

PHYTOCHEMICAL SCREENING AND BRINE SHRIMP TOXICITY EVALUATION OF TRADITIONAL PLANT REMEDIES USED IN CANCER MANAGEMENT IN NORTHWESTERN NIGERIA

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ABSTRACT

Cancer poses a growing healthcare challenge in Nigeria, driving reliance on traditional herbal medicine. This study evaluated the extraction yields, qualitative phytochemical compositions, and cytotoxicity of sixteen medicinal plant species traditionally used for tumor management in Northwestern Nigeria to prioritize candidates for anticancer bioprospecting. Ethanol and aqueous crude extracts were obtained by cold maceration of the dried leaves. Phytochemical screening targeted nine major secondary metabolite classes. Cytotoxicity was assessed using the brine shrimp (*Artemia salina*) lethality bioassay (BSLA) across three concentrations (10, 100, and 1000 µg/ml) to determine median lethal concentration (LC50) values. Ethanol extraction yielded higher mass recovery (mean 26.2%) and broader phytochemical diversity than aqueous extraction (mean 11.3%). All species showed the presence of flavonoids, steroids, phenols, saponins, and tannins, whereas anthraquinones were predominantly extracted by ethanol (68.8%). Five extracts demonstrated high cytotoxicity; ethanol extracts of *Senna nigricans* (LC50 = 7.16 µg/ml), *Ziziphus spina-christi* (7.66 µg/ml), *Lepidium sativum* (19.00 µg/ml), and *Senna singueana* (21.52 µg/ml), along with aqueous *Piliostigma reticulatum* (9.50 µg/mL). These findings support the ethnomedical use of several Northwestern Nigerian medicinal plants, prioritizing *S. nigricans*, *Z. spina-christi*, *P. reticulatum*, *L. sativum*, and *S. singueana* for bioassay-guided isolation of novel antiproliferative agents.

Keywords: Ethnobotany, Northwestern Nigeria, *Artemia salina*, Cytotoxicity, Phytochemical screening, Bioprospecting.

INTRODUCTION

Cancer has emerged as one of the most pressing non-communicable diseases confronting Nigeria's health system. Nigeria documented 269,109 cancer cases from 2018 to 2022, with the annual burden reaching an estimated 127,763 incident cases and 79,542 deaths. Breast cancer remains the most diagnosed malignancy in the country, followed by prostate, cervical, colorectal, and non-Hodgkin lymphoma (Omosun *et al.*, 2022). Late presentation, the high cost and limited geographic availability of radiotherapy and chemotherapy, and the catastrophic household expenditure associated with treatment continue to push a substantial proportion of patients, particularly in rural Northwestern Nigeria, toward traditional and herbal alternatives (Fayehun *et al.*, 2025).

Traditional medicine practitioners across Northwestern Nigeria maintain a rich, largely undocumented pharmacopoeia for the

management of tumors and cancer-like conditions. Recent cross-sectional ethnobotanical surveys among traditional medicine practitioners and herb sellers in Kaduna, Kano, Sokoto, and Jigawa States identified dozens of plant species cited for the management of breast cancer and related growths, with species from the families *Fabaceae* and *Combretaceae*, including *Guiera senegalensis*, *Cassia (Senna) singueana*, and *Boswellia odorata*, among the most frequently cited (Danladi *et al.*, 2025). Surveys conducted in Kwara, Niger, and South-Western Nigeria similarly document dozens of species used by traditional healers for tumor-related ailments, most of which remain pharmacologically unvalidated (Salawu *et al.*, 2021; Yahaya *et al.*, 2022). This pattern is consistent with the broader observation that a large share of clinically important anticancer agents in current use, from vinca alkaloids to taxanes, were originally identified through systematic pharmacological evaluation of plants with an ethnomedical history (Mbaveng *et al.*, 2019).

