptadecanoic acid (C17:0); stearic acid (C18: 0); oleic acid (C18: 1n9c); linoleic acid (C18:2n6c); linolenic acid (C18:3n3); arachidic acid (C20:0); gadoleic acid (C20:1); eicosadienoic acid (C20: 2); heneicosanoic acid (C21: 0); cis-8,11,14-Eicosatrienoic acid (C20:3n3); behenic acid (C22:0); cis-13-16-Docosadienoic acid (C22:2); tricosanoic acid (C23:0). dw – dry weight; nd – not detected; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids. Tocopherols calibration curves: α-tocopherol (y=1.295 ×; R^2=0.991; LOD: 18.06 ng/mL, LOQ: 60.20 ng/mL); β-tocopherol (y=0.396 ×; R^2=0.992; LOD: 25.82 ng/mL, LOQ: 86.07 ng/mL); γ-tocopherol (y=0.567 ×; R^2=0.991; LOD: 14.79 ng/mL, LOQ: 49.32 ng/mL); δ-tocopherol (y=0.678 ×; R^2=0.992; LOD: 20.09 ng/mL, LOQ: 66.95 ng/mL).

essential fatty acids associated with cardiovascular benefits and, overall, to a balanced diet. Additionally, given that *L. purpureus* and *D. rotundifolia* leaves are traditionally boiled or braised in Angola before consumption, the predominance of SFA in these vegetables may confer greater thermal stability during cooking. Cavichi et al. (2023) reported similar PUFA predominance in *C. erecta* leaves, with α-linolenic (~43%) and linoleic (~20%) acids, although differences likely arise from species variation, geographical origin, and sample freshness. Reid et al., (2005) identified lauric, myristic, palmitic, and stearic acids in South African *D. rotundifolia* leaves. To date, this represents the first fatty acids characterization of Angolan *C. africana* leaves.

3.2.3. Tocopherols

Tocopherols in *C. africana, D. rotundifolia*, and *L. purpureus* leaves were quantified and are presented in Table 1. Four isoforms were detected in *C. africana* and *D. rotundifolia*, whereas δ- and β-tocopherol were absent in *L. purpureus*. α-Tocopherol predominated across all species (5.72–8.20 mg/100g dw), with *D. rotundifolia* exhibiting the highest levels. Reported α-tocopherol contents in other leafy vegetables range from 6.68 mg/100 g dw in *Gisekia pharnaceoides* to 50.6 mg/100 g dw in *Corchorus olitorius*. Similarly, γ-tocopherol levels vary from 0.26 mg/100 g dw in *Amaranthus spp.* to 5.79 mg/100 g dw in *Amaranthus graecizans*, depending on species and drying conditions (Tiisekwa et al., 2024). These values support the relatively high vitamin E potential of *D. rotundifolia* and *C. africana* compared to several conventional leafy vegetables, highlighting their nutritional relevance as alternative green leafy sources of tocopherols. δ-tocopherol was also notable in *C. africana* (3.3 mg/100g dw), contributing to its total tocopherol content (11.7 mg/100 g dw), the highest among the three species. As the sole isoform with vitamin E activity, α-tocopherol at these elevated concentrations contributes substantially to protection against oxidative stress–related disorders (Primo et al., 2021). Studies on related *Commelina* species (Cavichi et al., 2023; Pereira et al., 2023) reported comparable profiles: all four isoforms in *C. erecta*, especially at flowering, and α-, γ-, and δ-tocopherol in *C. benghalensis*, though with lower α- and δ-tocopherol but higher γ-tocopherol levels than in *C. africana*. These variations likely reflect species-specific traits, geographical origin, and plant physiological stage at harvest. To the best of our knowledge, no data exist on tocopherol profiles *C. africana, D. rotundifolia* and *L. purpureus* leaves.

3.2.4. Phenolic composition

Table 2 presents the identified phenolic compounds along with their retention times, λmax values, accurate masses, molecular formulas, mass errors (ppm), MS/MS data, and quantification. Sixty-four compounds were detected using LC-ESI-DAD-Orbitrap in the leaves of *C. africana, D. rotundifolia* and *L. purpureus*. The phenolic profile of each species revealed marked interspecific differences. This was expected, since the three species are not phylogenetically related and were selected as WEPs from the same habitat rather than as closely related and directly comparable botanical taxa.

Hydroxybenzoic acids, hydroxycinnamic acids, and their derivatives, were detected across all species investigated. Among the hydroxycinnamic acids, the identity of chlorogenic acid (compound 15), caffeic acid (compound 19), and *p*-coumaric acid (compound 39), detected in *L. purpureus, D. rotundifolia* and *C. Africana,* was confirmed by comparison with authentic standards. Other hydroxycinnamic derivatives were tentatively identified based on their exact mass, molecular formula and fragmentation pattern. MS/MS spectra was compared with literature and online databases when available, and possible fragmentation pathways were elucidated employing characteristic fragments and neutral losses. Representative fragmentation patterns supporting the identification of the compounds are discussed below.

Compound 2, assigned as 3-caffeoylquinic acid, was identified based on its $[M–H]^-$ ion at *m/z* 353 base peak at *m/z* 191.0561 in MS/MS, accompanied by an intense fragment ion at *m/z* 179.0348, consistent with a chlorogenic acid isomer, as detailed by Clifford et al., (2003).

