Comprehensive Nutritional and Phytochemical Analysis of Selected West African Medicinal Plants with Antiparasitic Properties

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Abstract

Traditional medicinal plants remain pivotal in West African communities for managing parasitic infections. However, systematic characterisation of their nutritional and phytochemical profiles is limited, constraining pharmacological validation and potential nutraceutical development. This study comprehensively evaluated the proximate composition and phytochemical constituents of five commonly used medicinal plants: *Lagenaria siceraria*, *Corchorus olitorius*, *Ocimum gratissimum*, *Mangifera indica*, and *Newbouldia laevis*. Fresh leaves were collected, authenticated, and processed into ethanolic extracts. Proximate analyses, including protein, lipid, carbohydrate, fibre, ash, and moisture content, were conducted according to AOAC (2019) protocols. Qualitative phytochemical screening assessed the presence of alkaloids, tannins, flavonoids, saponins, steroids, anthraquinones, deoxy sugars, and phlobatannins. Data were analysed using one-way ANOVA with Tukey's post hoc test ($p < 0.05$). Results demonstrated substantial interspecies variation. *L. siceraria* contained the highest protein content (61.17 ± 4.25%), suggesting both nutritional and bioactive peptide potential. *C. olitorius* exhibited the highest lipid concentration (32.93 ± 1.09%), potentially facilitating solubilization of hydrophobic phytochemicals. Carbohydrate, fibre, and moisture content varied significantly across species, highlighting species-specific contributions to diet and pharmacology. Phytochemical screening revealed universal presence of alkaloids, steroids, and deoxy sugars, while tannins, flavonoids, saponins, anthraquinones, and phlobatannins showed species-specific distribution. Notably, *L. siceraria* exhibited the broadest phytochemical spectrum, supporting its traditional use against parasitic infections. The integration of nutritional and phytochemical data underscores potential synergistic effects, whereby macronutrients may enhance the bioavailability and efficacy of bioactive compounds. These findings validate ethnomedicinal practices and provide a foundational reference for isolating active compounds, evaluating pharmacological efficacy, and guiding future nutraceutical development.

Keywords: Antiparasitic plants; *Corchorus olitorius*; ethnomedicine; *Lagenaria siceraria*; nutraceutical potential; phytochemical profiling

Introduction

Parasitic infections, particularly soil-transmitted helminthiases, protozoan infestations, and schistosomiasis, remain significant contributors to global morbidity and mortality. The World Health Organisation (WHO, 2023) estimates that more than 1.5 billion people are infected with at least one species of intestinal helminth, representing nearly one-quarter of the world's population. The heaviest disease burden occurs in sub-Saharan Africa, where climatic conditions, poverty, poor sanitation, and limited access to medical facilities sustain high transmission rates (Molyneux *et al.*, 2021; Hotez *et al.*, 2022). Chronic parasitic infections often result in nutritional deficiencies, impaired growth, cognitive decline, anaemia, and increased vulnerability to opportunistic infections (Pullan *et al.*, 2020; Eze *et al.*, 2024). These morbidities perpetuate a cycle of malnutrition and socioeconomic deprivation, posing a critical barrier to achieving several United Nations Sustainable Development Goals (SDGs), particularly those related to health and well-being (SDG 3) and poverty eradication (SDG 1).

Although several synthetic antiparasitic agents such as albendazole, ivermectin, and praziquantel have been employed in control programs, the increasing emergence of drug-resistant parasite strains, coupled with limited accessibility, cost constraints, and adverse pharmacological effects, continues to undermine their long-term efficacy (Geary, 2022; Specht *et al.*, 2023). Moreover, the reliance on repeated mass drug administration campaigns has raised concerns about ecological and pharmacodynamic sustainability (Chaccour *et al.*, 2021). Consequently, the search for alternative or complementary therapies, particularly those derived from natural sources, has intensified. Traditional medicinal plants offer a promising avenue, given their long history of use, biocompatibility, and abundance of structurally diverse bioactive compounds (Ademiluyi *et al.*, 2023; Tiwari *et al.*, 2023).