The pharmacological rationale for this approach rests on the diverse secondary metabolites synthesized by plants, several classes of which possess well-characterized cytotoxic and antiproliferative activity relevant to carcinogenesis. Flavonoids modulate carcinogen activation, arrest the cell cycle, induce apoptosis, and interfere with angiogenesis and multidrug resistance through actions on NF-κB-dependent signaling and mitochondrial integrity (Ren *et al.*, 2003; Chahar *et al.*, 2011). Saponins, alkaloids, tannins, terpenoids, and anthraquinones have each been linked mechanistically to apoptosis induction, cell cycle arrest, and interference with the MAPK/ERK, p53, and death receptor pathways across a range of plant species (Bishayee & Sethi, 2016; Elekofehinti *et al.*, 2021). Because exhaustive *in vitro* screening of every candidate species against panels of human cancer cell lines is resource-intensive, the brine shrimp (*Artemia salina*) lethality assay, first standardized by Meyer *et al.* (1982), continues to serve internationally as a rapid, low-cost, and general bioassay for prioritizing plant extracts for more detailed anticancer evaluation. Cytotoxicity toward brine shrimp nauplii correlates broadly with cytotoxicity towards human cancer cell lines, and conventionally an extract with a median lethal concentration (LC50) below 30 µg/mL is regarded as highly toxic and a priority candidate for anticancer bioprospecting, between 30 and 1000 µg/mL as toxic, and above 1000 µg/mL as essentially non-toxic in this model (Meyer *et al.*, 1982; Krishnaraju *et al.*, 2005).

This study evaluated 16 medicinal plant species with documented folkloric use in managing cancer-related conditions in Northwestern Nigeria. The specific objectives were to (i) document the

macroscopic and morphological characteristics of the source leaves for pharmacognostic identification; (ii) compare the efficiency of traditional aqueous decoction and ethanolic extraction in recovering bioactive metabolites and preserving bioactivity; (iii) qualitatively screen both extract types for nine major phytochemical classes; and (iv) evaluate the cytotoxic potential of each extract using the brine shrimp lethality assay, for subsequent bioassay-guided fractionation and cell-line-based anticancer evaluation.

MATERIALS AND METHODS

Plant Preparation

Fresh leaf samples of sixteen medicinal plant species used in the traditional management of cancer-related ailments in Northwestern Nigeria were collected. Botanical identification and authentication of all plant specimens were performed by a taxonomist in the Department of Biological Sciences, Kaduna State University, Kaduna, Nigeria. Corresponding voucher specimens were deposited at the institutional herbarium, and unique voucher specimen numbers were assigned (Table 1). The samples were air-dried in the shade at ambient temperature and ground to a coarse powder using a mechanical grinder. Morphological and macroscopic characteristics of each species, including leaf type, shape, laminar dimensions, venation pattern, margin, and surface texture, were recorded following standard pharmacognostic procedures (Table 2) to support field verification and re-identification.

Plant Extraction

Cold maceration (72 hours with intermittent agitation) was employed using 100 g of each powdered plant sample in 100 ml absolute ethanol and distilled water separately (Ezeani *et al.*, 2025).

RESULTS

Table 1. Taxonomic identification, ethnobotanical profile, herbarium voucher numbers, and traditional administration methods of 16 traditional plants used in cancer management.