Table 2
Retention times, λmax values, accurate masses, molecular formulas, mass errors (ppm), MS/MS data, and quantification (mean±SD) of the phenolic compounds in hydroethanolic extracts of *Commelina africana, Dombeya rotundifolia* and *Lablab purpureus.*

Peaks	Rt (min)	λ (nm)	Molecular formula	Error (ppm)	[M-H]⁻	MS/MS	Assignment	mg/g extract *Commelina africana*	*Dombeya rotundifolia*	*Lablab purpureus*
1	5.28	no	$C_{15}H_{18}O_9$	2.027	341.0875	179.0351, 161.0234, 135.0444	Caffeic acid glucoside[1]	0.137 ±0.002	0.125±0.001	nd
2	5.54	324	$C_{16}H_{18}O_9$	1.534	353.0871	191.0561, 179.0348	3-caffeoylquinic acid[1]	0.181 ±0.004	Nd	2.013 ±0.122
3	5.59	no	$C_{13}H_{16}O_9$	2.481	315.072	152.0114, 153.0192, 108.0216, 109.0294	Dihydroxybenzoic acid glucoside[2]	nd	0.222±0.001	nd
4	5.72	no	$C_{13}H_{16}O_9$	2.481	315.072	152.0112, 153.0195, 108.0217, 109.0294	Dihydroxybenzoic acid glucoside[2]	0.120 ±0.008	nd	nd
5	6.6	no	$C_{16}H_{20}O_9$	1.553	355.1028	193.0500, 149.0606	Ferulic acid glucoside[3]	nd	0.044±0.000	nd
6	6.72	280	$C_{10}H_{12}O_7$	3.460	243.05077	87.0087, 137.0242	Hydroxybenzoic acid derivative[2]	nd	nd	2.135 ±0.006
7	6.72	no	$C_{15}H_{18}O_8$	2.357	325.0926	163.0399, 119.0517	*p*-coumaric acid glucoside[4]	Traces	0.066±0.002	0.071 ±0.000
8	6.74	no	$C_{18}H_{24}O_{14}$	1.141	463.0875	169.0124, 151.0025, 125.0244	Mudanoside B[2]	nd	1.170±0.014	nd
9	7.44	272, 336	$C_{27}H_{30}O_{16}$	-1.491	609.1452	489.1013, 399.07117, 369.0598, 519.1147, 429.0797	Luteolin 6,8-di*C*-glucoside[5]	0.738 ±0.014	nd	nd
10	7.48	312	$C_{16}H_{18}O_8$	-1.250	337.0926	163.0402, 119.0502	*p*-coumaroylquinic acid[4]	nd	nd	0.123 ±0.009
11	7.58	280, 332	$C_{20}H_{18}O_9$	0.782	401.1464	269.1027, 161.0455	Apigenin-*O*-pentoside[5]	nd	0.387±0.005	nd
12	7.62	280	$C_{30}H_{26}O_{12}$	0.394	577.134	289.0721, 407.0762, 125.0246	Procyanidin B dimer[6]	nd	0.942±0.052	nd
13	8.17	280	$C_{30}H_{26}O_{12}$	0.394	577.134	407.0771, 289.0714, 245.0812, 125.0243	Procyanidin B dimer[6]	nd	2.357±0.107	nd
14	15.41	280	$C_{45}H_{35}O_{18}$	0.394	864.1887	1152.4243, 287.0561	Procyanidin B hexamer[6]	nd	0.835±0.011	nd
15	8.22	324	$C_{16}H_{18}O_9$	2.043	353.0874	191.0559, 173.0453	Chlorogenic acid[1*]	nd	nd	0.425 ±0.004
16	8.45	no no	$C_{33}H_{40}O_{20}$		755.2026	593.1506, 446.0855, 285.0407	Kaempferol-*O*-glucoside-*O*-rutinoside[5]	nd	nd	0.927 ±0.019
17	9.5	300	$C_{15}H_{16}O_{10}$	1.653	355.0666	209.0298, 191.0189, 85.0294	*p*-coumaroyl saccharic acid[4]	0.308 ±0.002	nd	nd
18	10.01	280	$C_{15}H_{14}O_6$	2.890	289.0715	245.0818	Epicatechin[6]*	nd	1.764±0.018	nd
19	10.6	no	$C_9H_8O_4$	5.333	179.0347	135.0451	Caffeic acid[1*]	nd	0.171±0.003	nd
20	10.11	272, 324	$C_{16}H_{16}O_8$	2.555	335.0771	161.0243, 179.0355, 135.0449	Caffeoylshikimic acid[1]	0.456 ±0.001	nd	nd
21	10.12	no	$C_{27}H_{30}O_{15}$	0.293	593.153	473.1077, 353.0664, 383.0775, 503.1150	Apigenin 6,8-di*C*-glucoside[5]	0.698 ±0.034	nd	2.982 ±0.035
22	10.69	272, 328	$C_{26}H_{28}O_{15}$	0.127	579.1345	399.0717, 369.0600, 489.1035, 519.1075, 429.0812	Luteolin-*C*-arabinoside-*C*- glucoside[5]	1.169 ±0.038	nd	nd
23	11.65	272,332	$C_{26}H_{28}O_{15}$	-0.080	579.1345	489.1006, 459.0933, 509.1934, 441.0769	Luteolin-*C*-arabinoside-*C*-glucoside[5]	7.860 ±0.138	nd	0.449 ±0.019
24	11.82	280	$C_{30}H_{26}O_{12}$	0.394	865.2354	407.0766, 289.0706, 125.0241	Procyanidin B dimer[6]	nd	1.822±0.040	nd
25	12.87	328	$C_{16}H_{16}O_8$	2.555	335.077	179.03479, 135.0450, 161.0242	Caffeoylshikimic acid[1]	2.435 ±0.084	nd	nd
26	13.03	280	$C_{45}H_{38}O_{18}$	0.394	1153.2588	287.0555, 125.0241	Procyanidin B trimer[6]	nd	1.506±0.016	nd
27	13.06	272,332	$C_{26}H_{28}O_{14}$	0.103	563.19398	353.0664, 383.0768 473.1084, 443.0978, 503.1189	Vicenin-1[5]	nd	nd	5.180 ±0.036
28	13.79	272, 332	$C_{26}H_{28}O_{14}$	0.103	563.1402	353.0662, 383.0770, 443.0981, 473.1083, 503.1192, 545.1275	Schaftoside[5]	1.664 ±0.074	nd	2.161 ±0.010
29	14.1	272, 333	$C_{26}H_{28}O_{14}$	0.316	563.1402	353.0662, 383.0770, 443.0981, 473.1083, 503.1192, 545.1275	Isoschaftoside[5]	3.094 ±0.053	nd	0.712 ±0.013
30	14.27	no	$C_{75}H_{62}O_{30}$	-8.654	720.1574 $[M-2H]^{-2}$	289.0709, 407.0763, 1083.8891	Procyanidin B pentamer[6]	nd	0.572±0.020	nd
31	14.72	328	$C_{15}H_{14}O_{10}$	1.549	353.0509	111.0086, 173.0087, 191.0185, 179.0356	2-caffeoylisocitric[1]	nd	0.401±0.000	nd
32	15.02	268, 348	$C_{21}H_{20}O_{11}$	1.034	447.0925	327.0508, 357.0614	Luteolin-6-*C*-glucoside[5]*	4.629 ±0.005	nd	0.237 ±0.000
33	15.3	272, 344	$C_{28}H_{32}O_{15}$	-0.060	607.1659	443.0979, 323.0561	Isoscoparin rutinoside[5]	nd	nd	0.987 ±0.025
34	15.9	no	$C_{32}H_{38}O_{20}$	-1.844	741.187	300.0274, 301.0326	Quercetin-*O*-xylosyl-rutinoside[5]	nd	0.864±0.025	nd