In West Africa, the ethnomedicinal knowledge base surrounding plant-based remedies represents one of the richest in the world. Local communities have long employed herbal formulations for the prevention and treatment of parasitic and infectious diseases, reflecting centuries of empirical observation and cultural adaptation (Adegoke *et al.*, 1968; Bouquet, 1969; Ajayi *et al.*, 2022). Plants such as *Lagenaria siceraria* (bottle gourd), *Corchorus olitorius* (jute mallow), *Ocimum gratissimum* (African basil), *Mangifera indica* (mango), and *Newbouldia laevis* (boundary tree) are integral components of this ethnomedicinal system. Beyond their therapeutic roles, these species are culturally embedded in diet, ritual, and local pharmacopoeia, often used in decoctions, infusions, or poultices for the management of malaria, intestinal worms, dysentery, and other infections (Ojo *et al.*, 2021; Nwosu *et al.*, 2024).

Despite this longstanding traditional reliance, systematic scientific characterisation of their nutritional and phytochemical composition remains limited. Modern phytopharmacological validation requires an integrative approach that couples proximate analysis, which determines nutritional composition, with phytochemical screening to identify active secondary metabolites. Nutritional analysis is essential not only for evaluating the macronutrient value of medicinal plants but also for understanding the biochemical interactions that influence

pharmacokinetics and pharmacodynamics of plant-derived compounds (Yeshi *et al*., 2020; Oyeyemi *et al*., 2023). For example, proteins can function as carriers or precursors for bioactive peptides, while lipids enhance the solubility and bioavailability of lipophilic phytochemicals (Penny *et al*., 1994; Hamid *et al*., 2022). Carbohydrates and dietary fibres, on the other hand, may influence the metabolic stability and gut absorption of phytoconstituents, potentially modulating their antiparasitic efficacy (Usman *et al*., 2021).

Phytochemicals, particularly alkaloids, flavonoids, saponins, tannins, steroids, and anthraquinones, constitute the bioactive backbone of medicinal plants. Their pharmacological versatility is linked to multiple mechanisms of antiparasitic action: interference with neuromuscular transmission in helminths, disruption of energy metabolism, generation of reactive oxygen species, and inhibition of key parasite enzymes and nucleic acid synthesis (Saeed *et al*., 2022; Oyebode *et al*., 2024). For instance, alkaloids such as quinine and berberine exhibit broad-spectrum antiprotozoal activity, while saponins and tannins have been shown to damage parasite membranes and inhibit larval development (Anigboro & Avwioroko, 2021; Ndukwe *et al*., 2023). The presence of these compounds often correlates with both nutritional value and ethnopharmacological use, reflecting an evolutionary adaptation that confers protection against pests and pathogens, and incidentally benefits human health.

Several studies have investigated individual West African plants for specific bioactive compounds or nutritional content, yet few have comprehensively integrated both nutritional and phytochemical profiling within the same experimental framework (Oladeji *et al*., 2020; Adeyemi *et al*., 2021; Udoh *et al*., 2024). This fragmented approach limits the depth of insight into the biochemical synergy between nutrients and phytochemicals. A holistic evaluation is therefore required to elucidate how nutritional matrices may modulate phytochemical bioactivity and how such synergy underpins the traditional efficacy of medicinal plants in antiparasitic therapy (Ezeonu *et al*., 2023; Okoli *et al*., 2024). Furthermore, the pharmacological potential of these plants extends beyond antiparasitic effects. For instance, *L. siceraria* is known for antioxidant and hepatoprotective properties; *C. olitorius* is rich in vitamins, minerals, and mucilage with anti-inflammatory effects; O. gratissimum contains essential oils with antimicrobial action; M. indica leaves are rich in phenolic compounds with immunomodulatory effects; and N. laevis possesses analgesic and antifungal properties (Akinnibosun *et al*., 2023; Uchegbu *et al*., 2024). These diverse bioactivities suggest a multifunctional pharmacognostic profile, positioning these plants as valuable candidates for nutraceutical development and integrative disease management. Given the persistent burden of parasitic infections and the limitations of current pharmacotherapies, the present study aims to conduct a comprehensive nutritional and phytochemical characterisation of five selected West African medicinal plants, namely *Lagenaria siceraria*, *Corchorus olitorius*, *Ocimum gratissimum*, *Mangifera indica*, and *Newbouldia laevis*, traditionally employed for the treatment of parasitic infections. By establishing a detailed biochemical profile, this study seeks to strengthen the empirical basis for their ethnomedicinal applications and to identify promising candidates for pharmacological validation, drug development, and potential incorporation into nutraceutical formulations