S/N	Scientific Name	Family Name	Local Name	Common Name	Voucher No.
1	<i>Guiera senegalensis</i> J.F.Gmel.	Combretaceae	Sabara/barbarta	Senegal quiera	794
2	<i>Cassia singueana</i> Delile	Fabaceae	Runhu/Dan tamburawa	Winter Cassia	884
3	<i>Albizia chevalieri</i> Harms.	Fabaceae	Katsari	Flea	99
4	<i>Boswellia odorata</i> Hutch.	Burseraceae	Ararrabi	Frankincense	609
5	<i>Combretum micranthum</i> G.Don	Combretaceae	Geza	Kinkeliba	1128
6	<i>Anogeissus leiocarpa</i> (DC.) Guill. and Perr.	Combretaceae	Marke	African birch	193
7	<i>Tamarindus indica</i> L.	Fabaceae	Tsamiya	Tamarind	440
8	<i>Annona senegalensis</i> Pers.	Annonaceae	Gwandar Daji	Custard apple	1217
9	<i>Ricinus communis</i> L.	Euphorbiaceae	Zurman	Castor oil plant	321
10	<i>Ziziphus spina-christi</i> (Mill.) Georgi	Rhamnaceae	magarya	Jujube	4802
11	<i>Vachellia nilotica</i> (L.) P.J.H. Hurter and Mabb.	Fabaceae	Bagaruwa	Egyptian thorn	2
12	<i>Piliostigma reticulatum</i> (DC.) Hochst.	Fabaceae	Kalgo	Camel's foot	93
13	<i>Diospyros mespiliformis</i> Hochst. ex A.DC.	Ebenaceae	Kanya/kaiwa	Ebony tree	920
14	<i>Lepidium sativum</i>	Cruciferae	Lansir/lafsur	Garden cress	77
15	<i>Parkia biglobosa</i> (Jacq.) G.Don	Fabaceae	Dorawa	African locust bean	900
16	<i>Moringa oleifera</i> Lam.	Moringaceae	Zogale	Drumstick tree	8

. The extracts were filtered through Whatman No. 1 filter paper, and the solvent was removed using a rotary evaporator at 40 °C. The Crude extracts were then stored in a refrigerator at 4°C for further analyses (Table 3). The percentage of extraction yield (%) was determined using the following formula:

- Percentage yield = Weight of extract /Weight of sample × 100

Qualitative Phytochemical Analysis

Ethanolic and aqueous crude extracts of all 16 plant species were qualitatively evaluated for alkaloids, flavonoids, steroids, terpenoids, anthraquinones, phenols, saponins, tannins, and cardiac glycosides (Table 4) using standard methods described by (Brain & Turner, 1975; Evans, 2009).

Brine Shrimp Lethality Assay (BSLA)

Cytotoxicity was evaluated by the lethality bioassay of brine shrimp (*Artemia salina*) using the general method as described by Meyer *et al.* (1982) and Supomo *et al.*, (2019) with slight modifications. The eggs of the brine shrimp were obtained from the central laboratory of Bayero University Kano (BUK) and incubated in artificial seawater under constant illumination for 48 hours to produce active swimming nauplii. Ten nauplii were transferred into each test vial containing test solutions of ethanolic or water extract at final concentrations of 10, 100, and 1000 µg/ml, each concentration in triplicate. The vials were kept under illumination for 24 h, after which the number of surviving nauplii was counted, and the number of dead organisms (out of 30 nauplii tested at each concentration in three replicates) and the corresponding percentage mortality were calculated.

Morphological and macroscopic characteristics

The 16 species covered nine plant families and showed a significant diversity in leaf structure, from simple to fully fringed

leaves (Table 2). This morphological documentation is intended to support the identification of field material and the re-collection of genuine plant material in the later stages of the work.

Table 2: Morphological and macroscopic characteristics of the sixteen selected plant species.