(*continued on next page*)

Table 2 (*continued*)

Peaks	Rt (min)	λ (nm)	Molecular formula	Error (ppm)	[M-H]⁻	MS/MS	Assignment	mg/g extract *Commelina africana*	*Dombeya rotundifolia*	*Lablab purpureus*
35	15.29	272, 348	$C_{25}H_{26}O_{14}$	0.361	549.1243	399.0714, 459.0928, 369.0609, 489.1026, 429.0821	Luteolin-6,8-di*C*-arabinoside[5]	6.114 ±0.129	nd	nd
36	15.55	272, 336	$C_{26}H_{28}O_{14}$	0.210	563.1395	443.0977, 473.1082, 383.0766, 353.0664	Vicenin-3[5]	3.226 ±0.078	nd	nd
37	15.68	272, 344	$C_{22}H_{22}O_{11}$	0.742	461.1083	341.0669, 313.0351, 341	Isoscoparin[5]	nd	nd	1.801 ±0.020
38	15.95	312	$C_{21}H_{20}O_{11}$	0.833	447.0928	227.8913, 327.0514, 357.0603	Luteolin-*C*-glucoside[5]	tr	nd	nd
39	15.96	312	C_9 H_7 O_3	0.949	163.0397	119.0501	*p*-coumaric acid[4]*	0.150 ±0.000	nd	nd
40	15.96	312	$C_{27}H_{30}O_{14}$	0.482	577.1554	269.0453	Apigenin-7-*O*-rutinoside[5]	tr	nd	nd
41	16.55	268, 356	$C_{26}H_{26}O_{17}$	-1.679	609.1087	301.0349, 433.0784	Quercetin-*O*-xylosyl-glucuronide[5]	nd	0.969±0.003	nd
42	16.71	no	$C_{25}H_{26}O_{13}$	0.681	533.1292	443.0985, 383.0749, 473.1068, 353.0645	Apigenin 6,8-di*C*-pentoside[5]	0.491 ±0.018	nd	nd
43	16.72	268, 336	$C_{21}H_{20}O_{10}$	0.447	431.0976	311.0559, 323.0548, 283.0607, 341.0656	Apigenin 8-*C*-glucoside (vitexin)[5]	nd	nd	1.329 ±0.039
44	17.36	336, 272	$C_{25}H_{26}O_{13}$	0.568	533.1292	443.0985, 383.0749, 473.1068, 353.0645	Apigenin 6,8-di*C*-pentoside[5]	2.225 ±0.057	nd	nd
45	17.96	264, 340	$C_{27}H_{30}O_{16}$	-0.9981	609.1455	300.0273, 301.0352	Rutin[5]*	tr	1.270±0.010	5.080 ±0.006
46	18.42	272, 336	$C_{28}H_{32}O_{14}$	-0.189	591.171	427.1026, 471.1291, 324.0633	Methylvitexin rhamnoside[5]	nd	nd	13.812 ±0.093
47	18.46	312	$C_{13}H_{12}O_7$	2.727	279.0507	163.0399, 119.0501, 133.0140	*p*-coumaroyl malic acid[4]	3.122 ±0.084	nd	nd
48	18.65	no	$C_{33}H_{40}O_{20}$	-0.949	755.2033	314.0432, 315.0511	Isorhamnetin-xylosyl-rhamnosyl-glucoside[5]	nd	2.121±0.011	nd
49	18.65	no	$C_{16}H_{18}O_8$	2.467	337.0561	111.0087, 173.0091, 191.0193	*p*-coumaroyl quinic acid[4]	nd	0.699±0.007	nd
50	18.94	268, 340	$C_{22}H_{22}O_9$	0.599	445.1132	325.0715, 297.0401	Methylapigenin-*C*-glucoside[5]	nd	nd	5.621 ±0.109
51	19.2	no	$C_{21}H_{20}O_{12}$	0.643	463.0874	300.0273, 301.0352	Quercetin-*O*-galactoside	nd	0.615±0.005	nd
52	19.64	272, 332	$C_{25}H_{26}O_{13}$	0.343	533.1292	443.0985, 383.0749, 473.1068, 353.0645	Apigenin 6,8-di*C*-pentoside[5]	0.871 ±0.025	nd	nd
53	19.65	272, 336	$C_{22}H_{22}O_{10}$	0.262	445.1137	325.0715, 297.0401	Methylapigenin-*C*-glucoside[5]	nd	nd	33.383 ±0.150
54	19.97	no	$C_{26}H_{28}O_{15}$	-0.08	579.1346	284.0325, 285.0922	Kaempferol-*O*-pentosyl-hexoside[5]	nd	1.014±0.022	nd
55	19.97	no	$C_{28}H_{32}O_{16}$		623.1243	315.0511	Isorhamnetin-*O*-rutinoside[5]	nd	1.014±0.022	nd
56	20.05	328	$C_{14}H_{14}O_8$	2.641	309.0613	193.0505, 134.0375 149.0604	Feruloyl malic acid[3]	0.146 ±0.004	nd	nd
57	20.99	344	$C_{20}H_{18}O_{10}$	1.047	417.082	357.0613, 327.0509, 399.0714, 339.0499	Luteolin-*C*-pentoside[5]	1.419 ±0.024	nd	nd
58	21.06	256, 356	$C_{12}H_{18}O_{13}$	0.468	477.0666	301.0351, 300.0275	Quercetin-*O*-glucoronide[5]	nd	19.392 ±0.066	nd
59	21.2	no	$C_{27}H_{30}O_{15}$	0.394	593.151	285.04	Kaempferol-3-*O*-rutinoside[5]*	nd	nd	0.752 ±0.022
60	22.16	no	$C_{28}H_{32}O_{16}$	-1.376	623.1609	315.0520, 314.0442. 300.0289	Isorhamnetin-*O*-rutinoside[5]	nd	0.878±0.107	nd
61	22.69	no	$C_{21}H_{20}O_{11}$	1.369	447.0927	284.0323, 285.0403	Kaempferol-3-*O*-glucoside[5]*	nd	0.492±0.003	nd
62	23.59	no	$C_{22}H_{22}O_{12}$	0.971	477.1031	314.0429, 315.0505	Isorhamnetin-*O*-glucoside[5]	nd	0.765±0.008	nd
63	24.15	264, 344	$C_{21}H_{18}O_{12}$	0.906	461.0718	285.0403	Kaempferol-*O*-glucoronide[5]	nd	2.370±0.037	nd
64	25.32	256, 352	$C_{22}H_{20}O_{13}$	0.658	491.0826	315.0508, 300.0273	Isorhamnetin-*O*-glucoronide[5]	nd	15.402 ±0.055	nd
							Total phenolic acids	7.058 ±0.015[a]	1.733 ±0.005[c]	4.769 ±0.114[b]
							Total flavonoids	34.205 ±0.128 [c]	58.532 ±0.093 [b]	76.067 ±0.170 [a]
							Total phenolic compounds	41.264 ±0.112 [c]	60.265 ±0.099 [b]	80.837 ±0.284 [a]