Materials and Methods

Plant Collection and Authentication

Fresh plant materials were collected from Umuihi Ogbenneisii, Ahiazu-Mbaise Local Government Area, Imo State, Nigeria, during the early rainy season, which coincides with peak leaf growth and optimal secondary metabolite biosynthesis. The selected species, namely *Lagenaria siceraria* (FHJ230), *Corchorus olitorius* (FHI 109017), *Ocimum gratissimum* (FHI 111995), *Mangifera indica* (FHI 108943), and *Newbouldia laevis* (FHI 108287), were chosen based on documented ethnomedicinal relevance for the treatment of parasitic and gastrointestinal infections in southeastern Nigeria (Ojo *et al*., 2021; Ajayi *et al*., 2022). Inclusion criteria prioritised plants with consistent traditional use, local availability, and reported antiparasitic or antimicrobial properties.

Environmental variables, including soil type, rainfall patterns, ambient sunlight, and microclimate conditions, were recorded to account for their potential impact on nutrient and metabolite profiles. Only mature, healthy leaves free from visible disease, pest infestation, or mechanical injury were harvested between 8:00 and 10:00 am to minimise diurnal variation. Samples were immediately transported in ventilated containers to the laboratory and processed within 24 h to preserve biochemical integrity (Abubakar & Haque, 2021). Taxonomic identification was performed at the Department of Plant Science and Biotechnology, Imo State University, Owerri, using morphological characteristics and comparison with authoritative floras and herbarium references (Harborne, 1998; Sofowora, 2008). Voucher specimens for these species are preserved at the Forestry Research Institute of Nigeria (FRIN) Herbarium, Ibadan, and Federal College of Forestry, Jos, serving as reference material. Detailed photographic documentation and morphological records were maintained to ensure reproducibility and future verification.

Sample Preparation and Extraction

Collected leaves were thoroughly washed under running tap water, followed by distilled water to remove dust, debris, and epiphytes. The cleaned samples were shade-dried for 7–10 days at ambient temperature (28 ± 2 °C) to prevent degradation of thermolabile metabolites. Residual moisture was removed by oven-drying at 50 ± 5 °C for 4 h to yield uniformly dehydrated samples. The dried leaves were ground into fine powder using an electric blender (Philips HR-2001, Netherlands), passed through a 0.5 mm mesh sieve to ensure homogeneity, and stored in airtight amber bottles at room temperature until extraction.

Crude ethanolic extracts were prepared by maceration, a technique suitable for broad-spectrum extraction of secondary metabolites (Harborne, 1998; Edeoga *et al*., 2020). Precisely 50 g of powdered leaf sample from each species was soaked in 500 mL of 95% ethanol in a conical flask, agitated intermittently for 72 h at room temperature, and filtered through Whatman No. 1 filter paper. The filtrate was concentrated under reduced pressure using a rotary evaporator (Büchi R-300, Switzerland) at 40 °C to yield a semi-solid crude extract. Extracts were weighed, labelled, and stored at 4 °C in sealed containers for subsequent analyses. All instruments were calibrated according to manufacturer instructions, and moisture content was measured before extraction to correct for residual water and ensure accuracy of downstream proximate analyses.