S/N	Plant Species	Leaf Type	Shape	Length (cm)	Width (cm)	Venation Pattern	Margin	Surface Texture
1	<i>Guiera senegalensis</i>	Simple	Oblong-elliptic	2–4	1–3	Pinnate-looped	Entire	Velvety-pubescent
2	<i>Cassia singueana</i>	Paripinnate compound	Ovate-elliptic	2–5	1–2.5	Pinnate-reticulate	Entire	Smooth (glabrous)
3	<i>Albizia chevalieri</i>	Bipinnately compound	Narrow-oblong	1–2	0.3–0.6	Parallel-reticulate	Entire	Fine-pubescent
4	<i>Boswellia odorata</i>	Imparipinnate compound	Ovate-lanceolate	4–9	2–4	Reticulate	Entire	Leathery (coriaceous)
5	<i>Combretum micranthum</i>	Simple	Elliptic-obovate	5–11	3–6	Pinnate	Entire	Papery (chartaceous)
6	<i>Anogeissus leiocarpa</i>	Simple	Ovate-lanceolate	2–8	1.5–3	Pinnate-looped	Entire	Smooth
7	<i>Tamarindus indica</i>	Paripinnate compound	Oblong-linear	1–3	0.5–1	Reticulate	Entire	Smooth (glabrous)
8	<i>Annona senegalensis</i>	Simple	Ovate-oblong	6–16	4–10	Prominent net-veined	Entire	Leathery / velvety lower
9	<i>Ricinus communis</i>	Simple (deeply divided)	Peltate (7–11 lobed)	15–50	15–50	Palmate	Serrate	Smooth
10	<i>Ziziphus spina-christi</i>	Simple	Ovate-elliptic	2–6	1.5–4	3-basal veins	Crenate-serrate	Shiny-smooth
11	<i>Vachellia nilotica</i>	Bipinnately compound	Linear-oblong	0.3–0.7	0.1–0.2	Obscure	Entire	Smooth
12	<i>Piliostigma reticulatum</i>	Simple	2-lobed (camel-foot)	5–12	6–12	Palmate-fan	Entire	Leathery (coriaceous)
13	<i>Diospyros mespiliformis</i>	Simple	Elliptic-oblong	4–14	2–5	Reticulate	Entire (wavy)	Glossy-leathery
14	<i>Lepidium sativum</i>	Dissected rosette	Pinnatipartite (lobed)	4–12	2–4	Reticulate	Incised-toothed	Soft-fleshy
15	<i>Parkia biglobosa</i>	Bipinnately compound	Strictly oblong	0.8–1.8	0.3–0.5	Parallel-obscure	Entire	Smooth
16	<i>Moringa oleifera</i>	Tripinnately compound	Obovate-elliptic	1–2.5	0.5–1.2	Reticulate	Entire	Soft-fragile

Extraction Yields and Physical Characteristics

Table 3 summarizes the extraction yields, physical consistencies, and color profiles of the 16 medicinal plant species extracted using

ethanol and water. Across all species evaluated, ethanolic extraction consistently produced higher percentage yields than aqueous extraction.

Table 3: Extraction yields and physical profiles of ethanolic and aqueous crude extracts

S/N	Plant Name	Ethanolic Yield (%)	Aqueous Yield (%)	Extract Colour	Nature of Extract
1	<i>Lepidium sativum</i> (LF)	27.3	13.35	Blackish green	Gummy
2	<i>Guiera senegalensis</i> (SBR)	32	9	Brown	Granules/gummy
3	<i>Ricinus communis</i> (ZRM)	22.4	11.1	Reddish brown	Semi-solid/gummy
4	<i>Albizia chevalieri</i> (KTR)	36	14.9	Green	Gummy
5	<i>Senna nigricans</i> (GZ)	22.7	7.4	Reddish brown	Granules/gummy
6	<i>Annona senegalensis</i> (GD)	17	9.9	Dark green	Gummy/sticky paste
7	<i>Anogeissus leiocarpa</i> (MRK)	34.7	10.55	Dark brown	Gummy/semi-solid
8	<i>Boswellia odorata</i> (ARB)	20.55	10.1	Light brown/amber	Viscous resinous/gummy
9	<i>Tamarindus indica</i> (TSM)	26	10.3	Green	Sticky paste/gummy
10	<i>Senna singueana</i> (RNH)	41.75	18.2	Blackish green	Gummy/semi-solid
11	<i>Diospyros mespiliformis</i> (KNY)	21.5	10.25	Dark brown	Powder/crystalline granules
12	<i>Vachellia nilotica</i> (BGR)	12.8	5.15	Dark reddish brown	Gummy/solid resin
13	<i>Parkia biglobosa</i> (DW)	18.8	6.1	Brown	Granules/powder
14	<i>Ziziphus spina-christi</i> (MY)	44.3	17.35	Green	Granules
15	<i>Moringa oleifera</i> (ZGL)	14.45	8.9	Bright green	Gummy/fine paste
16	<i>Piliostigma reticulatum</i> (KLG)	27.15	17.8	Dark brown	Gummy