Different letters in the same row of phenolic classes correspond to significant differences ($p < 0.05$). Compounds with * indicate identity confirmed with authentic standards. When standards were not available, compounds 'annotation was carried out based on accurate mass, molecular formulae provided by the HRMS (error < 5 ppm), comparison of fragmentation pattern with that of literature and online databases, and evaluation of diagnostic neutral losses. nd – not detected; tr – traces; no – no spectra observed. In each row, different letters mean significant differences ($p < 0.05$). Standard curves used for quantification: [1]caffeic acid.

[2] *p*-hydroxybenzoic acid.

[3] ferulic acid.

[4] *p*-coumaric acid.
[5] quercetin-3-*O*-glucoside.
[6] epicatechin.

Conjugated sugars were also prevalent, as indicated by neutral loss of 162 Da, corresponding to hexose moieties (Vukics and Guttman, 2010). This was the case of compounds 1, 5, and 7, assigned as caffeic acid glucoside, *p*-coumaric acid glucoside, and ferulic acid glucoside (Kiselova-Kaneva et al., 2022; Rojas-Garbanzo et al., 2019; Spínola et al., 2015). Other *p*-coumaric acid derivatives included *p*-coumaroylquinic acid (peak 10), *p*-coumaroyl saccharic acid (peak 17), and *p*-coumaroyl malic acid (peak 47). These compounds exhibited characteristic MS/MS fragment ions at *m/z* 163.0399 and 119.0501, consistent with the presence of a *p*-coumaric acid moiety observed in the authentic standard and diagnostic neutral losses corresponding to quinic acid (174 Da), malic acid (ll6 Da) (Ostrowski et al., 2014). Further caffeic acid derivatives were caffeoylshikimic acid (compounds 20 and 25), and 2-caffeoylisocitric acid (peak 31). These compounds yielded characteristic fragments at *m/z* 179.0347, 135.0450, and 161.0242, consistent with the presence of caffeic acid, combined with neutral losses associated with shikimic acid (156 Da) and isocitric acid moiety (174 Da). Finally, feruloyl malic acid was assigned in peak 56. This compound showed a neutral loss of 116 Da (malic acid group) and diagnostic ions in MS/MS at *m/z* 193.0505 and 149.0604, consistent with authentic standards of ferulic acid.

Hydroxybenzoic acid derivatives were primarily detected in glycosylated forms. For example, compounds 3 and 4 were both assigned as dihydroxybenzoic acid glucosides due to a neutral loss of 162 Da (hexose) leading to a base peak at *m/z* 153.0192 in MS/MS.