Proximate Composition Analysis

The proximate composition (moisture, ash, lipid, protein, fibre, and carbohydrate) of the plant powders was determined using standard AOAC procedures (AOAC, 2019), with minor modifications as detailed below. All measurements were conducted in triplicate (n = 3), and blanks were included in lipid and protein determinations

.to correct for background interference.

• Moisture Content: Approximately 5 g of each sample was dried in a hot air oven at 105 °C until constant weight was achieved. Moisture percentage was calculated based on the difference between initial and final weights.
• Ash Content: Dried samples were incinerated in a muffle furnace at 550 °C for 7 h until grayish-white ash, representing total inorganic mineral content, was obtained.
• Crude Lipid Content: Lipids were extracted using a Soxhlet apparatus with petroleum ether (boiling point 40-60 °C) for 6 h, then air-dried and weighed.
• Crude Protein Content: Total nitrogen content was determined by the Kjeldahl method and multiplied by the nitrogen-to-protein conversion factor of 6.25.
• Crude Fibre Content: Sequential acid (1.25% H_2SO_4) and alkali (1.25% NaOH) digestion was performed, followed by drying, ashing, and weighing.
• Carbohydrate Content: Calculated by difference:
Carbohydrate (%) = 100− (Moisture + Protein + Lipid + Fiber + Ash)

Values were expressed on a dry-weight basis to enable interspecies comparison. Observed unusually high proximate values were considered in the context of cultivar-specific nutrient accumulation and environmental factors during growth (Onwuka, 2018; Adegbite *et al.*, 2022).

Phytochemical Screening

Qualitative phytochemical analysis was conducted using standard colourimetric and precipitation assays to detect major secondary metabolite classes (Harborne, 1998; Sofowora, 2021). The ethanolic extracts were subjected to the following tests:
• Alkaloids: Dragendorff's, Mayer's, Wagner's, and Hager's reagents; orange, cream, or reddish-brown precipitate indicated presence.
• Tannins: Bromine water and ferric chloride; bluish-black or greenish precipitate confirmed presence.
• Flavonoids: 10% lead acetate and alkaline reagent tests; yellow colouration signified presence.
• Saponins: Frothing test; persistent foam indicated saponins.
• Steroids: Salkowski and Liebermann-Burchard tests; reddish-brown and green colouration indicated steroidal nuclei.
• Anthraquinones: Bornträger's test; pink or red colouration in ammoniacal layer indicated free anthraquinones.
• Phlobatannins: Boiling with 1% HCl produced a red precipitate.
• Deoxy Sugars: Fehling's test; brick-red precipitate indicated reducing sugars.

Each test was performed in triplicate, and results were reported qualitatively as present (+) or absent (-). Validation was ensured using known positive standards (e.g., quinine for alkaloids, rutin for flavonoids) (Okwu & Ukanwa, 2023).

Statistical analysis

All experimental determinations were performed in triplicate (n = 3). Data were expressed as mean ± standard deviation (SD) and analysed using IBM SPSS Statistics version 27.0 (IBM Corp., USA). One-way ANOVA was performed to assess differences among species (degrees of freedom: df = 2, 12), followed by Tukey's post hoc multiple comparison test. Normality and homogeneity of variance were confirmed using Shapiro-Wilk and Levene's tests, respectively. Statistical significance was accepted at $p < 0.05$. Graphical representations and descriptive summaries were generated using GraphPad Prism 9.0. Pearson correlation coefficients (r) were calculated to explore potential relationships between nutritional and phytochemical parameters, acknowledging that correlations are exploratory and do not imply causation (Field, 2018; Bolarinwa, 2023).