Figure 1. Ethanolic and aqueous percentage extraction yields of sixteen medicinal plant species

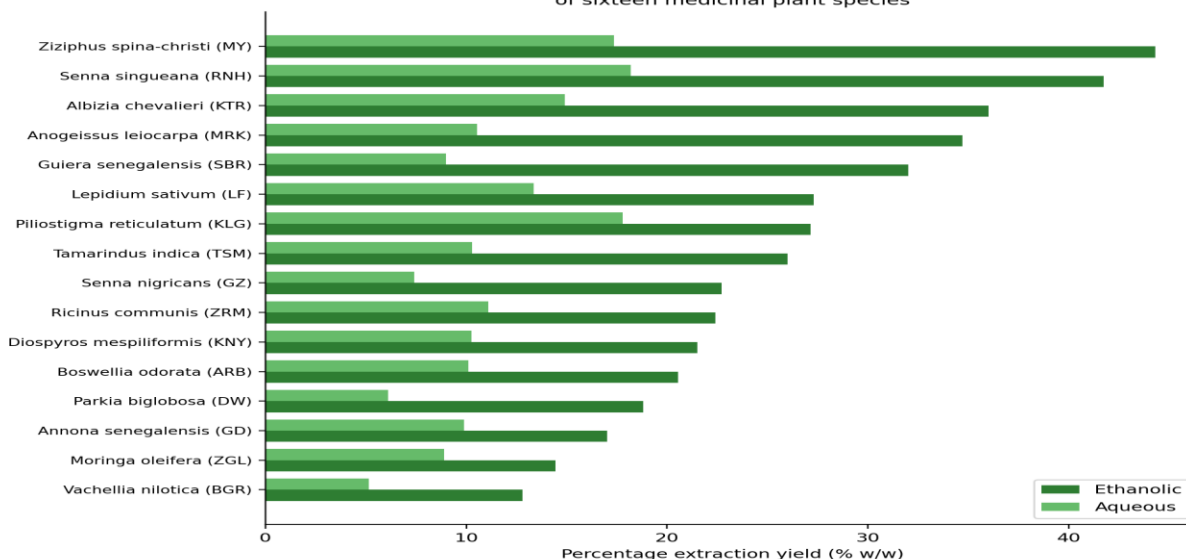


Figure 1: Ethanolic and aqueous percentage extraction yields of the sixteen medicinal plant species

All sixteen ethanolic and aqueous extracts tested positive for flavonoids, steroids, phenols, saponins, and tannins, indicating that these classes were widely and consistently extractable from the leaf material regardless of solvent polarity (Tables 4 and 5; Figures 1 and 2). Alkaloids were detected in fifteen of the sixteen ethanolic extracts but absent only in *Tamarindus indica*, and in all sixteen aqueous extracts. The clearest solvent-dependent difference was observed for anthraquinones, which were detected in 11 of 16 (68.8 %) ethanolic extracts but only 4 of 16 (25%) in the aqueous extracts. Terpenoids were present in 14 of 16 ethanolic extracts but

only 10 of 16 in aqueous extracts, while cardiac glycosides were identified in 10 of 16 extracts of each solvent type. Ethanolic extracts showed a slightly more robust phytochemical profile (mean 7.8 of 9 classes), supporting the extraction-yield findings that ethanol recovered a broader spectrum of secondary metabolites from these plants. *Lepidium sativum*, *Ziziphus spina-christi*, and *Piliostigma reticulatum* ethanolic extracts were the only three in which all nine phytochemical classes demonstrated positive results.