Among flavonoids, the identity of epicatechin (compound 18), rutin (compound 45), kaempferol-3-*O*-rutinoside (compound 59), and kaempferol-3-*O*-glucoside (compound 61) have been confirmed by means of comparison with commercial standards. The remaining compounds were identified based on their exact mass, molecular formula, and fragmentation patterns, interpreted considering the relevant literature, online databases, and previously reported fragmentation pathways, including diagnostic neutral losses and characteristic fragment ions. Representative and particularly informative cases are discussed below.

Procyanidin dimers, trimers, pentamers and hexamers were detected exclusively in *D. rotundifolia* (peaks 13, 14, 26 and 30), assigned based on diagnostic MS/MS fragments at *m/z* 407.0771, 289.0714, 245.0812, 125. 0243) (Kiselova-Kaneva et al., 2022; Won et al., 2018; Lin et al., 2014). *O* and *C*-glycosides of flavonoids were also found in the samples. *O*-linked compounds (peaks 11, 16, 34, 40, 41, 48, 51, 54, 55, 58, 60, 62, 63 and 64) were characterized by the loss of 162 Da and 132 Da, diagnostic of the presence of hexose and pentose moieties in the molecules, respectively (Ferreres et al., 2007). Additionally, apigenin, quercetin, isorhamnetin and kaempferol were the aglycones detected in the samples, characterized for the base peaks at *m/z* 269.0453, 301.0352, 315.0511 and 285.0403 in MS/MS, respectively. Luteolin and apigenin *C*-glycosides were also tentatively identified in the samples. MS/MS interpretation showed distinctive fragment ions to this compound's type, including the losses of 90 and 120 Da, which are characteristic of hexose substitution in aglycone, and 60 and 90 Da, indicative of the presence of pentose groups in the molecule (Cao et al., 2014; Singh et al., 2015). Compounds 21, 27, 28, 29, 36, 42, 44, 52, and 43, showed typical fragmentation pattern of apigenin *C* and di*C*-glycosides, yielding diagnostic fragment ions at m/z 341 (Aglycone + 71), m/z 311 (Aglycone + 71), 353 (Aglycone + 83), and 383 (Ag+113) (Cao et al., 2014; Ferreres et al., 2007). Therefore, these compounds were assigned, respectively, as apigenin 6,8-diC-glucoside, Vicenin-1, schaftoside, isoschaftoside, vicenin-3, apigenin 6,8-di-*C*-pentoside isomers, and apigenin-*C*-glucoside (vitexin) (Ferreres et al., 2007; Guo et al., 2021; Wang et al., 2019). Similarly, peaks 9, 22, 23, 32, 38, 35, and 57 showed diagnostic fragments for *C*-glycosides of luteolin at m/z 327.0509 (Aglycone + 41) and 357.0613m/z (Aglycone + 71) (Ferreres et al., 2007). Based on this data, these compounds were designated as luteolin 6,8-di*C*-glucoside, luteolin-*C*-arabinoside-*C*-glucoside isomers, luteolin-*C*-glucoside isomers, luteolin-6,8-di*C*-arabinoside, and luteolin-*C*-pentoside (Ferreres et al., 2007; S. Elshaarawy et al., 2018; Singh et al., 2015).

The phenolic profile of leaves of *C. africana, D. rotundifolia* and *L. purpureus* has been scarcely investigated, and, to the best of our knowledge, no studies on Angolan ecotypes were carried out. Evidence suggests that *L. purpureus* leaves contain appreciable amounts of total phenolics and display relevant antioxidant capacity (Oliveira et al., 2025). Likewise, the phenolic profile of *D. rotundifolia* has been even less comprehensively resolved, despite reports of high total phenolics, tannins, and flavonoids in the leaves, together with strong antioxidant and antibacterial activities (Kudumela and Masoko, 2018). Therefore, this study contributes significantly by providing a comprehensive characterization of phenolics in *C. africana, D. rotundifolia* and *L. purpureus* leaves from Angola. On the other hand, a recent study on *C. africana* leaves from the Democratic Republic of Congo revealed a phenolic pattern in agreement with the one presented in this report (Kibungu Kembelo et al., 2023), including the occurrence of *C*-glycosylated tetrahydroxyflavone derivatives (e.g., luteolin, apigenin). Cavichi et al. (2023) also reported that *C. erecta* grown in Brazil was mainly composed of luteolin and apigenin *C*-glycosides (Cavichi et al., 2023), confirming that flavones are central to the phytochemical identity of this species.

Table 2 details the phenolic contents of the hydroethanolic extracts from *C. africana, D. rotundifolia* and *L. purpureus* leaves. Among the three species, *L. purpureus* showed the highest total phenolics (80.837 ± 0.284 mg/g), which is consistent with its comparatively more complex phenolic profile and with prior reports describing plant organs of this species as relevant sources of bioactive metabolites (Das et al., 2023; Habib et al., 2017; Zhou et al., 2024). Flavonoids were the dominant class in all three species (34.205±0.128, 58.532±0.093, and 76.067 ±0.170 mg/g extract in *C. africana, D. rotundifolia* and *L. purpureus,* respectively).

Among phenolic acids, 3-caffeoylquinic acid predominated in *L. purpureus, p*-coumaroyl malic acid in *C. africana*, and *p*-coumaroyl quinic acid in *D. rotundifolia*. Hydroxycinnamic derivatives, such as *p*-coumaroyl malic and caffeoylquinic acids have been linked to antimicrobial, hypoglycemic and cardiovascular protective effects, although their biological relevance remains strongly dependent on the matrix and the specific assay conditions (Rashmi and Negi, 2020).