Results and Discussion

Proximate Composition of Selected Medicinal Plants

Proximate analyses revealed substantial interspecies variability in macronutrient composition (Table 1; Figures 1a-g), reflecting the biochemical diversity of the five studied medicinal plants. *Lagenaria siceraria* exhibited the highest protein content (61.17 ± 4.25%), exceeding previous reports of 28–35% in seeds (Adewusi & Osagie, 1999) and 1–2% in pulp (Udeh *et al.*, 2023). Such elevated protein levels may result from cultivar-specific nutrient accumulation, optimal environmental conditions during the early rainy season, or methodological differences in proximate assays. *Corchorus olitorius* contained the highest lipid concentration (32.93 ± 1.09%), suggesting enhanced solubility and bioavailability of lipophilic phytochemicals, which may facilitate their potential therapeutic activity. *Mangifera indica* demonstrated the highest carbohydrate content (59.21 ± 3.39%), consistent with its traditional use as an energy source and as a carrier for polyphenolic bioactives. *Newbouldia laevis* displayed elevated fibre (23.01 ± 0.36%), supporting its digestive and detoxifying roles in ethnomedicine. Moisture content across all species was low (<0.15%), indicating favourable shelf stability, reduced microbial susceptibility, and potential for long-term storage, key parameters in pharmacognostic preparation (Olaoye *et al.*, 2024). One-way ANOVA revealed significant interspecies differences for moisture ($F = 144.16$, df = 4, 10, $p = 1.66 \times 10^{-5}$), lipid ($F = 21.49$, df = 4, 10, $p = 0.0048$), protein ($F = 10.68$, df = 4, 10, $p = 0.016$), and carbohydrate ($F = 11.57$, df = 4, 10, $p = 0.0139$), while fiber, ash, and energy were not significantly different (Table 2). These variations likely reflect genetic diversity, environmental adaptation, and ecological specialisation affecting nutrient allocation. High protein and lipid contents not only confer nutritional value but may also stabilise and enhance the bioavailability of lipophilic phytochemicals, whereas health, immune modulation, and host resilience against parasitic infections (Yeshi *et al.*, 2020; Eze *et al.*, 2023).

Phytochemical Composition and Distribution

Qualitative screening revealed that alkaloids, steroids, and deoxy sugars were present in all species, whereas tannins, flavonoids, saponins, anthraquinones, phlobatannins, and cardiac glycosides exhibited species-specific distribution (Table 3; Figure 2). Lagenaria siceraria showed the broadest phytochemical spectrum, including phlobatannins and anthraquinones, consistent with its extensive ethnomedicinal application in West Africa. (Adewusi & Osagie, 1999; Udeh *et al.*, 2023). Each metabolite class possesses recognised antiparasitic mechanisms: alkaloids disrupt parasite neuromuscular coordination, tannins complex with cuticular proteins, and saponins compromise membrane integrity (Waller *et al.*, 2001; Sparg *et al.*, 2004; Hoste *et al.*, 2006). Flavonoids and anthraquinones exhibit antioxidant, immunomodulatory, and cytotoxic effects on helminth larvae (Saeed *et al.*, 2022; Tiwari *et al.*, 2023). While the co-occurrence of multiple bioactive classes suggests potential polypharmacological synergy, these interactions remain hypothetical and require empirical validation. The co-occurrence of multiple bioactive classes in *L. siceraria* suggests polypharmacological synergy, where multiple compounds act on distinct biological targets to enhance antiparasitic potency (Yeshi *et al.*, 2020; Ojo *et al.*, 2021). Such synergistic interactions are a hallmark of ethnobotanical formulations and may explain the efficacy of traditional remedies compared to isolated compounds (Adeyemi *et al.*, 2021).

Table 1. Proximate composition (%) of five medicinal plants.