Table 4. Qualitative phytochemical screening of ethanolic leaf extracts

S/N	Plant Name	Alk	Fla	Ste	Ter	Ant	Phe	Sap	Tan	CG
1	<i>Lepidium sativum</i> (LF)	+	+	+	+	+	+	+	+	+
2	<i>Guiera senegalensis</i> (SBR)	+	+	–	+	+	+	+	+	+
3	<i>Ricinus communis</i> (ZRM)	+	+	–	–	+	+	+	+	+
4	<i>Albizia chevalieri</i> (KTR)	+	+	+	+	+	+	+	–	+
5	<i>Senna nigricans</i> (GZ)	+	+	+	+	+	+	+	–	+
6	<i>Annona senegalensis</i> (GD)	+	+	+	+	–	+	+	+	–
7	<i>Anogeissus leiocarpa</i> (MRK)	+	+	+	+	–	+	+	+	+
8	<i>Boswellia odorata</i> (ARB)	+	+	+	+	–	+	–	–	–
9	<i>Tamarindus indica</i> (TSM)	–	+	+	+	+	+	+	+	+
10	<i>Senna singueana</i> (RNH)	+	+	+	+	–	+	+	+	–
11	<i>Diospyros mespiliformis</i> (KNY)	+	+	+	+	+	+	+	+	–
12	<i>Vachellia nilotica</i> (BGR)	+	+	+	+	+	+	+	+	–
13	<i>Parkia biglobosa</i> (DW)	+	+	+	+	+	+	+	+	–
14	<i>Ziziphus spina-christi</i> (MY)	+	+	+	+	+	+	+	+	+
15	<i>Moringa oleifera</i> (ZGL)	+	+	+	+	–	+	+	+	+
16	<i>Piliostigma reticulatum</i> (KLG)	+	+	+	+	+	+	+	+	+

+ = present; – = absent. Alk = alkaloids; Fla = flavonoids; Ste = steroids; Ter = terpenoids; Ant = anthraquinones; Phe = phenols; Sap = saponins; Tan = tannins; CG = cardiac glycosides.

Table 5: Qualitative phytochemical screening of aqueous leaf extracts

S/N	Plant Name	Alk	Fla	Ste	Ter	Ant	Phe	Sap	Tan	CG
1	<i>Lepidium sativum</i> (LF)	+	+	+	+	–	+	+	+	+
2	<i>Guiera senegalensis</i> (SBR)	+	+	+	+	+	+	+	+	+
3	<i>Ricinus communis</i> (ZRM)	+	+	–	–	–	+	+	+	+
4	<i>Albizia chevalieri</i> (KTR)	+	+	+	–	–	+	+	–	+
5	<i>Senna nigricans</i> (GZ)	+	+	+	–	+	+	+	–	+
6	<i>Annona senegalensis</i> (GD)	+	+	+	+	–	+	+	+	–
7	<i>Anogeissus leiocarpa</i> (MRK)	+	+	+	+	–	+	+	+	+
8	<i>Boswellia odorata</i> (ARB)	+	+	+	+	–	+	–	+	–
9	<i>Tamarindus indica</i> (TSM)	+	+	+	+	–	+	+	+	+
10	<i>Senna singueana</i> (RNH)	+	+	+	–	+	+	+	+	–
11	<i>Diospyros mespiliformis</i> (KNY)	+	+	+	+	–	+	+	+	–
12	<i>Vachellia nilotica</i> (BGR)	+	+	+	–	–	+	+	+	–
13	<i>Parkia biglobosa</i> (DW)	+	+	+	+	–	+	+	+	–
14	<i>Ziziphus spina-christi</i> (MY)	+	+	+	+	–	+	+	+	+
15	<i>Moringa oleifera</i> (ZGL)	+	+	+	+	–	+	+	+	+
16	<i>Piliostigma reticulatum</i> (KLG)	+	+	+	–	–	+	+	+	+

+ = present; – = absent. Alk = alkaloids; Fla = flavonoids; Ste = steroids; Ter = terpenoids; Ant = anthraquinones; Phe = phenols; Sap = saponins; Tan = tannins; CG = cardiac glycosides.