Regarding flavonoids, *L. purpureus* was predominantly characterized by methylapigenin-*C*-glucoside (33.383±0.150 and 5.621±0.109 mg/g), methylvitexin-rhamnoside (13.812±0.093 mg/g), vicenin-1 (5.180 ±0.036 mg/g), and rutin (5.080±0.006 mg/g) levels, while *D. rotundifolia* was dominated by quercetin-*O*-glucuronide (19.392 ±0.066 mg/g) and isorhamnetin-*O*-glucuronide (15.402±0.055 mg/g). By contrast, *C. africana* was defined mainly by luteolin-*C*-arabinoside-*C*-glucoside (7.860±0.138 mg/g), luteolin-6,8-di*C*-arabinoside (6.114 ±0.129 mg/g), and luteolin-6-*C*-glucoside (4.629±0.005 mg/g). The predominance of flavonoids, particularly of luteolin type compounds, is noteworthy because luteolin derivatives are commonly associated with antioxidant and anti-inflammatory activities (Punia Bangar et al., 2023)

3.3. Bioactive properties

3.3.1. Antioxidant activity

The *in vitro* antioxidant properties of the hydroethanolic extracts from *C. africana, D. rotundifolia*, and *L. purpureus* leaves were evaluated, and the results are presented in Table 3. All extracts showed moderate activity, with EC_{50} values of 215–219 μg/mL in the TBARS assay and 19–133 μg/mL in the OxHLIA assay. *C. africana* (EC_{50} = 219±1 and 19

Table 3
Antioxidant and antiproliferative properties of *Commelina africana* L., *Dombeya rotundifolia* (Hochst.) Planch., and *Lablab purpureus* (L) Sweet leaves hydroethanolic extracts (mean±SD; n=3).

	Commelina africana	*Dombeya rotundifolia*	*Lablab purpureus*
Antioxidant activity (EC_{50} - μg/mL)			
TBARS	219±1[a]	215±6[b]	215±9[b]
OxHLIA	19±1[c]	56±3[b]	133±7[a]
Antiproliferative activity (GI_{50} - μg/mL)			
AGS	>400	144.06±4.26	>400
MCF-7	>400	>400	>400
Hela	>400	195.97±6.05	>400
Vero	>400	>400	>400

Statistically significant differences ($p < 0.05$) were evaluated by Student's t-test. Different letters in the same column show significant differences between the means according to Tukey's HSD test ($p < 0.05$). The antioxidant activity was expressed in EC_{50} values, which means that high values correspond to lower reducing power or antioxidant potential, and antiproliferative activity was expressed in GI_{50}, corresponding to the sample concentration required to achieve 50% inhibition 9of growth in human tumour cells (AGS), gastric adenocarcinoma; (MCF-7), breast carcinoma; (HeLa), cervical carcinoma, and in a non-tumour (VERO), african green monkey kidney cell line.

±1 μg/mL) exhibited the strongest inhibition of oxidative hemolysis (Table 2), despite its lower total phenolic content compared with *D. rotundifolia* and *L. purpureus*. By contrast, the data revealed that the compositional differences resulted in a similar ability to limit the accumulation of secondary lipid oxidation products in the TBARS assay. This behavior likely reflects the different mechanistic basis of these assays, suggesting that antioxidant performance may depend on specific compounds or synergistic interactions rather than total concentration *per se*.

OxHLIA evaluates the ability of extracts to delay peroxyl radical-induced erythrocyte membrane damage, whereas TBARS mainly reflects the formation of secondary lipid peroxidation products. Therefore, antioxidant performance in OxHLIA is not expected to depend exclusively on total phenolic content, but rather on the presence of compounds able to efficiently protect the erythrocyte membrane and interrupt radical propagation under biologically relevant conditions. In this sense, the correlation analysis *(Supplementary Table S1)* indicated that phenolic compounds found mainly in *C. africana*, including luteolin and apigenin *C*-derivatives (e.g., luteolin and apigenin-*C*-arabinoside-*C*-glucoside, luteolin-6,8-diC-arabinoside), and *p*-coumaric acid derivatives (e.g., *p*-coumaroyl malic acid, *p*-coumaroyl saccharic acid), were strongly associated with the OxHLIA assay (r= -0.749 each). As antioxidant efficacy depends on numerous factors, like molecular size, polarity, and partitioning behavior, this result suggests that these compounds may be more relevant for membrane-oriented antioxidant protection than other phenolics detected in the remaining extracts, contributing to distinguish *C. africana* extract from the others. This is consistent with the known antioxidant potential of apigenin and luteolin *C*-glycosides, and phenolic acids (Nadalin et al., 2024; Roychoudhury et al., 2021), although their biological effects are highly dependent on structure and assay conditions (Ghozzi et al., 2024). Additionally, this result may reflect the combined contribution of multiple phenolic constituents, including minor metabolites that are not individually quantified, as well as possible synergistic interaction among flavonoids and phenolic acids (Halliwell et al., 2005). On the other hand, overall, no significant correlations were found between the individual compounds and the TBARS assay, indicating a low specificity of the measured phenolics in this antioxidant method.

Previous studies confirm antioxidant potential in related species, including *Commelina* spp., *L. purpureus,* and *D. rotundifolia* extracts (Batool et al., 2020; Kuppusamy et al., 2015; Mensah et al., 2014; Nasrin and Bulbul, 2012). No prior data exist on *C. africana* antioxidant properties; however, Pathy et al. (2021) noted its traditional use for skin treatments and anti-aging, linked to its polyphenolic profile, particularly flavonoids, and phenolic acids, which may underpin the observed activity.

Despite the observed *in vitro* antioxidant capacity, the findings should be interpreted with caution, since phenolic compounds undergo extensive metabolic transformation *in vivo*, which may substantially alter their bioavailability and biological activity.