Parameter	*O. gratissimum*	*N. laevis*	*L. siceraria*	*M. indica*	*C. olitorius*
Ash (%)	10.22 ± 0.30	10.30 ± 1.25	11.25 ± 0.55	8.53 ± 0.14	10.33 ± 0.28
Moisture (%)	0.098 ± 0.0005	0.024 ± 0.0016	0.083 ± 0.0204	0.069 ± 0.0334	0.143 ± 0.0077
Lipid (%)	0.688 ± 0.262	28.54 ± 0.85	20.10 ± 0.78	2.56 ± 0.26	32.93 ± 1.09
Protein (%)	29.17 ± 2.70	28.95 ± 4.53	61.17 ± 4.25	23.52 ± 3.44	32.88 ± 4.49
Carbohydrate (%)	46.97 ± 2.57	9.28 ± 5.46	5.48 ± 1.43	59.21 ± 3.39	11.12 ± 3.04
Fibre (%)	12.93 ± 0.27	23.01 ± 0.36	5.67 ± 0.44	5.98 ± 0.15	12.57 ± 0.84
Energy (kcal/100 g)	307.40 ± 0.66	267.10 ± 5.28	347.03 ± 21.62	343.81 ± 3.35	298.34 ± 12.67

Data represent mean ± SD (n = 3). Energy expressed as kcal/100 g.