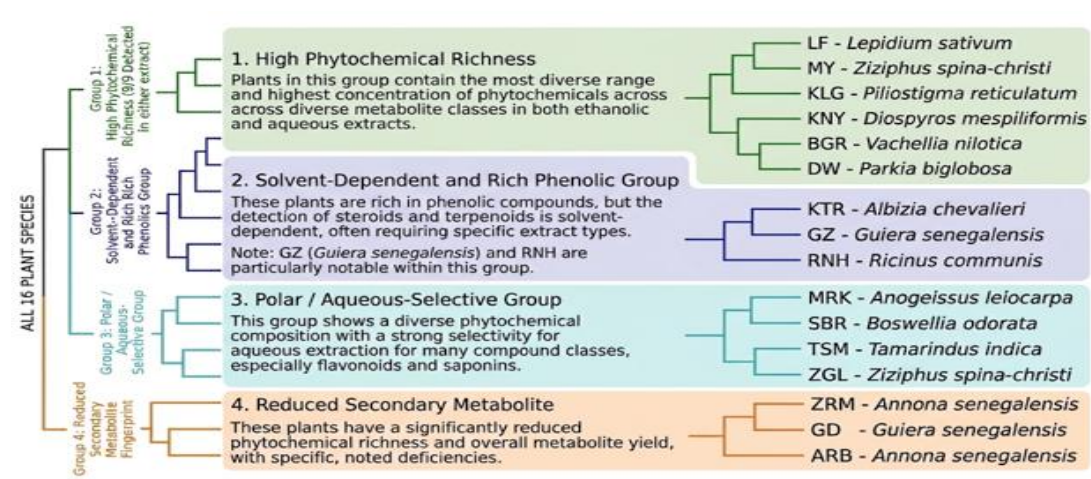


Figure 2: Hierarchical categorization based on detailed phytochemical screening

Brine shrimp lethality assay

Among the thirty-two plant extracts evaluated from sixteen plant species using the Brine Shrimp (*Artemia salina*) Lethality Bioassay, toxicity was classified according to the benchmark criteria established by Meyer *et al.* (highly toxic: $LC_{50} \leq 30 \mu\text{g/ml}$; toxic: $30\text{--}1000 \mu\text{g/ml}$; non-toxic: $LC_{50} > 1000 \mu\text{g/ml}$). Five extracts demonstrated potent cytotoxicity ($LC_{50} \leq 30 \mu\text{g/ml}$), led by ethanolic preparations of *Senna nigricans* (7.16 $\mu\text{g/ml}$), *Ziziphus spina-christi* (7.66 $\mu\text{g/ml}$), *Lepidium sativum* (19.00 $\mu\text{g/ml}$), and

Senna singueana (21.52 $\mu\text{g/ml}$), alongside the aqueous extract of *Piliostigma reticulatum* (9.50 $\mu\text{g/ml}$). Twenty-one extracts showed moderate toxicity (35.60–496.27 $\mu\text{g/ml}$), four aqueous extracts were non-toxic ($LC_{50} > 1000 \mu\text{g/mL}$), and the two aqueous extracts of *S. singueana* and *Moringa oleifera* showed insufficient mortality to establish an LC_{50} . The high lethality of the positive control (1.24 $\mu\text{g/ml}$) and minimal vehicle mortality in the negative control (2534.05 $\mu\text{g/mL}$) confirmed assay validity.

Table 6. *In vitro* cytotoxicity and toxicity classification of aqueous and ethanolic extracts of selected medicinal plant species against