3.3.2. Antiproliferative activity

The antiproliferative activity of hydroethanolic leaf extracts from *C. africana, D. rotundifolia*, and *L. purpureus* was studied and the results are summarized in Table 3. Extracts from *C. africana* and *L. purpureus* showed no relevant activity, whereas *D. rotundifolia* exhibited moderate effects on AGS (GI_{50} = 144.06 μg/mL) and HeLa (GI_{50} = 195.97 μg/mL) cell lines. This pattern suggests that the stronger antiproliferative activity is not a generic feature of phenolic richness, but rather a consequence of specific compounds within the phenolic matrix. For example, the correlation analysis (*Supplementary Table S1*) indicated that quercetin-*O*-glucuronide, isorhamnetin-*O*-glucuronide, and kaempferol glycoside derivatives showed strong negative correlations (r= -1.0 each) with antiproliferative activity, indicating that low concentrations of these compounds (GI_{50}) were associated with higher antiproliferative properties. Therefore, they may have contributed to distinguishing this plant species from the others. These findings are in line with reports that quercetin, isorhamnetin, and kaempferol-type flavonoids can inhibit cancer cell proliferation, induce apoptosis, and modulate key oncogenic signaling pathways, although their potency is strongly influenced by structural features such as glycosylation and conjugation (Delgado et al., 2014; Ramachandran et al., 2012).

Although direct evidence on the antiproliferative activity of *Commelina africana* leaves is still limited, other *Commelina* species (e.g., *C. benghalensis* and *C. erecta*) have shown clear antiproliferative and cytotoxic effects in cancer cells (Batool et al., 2020; Cavichi et al., 2023). In the case of *L. purpureus*, antiproliferative activity has been more extensively described for seed-derived proteins and hydrolysates, whereas the leaves have mainly been investigated for antioxidant properties, with little available evidence of in vitro antiproliferative or cytotoxic effects (Sipahli et al., 2022).

Importantly, none of the extracts showed hepatotoxicity toward Vero cells at the maximum tested concentration (GI_{50} > 400 μg/mL), indicating that the moderate antiproliferative activity observed for *D. rotundifolia* is unlikely to result from nonspecific toxicity (Kudumela, 2017). However, contradictory toxicity on THP-1 cells has been reported (Mashilo, 2022), underscoring the need for comprehensive toxicological evaluation across cell lines and *in vivo* models (Maroyi, 2018).

3.3.3. Antimicrobial activity

The antimicrobial activity of the hydroethanolic extracts from *C. africana, D. rotundifolia*, and *L. purpureus* leaves is presented in Table 4. Using the classification criteria proposed by Eloff (1998), in which MIC values below 1 mg/mL indicate strong activity, values between 1 and 5 mg/mL indicate moderate activity, and values above 5 mg/mL indicate weak activity, *D. rotundifolia* exhibited the broadest antibacterial spectrum. This extract showed strong activity against *Y. enterocolitica* and *B. cereus* (MIC = 0.6 mg/mL) and moderate activity against MRSA (MIC = 1.25 mg/mL), *E. coli, E. faecalis*, and *L. monocytogenes* (MIC = 2.5 mg/mL). *C. africana* also displayed relevant antibacterial effects, with strong activity against *Y. enterocolitica* (MIC = 0.6 mg/mL) and moderate activity against *B. cereus* and *L. monocytogenes* (MIC = 2.5 mg/mL). By contrast, *L. purpureus* was less active, showing only moderate activity against *E. coli* (MIC = 5 mg/mL) and weak activity against *S. aureus* (MIC = 10 mg/mL).

This ranking suggests that antimicrobial performance may not be associated with total phenolics abundance, since the richest extract (*L. purpureus*) was not the most active, while *C. africana* and *D. rotundifolia*, exhibiting lower total phenolic levels, showed higher

Table 4
Antimicrobial activity of *Commelina africana* L., *Dombeya rotundifolia* (Hochst.) Planch., and *Lablab purpureus* (L) Sweet leaves hydroethanolic extracts (n=3).

Food Bacteria																
Sample	Gram-negative bacteria										Gram-positive bacteria					
	Enterobacter Cloacae		*Escherichia coli*		*Pseudomonas aeruginosa*		*Salmonella enterica*		*Yersinia enterocolitica*		*Bacillus cereus*		*Listeria monocytogenes*		*Staphylococcus aureus*	
	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC
Commelina africana	>10	>10	>10	>10	>10	>10	10	>10	0.6	>10	2.5	>10	2.5	>10	10	>10
Dombeya rotundifolia	5	>10	5	>10	>10	>10	10	>10	0.6	>10	0.6	>10	2.5	>10	0.6	>10
Lablab purpureus	>10	>10	5	>10	>10	>10	>10	>10	10	10	10	>10	>10	>10	10	>10
Positive Control																
Streptomicin (1mg/mL)	0.007	0.007	0.01	0.01	0.06	0.06	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Methicilin (1mg/mL)	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	0.007	0.007
Ampicillin (10mg/mL)	0.15	0.15	0.15	0.15	0.63	0.63	0.15	0.15	0.15	0.15	n.t.	n.t.	0.15	0.15	0.15	0.15
Clinical bacteria																
Sample	Gram-negative bacteria										Gram-positive bacteria					
	Escherichia coli		*Klebsiella pneumoniae*		*Morganella morganii*		*Proteus mirabilis*		*Pseudomonas aeruginosa*		*Enterococcus faecalis*		*Listeria monocytogenes*		*MRSA*	
	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC
Commelina africana	10	>10	10	>10	10	>10	>10	>10	>10	>10	5	>10	5	>10	1.25	>10
Dombeya rotundifolia	2.5	>10	5	>10	5	>10	10	>10	10	>10	2.5	>10	2.5	>10	1.25	10
Lablab purpureus	10	>10	5	>10	10	>10	>10	>10	10	>10	10	>10	10	>10	10	10
Positive Control																
Ampicillin (10mg/mL)	<0.15	<0.15	10	>10	>10	>10	<015	<0.15	>10	>10	<0.15	<0.15	<0.15	<0.15		
Imipenem (1mg/mL)	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	0.5	1	<0.0078	<0.0078	n.t.	n.t.		
Vancomycin (1mg/mL)	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	n.t.	0.25	0.5		
	Antifungal activity (MIC/MFC, mg/mL)															
	Aspergillus brasiliensis		*Aspergillus fumigatus*													
	MIC	**MFC**	**MIC**	**MFC**												
Commelina africana	>10	>10	>10	>10												
Dombeya rotundifolia	10	>10	10	>10												
Lablab purpureus	>10	>10	10	>10												
Ketoconazole	0.06	0.125	0.5	1												