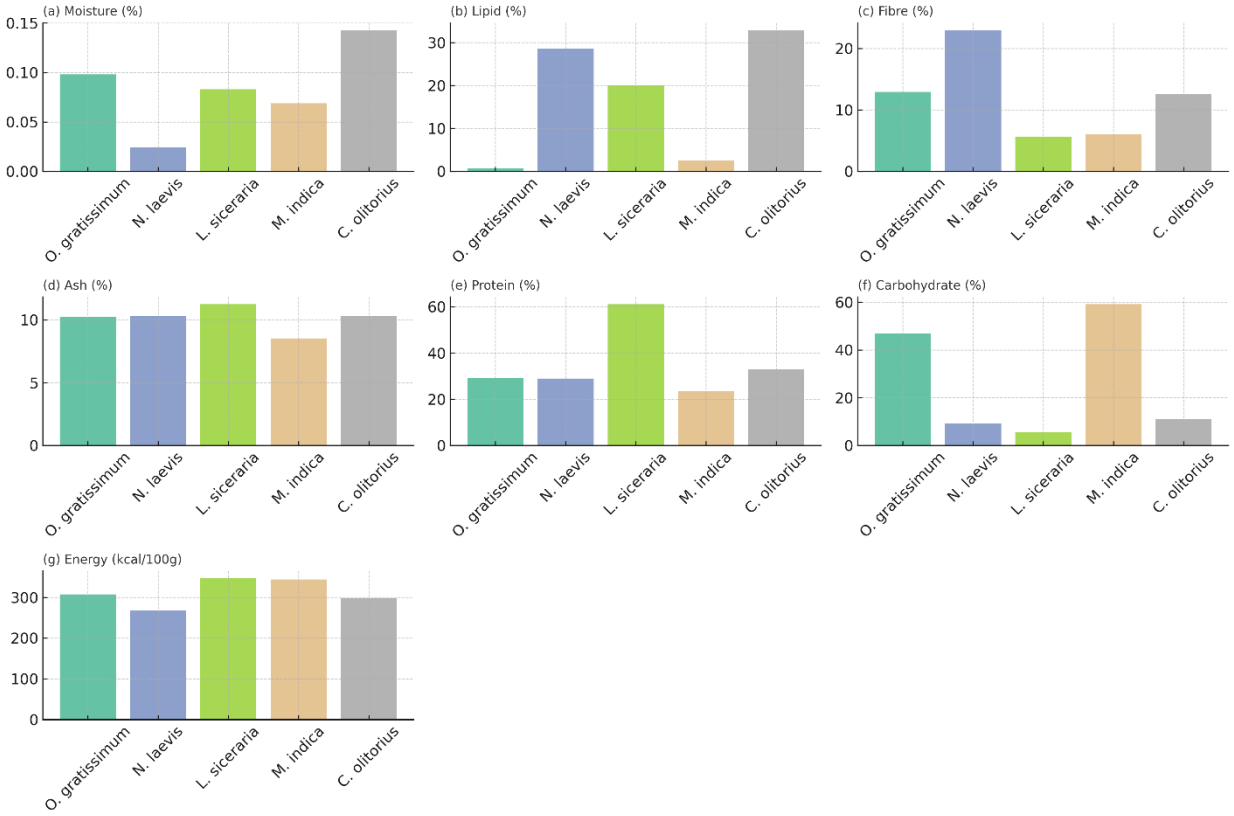

Figure 1. Multi-panel bar charts showing proximate composition of five medicinal plants. Panels represent (a) moisture (%), (b) lipid (%), (c) fibre (%), (d) ash (%), (e) protein (%), (f) carbohydrate (%), and (g) energy (kcal/100 g). Values represent mean ± SD (n = 3). Statistically significant differences (ANOVA, $p < 0.05$) are indicated with asterisks.

Comparison with Reported Data

Although proximate and phytochemical profiles broadly align with previous studies, several notable deviations were observed. Protein content in *L. siceraria* (61.17%) substantially exceeds prior reports of 28-35% (Adewusi & Osagie, 1999), while lipid content in *C. olitorius* (32.93%) surpasses historical values (<1%; Oboh & Ekperigin, 2004). Discrepancies may arise from soil fertility, microclimatic conditions, plant maturity, or methodological differences in analytical procedures. Environmental stressors are known to upregulate defensive metabolites, thereby influencing the proximate composition and accumulation of secondary metabolites (Udeh *et al.*, 2023). These observations emphasise the importance of region-specific standardisation in nutritional and phytochemical assessments.

Nutritional-Phytochemical Synergy and Ethnomedicinal Implications

Integration of proximate and phytochemical data highlights dual nutraceutical and pharmacological

Table 2. One-way ANOVA results for proximate composition of five medicinal plants.

Component	F-statistic	df	p-value	Interpretation
Moisture	144.16	4, 10	1.66×10^{-5}	Highly significant
Lipid	21.49	4, 10	0.0048	Significant
Fibre	4.55	4, 10	0.0689	Not significant
Ash	0.88	4, 10	0.5228	Not significant
Protein	10.68	4, 10	0.016	Significant
Carbohydrate	11.57	4, 10	0.0139	Significant
Energy	0.89	4, 10	0.5206	Not significant

potential. High protein in *L. siceraria* may facilitate peptide-mediated anthelmintic activity and antioxidant defence, while lipid-rich *C. olitorius* could enhance absorption of hydrophobic phytoconstituents such as steroids and flavonoids. Carbohydrate-rich *M. indica* serves as both an energy source and a vehicle for polyphenolic compounds, and fibre-rich *N. laevis* supports gut motility and detoxification, aiding parasite expulsion. These findings suggest potential complementary interactions between macronutrients and phytochemicals, though direct synergistic effects require experimental confirmation. Collectively, these plants exemplify the concept of "food as medicine", integrating nutritional and therapeutic benefits.

Table 3. Qualitative phytochemical screening of five medicinal plants. Presence (+) or absence (-) of secondary metabolites.

Phytochemical	OG	NL	LS	MI	CO
Steroids	+	+	+	+	+
Phlobatannins	-	-	+	-	-
Cardiac glycosides	+	-	+	+	+
Deoxy sugars	+	+	+	+	+
Anthraquinones	-	-	+	-	-
Saponins	-	+	-	-	+
Tannins	-	-	+	+	-
Alkaloids	+	+	+	+	+
Flavonoids	+	-	+	-	+

flora for bioprospecting and drug discovery. It is recommended that future research should focus on isolating, purifying, and structurally elucidating bioactive phytochemicals, particularly from *L. siceraria* and *C. olitorius*, using chromatographic and spectroscopic techniques (LC-MS, NMR). Nutritional-Phytochemical Synergy Studies should also be conducted using integrated omics-based studies (metabolomics + proteomics) to explore synergistic relationships between macronutrients and secondary metabolites influencing antiparasitic mechanisms.