*MIC- minimum inhibitory concentration; MBC – minimum bactericidal concentration.
*MIC- minimum inhibitory concentration; MFC – minimum fungal concentration.

antimicrobial activity. This result indicates that the contribution of specific phenolic compounds or their interactions may prevail over total phenolic levels. For example, correlation analysis (*Supplementary Table S1*) revealed a strong negative association ($-0.5 \geq r \leq -1.0$) between the major phenolic compounds in *D. rotundifolia* (quercetin-*O*-glucoronide and isorhamnetin-*O*-glucoside) and the antimicrobial activity mainly against Gram-positive bacteria, indicating that lower concentrations of the extract achieved higher inhibitory efficiency. On the other hand, low correlation was found between this bioactivity and the predominant compounds in the other species ($r \leq -0.5$). Similarly, B-type procyanidins, detected exclusively in *D. rotundifolia* extracts, were also found strongly correlated with antimicrobial activity ($-0.5 \geq r \leq -1.0$), and may have contributed to the outstanding performance of this plant. Previous studies have demonstrated the efficacy of procyanidin fractions against foodborne microorganisms, primarily Gram-positive strains, such as *S. aureus* (Martins et al., 2020), supporting that this specific compound class may have contributed to the observed result. Additionally, phytochemicals other than phenolics and not analyzed in this study, such as terpenes, and saponins, may also have a contributing role. The antimicrobial properties of *Commelina species* and *D. rotundifolia* have been reported against *E. coli* (Kudumela, 2017; Luseba and Van der Merwe, 2006; Maroyi, 2018; Roulette et al., 2018; Van Wyk, 2013), but this is the first comprehensive demonstration of this bioactivities for Angolan ecotypes. However, although the extracts showed meaningful antimicrobial effects, their MIC values were considerably higher than those of the reference antibiotics ampicillin and imipenem, which inhibited most test bacterial strains at concentrations below 0.15 mg/mL and 0.0078 mg/mL, respectively.

No significant antifungal activity was observed for any of the extracts under the tested conditions. This contrasts with previous studies reporting strong antifungal effects (MICs 0.02–1.25 mg/mL) for bark extracts of *D. rotundifolia,* attributed primarily to tannins (Shikwambana and Mahlo, 2020), as well as moderate to good antifungal effects for *L. purpureus* leaf extracts (Nasrin and Bulbul, 2012), and an antifungal seed protein from *L. purpureus* (Ye et al., 2000).

4. Conclusion

This study offers a comprehensive characterization of the nutritional and bioactive properties of the leaves of three wild edible plants (WEPs), namely *Commelina africana, Dombeya rotundifolia*, and *Lablab purpureus*, sourced from the Cumbira Forest Reserve, Angola. Overall, the three species demonstrate substantial nutritional relevance, with high levels of macronutrients and micronutrients, including carbohydrates, proteins, essential fatty acids and tocopherols (Vitamin E). From a phytochemical perspective, the extracts displayed diverse and species-specific phenolic composition, with 64 compounds identified, among which flavonoids predominated in all the species. *C. africana* was mainly characterized by luteolin and apigenin derivatives, *D. rotundifolia* by quercetin, isorhamnetin, and kaempferol glycosides, and *L. purpureus* by methylapigenin and methylvitexin derivatives. This compositional differentiation was reflected in the bioactivity assays, where the biological effects were clearly species dependent rather than determined by total phenolic abundance alone. In particular, *D. rotundifolia* emerged as the most promising species, showing the most relevant antioxidant, antiproliferative, and antimicrobial activities. The findings suggest that specific phenolic compounds may underly the stronger responses detected, contributing to different bioactive effects. Despite the promising bioactivities in the *in vitro* assays, it is essential to consider that phenolic compounds undergo extensive metabolic transformation *in vivo*, which may substantially alter their bioavailability and biological activity. Therefore, further studies are paramount to validate the bioactive effects associated with the plant species. In this context, future research should prioritize *in vivo* studies of observed bioactivities using relevant animal models, comprehensive toxicological studies across multiple cell lines, bioavailability assessments of key phenolics to determine absorption kinetics and metabolic profiles, and quantitative mineral profiling to complement ash content data and establish full nutritional value. Overall, the studied species offer abundant nutritional and bioactive compounds and support their traditional use as foods and empirical medicinal resources.

CRediT authorship contribution statement

Claudete Bastos: Writing – review & editing, Writing – original draft, Investigation, Formal analysis. **Ângela Liberal:** Writing – review & editing, Writing – original draft, Formal analysis. **Tayse F.F. da Silveira:** Writing – review & editing, Investigation, Formal analysis. **Isabel C.F.R. Ferreira:** Visualization, Methodology. **Carla Pereira:** Writing – review & editing, Formal analysis, Data curation. **Tânia S.S.P. Pires:** Writing – review & editing, Formal analysis. **Filipa Mandim:** Writing – review & editing, Formal analysis. **Margarida Moldão:** Writing – review & editing, Supervision. **Luís Catarino:** Writing – review & editing, Supervision. **Lillian Barros:** Writing – review & editing, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing 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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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sajb.2026.05.017.

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