In vivo Efficacy and toxicological Validation should assess safety profiles, dose-response relationships, and pharmacodynamics to establish therapeutic thresholds for safe human use. Sustainable Cultivation and Conservation should be encouraged, as community-based cultivation of these species can help prevent overharvesting, promote biodiversity, and sustain local economic value chains. Lastly, Bioinformatics-Guided Screening may be employed using computational docking and network pharmacology to predict molecular targets of identified compounds, enhancing precision in drug development pipelines.

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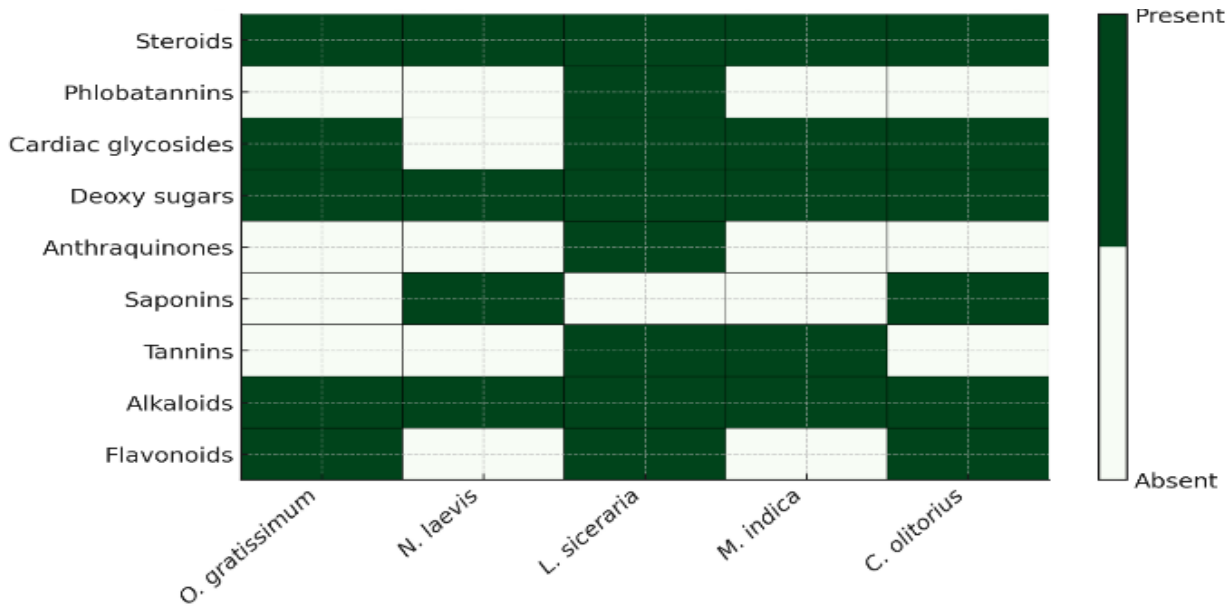

Figure 2. Binary heatmap illustrating the presence (green) or absence (grey) of nine phytochemical classes in five medicinal plants. Screening is qualitative; presence does not indicate concentration

Conclusion

This study provides a comprehensive biochemical assessment of *Lagenaria siceraria*, *Corchorus olitorius*, *Ocimum gratissimum*, *Mangifera indica*, and *Newbouldia laevis*, integrating proximate and phytochemical perspectives. Significant interspecies variation was observed, with *L. siceraria* demonstrating superior protein and phytochemical diversity, and *C. olitorius* exhibiting high lipid and saponin contents conducive to enhanced bioavailability of lipophilic compounds. These attributes substantiate their ethnomedicinal applications and potential for nutraceutical and pharmaceutical development. The dual role of these plants as functional foods and sources of antiparasitic agents underscores their relevance in sustainable health strategies and supports the rational selection of West African medicinal

Declaration of interest

The authors declare no conflict of interest.

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