S/N	Plant Species	Extract Type	LC_{50} ($\mu\text{g/mL}$)	Toxicity Category
1	<i>Senna nigricans</i> (GZ)	Ethanolic extract	7.16	Highly toxic
2	<i>Ziziphus spina-christi</i> (MY)	Ethanolic extract	7.66	Highly toxic
3	<i>Piliostigma reticulatum</i> (KLG)	Aqueous extract	9.5	Highly toxic
4	<i>Lepidium sativum</i> (LF)	Ethanolic extract	19	Highly toxic
5	<i>Senna singueana</i> (RNH)	Ethanolic extract	21.52	Highly toxic
6	<i>Diospyros mespiliformis</i> (KNY)	Ethanolic extract	35.6	Toxic
7	<i>Senna nigricans</i> (GZ)	Aqueous extract	37.8	Toxic
8	<i>Ricinus communis</i> (ZRM)	Ethanolic extract	39.48	Toxic
9	<i>Parkia biglobosa</i> (DW)	Ethanolic extract	42.18	Toxic
10	<i>Albizia chevalieri</i> (KTR)	Aqueous extract	49.74	Toxic
11	<i>Albizia chevalieri</i> (KTR)	Ethanolic extract	58.82	Toxic
12	<i>Anogeissus leiocarpa</i> (MRK)	Ethanolic extract	58.9	Toxic
13	<i>Anogeissus leiocarpa</i> (MRK)	Aqueous extract	69.33	Toxic
14	<i>Annona senegalensis</i> (GD)	Ethanolic extract	70.83	Toxic
15	<i>Diospyros mespiliformis</i> (KNY)	Aqueous extract	82.01	Toxic
16	<i>Guiera senegalensis</i> (SBR)	Aqueous extract	116.07	Toxic
17	<i>Piliostigma reticulatum</i> (KLG)	Ethanolic extract	117.04	Toxic
18	<i>Guiera senegalensis</i> (SBR)	Ethanolic extract	118.59	Toxic
19	<i>Ricinus communis</i> (ZRM)	Aqueous extract	177.26	Toxic
20	<i>Parkia biglobosa</i> (DW)	Aqueous extract	193.34	Toxic
21	<i>Moringa oleifera</i> (ZGL)	Ethanolic extract	244.53	Toxic
22	<i>Annona senegalensis</i> (GD)	Aqueous extract	266.61	Toxic
23	<i>Lepidium sativum</i> (LF)	Aqueous extract	288.66	Toxic
24	<i>Boswellia odorata</i> (ARB)	Ethanolic extract	417.98	Toxic
25	<i>Tamarindus indica</i> (TSM)	Ethanolic extract	440.81	Toxic
26	<i>Vachellia nilotica</i> (BGR)	Ethanolic extract	496.27	Toxic
27	<i>Ziziphus spina-christi</i> (MY)	Aqueous extract	1445.77	Non-toxic
28	<i>Boswellia odorata</i> (ARB)	Aqueous extract	1491.95	Non-toxic
29	<i>Vachellia nilotica</i> (BGR)	Aqueous extract	1492.87	Non-toxic
30	<i>Tamarindus indica</i> (TSM)	Aqueous extract	1587.01	Non-toxic
31	<i>Senna singueana</i> (RNH)	Aqueous extract	—	Not determinable
32	<i>Moringa oleifera</i> (ZGL)	Aqueous extract	—	Not determinable
—	Standard (Potassium dichromate) *	Control	1.24	Highly Cytotoxic
—	Control (Artificial seawater) *	Control	2534.05	Non-toxic

DISCUSSION

Across all 16 species, ethanolic extraction yielded higher extracts than aqueous extraction. Ethanolic extraction yields ranged from 12.80% in *Vachellia nilotica* to 44.30% in *Ziziphus spina-christi*, while aqueous extraction yields ranged from 5.15% in *V. nilotica* to 18.20% in *Senna singueana*. This is attributed to the amphipathic nature of ethanol, which penetrates the lipophilic barriers of plant cell membranes and dissolves both moderately polar polyphenols and non-polar metabolites such as alkaloids, aglycone flavonoids, terpenoids, and resinous saponins. (Truong *et al.*, 2019). Conversely, water selectively extracts high-molecular-weight hydrophilic constituents, including polysaccharides, mucilages, and inorganic salts, which usually make up a smaller share of dry

plant mass (Zhang *et al.*, 2023).

The crude extract yields observed across the evaluated species reflect distinct taxon-specific phytochemical and structural profiles. The high ethanolic recovery from *Ziziphus spina-christi* (44.30%) and *Senna singueana* (41.75%) aligns with reports for *Rhamnaceae* and *Fabaceae* species (>38–42%), driven by rich accumulations of ethanol-soluble cyclopeptide alkaloids, flavonoid glycosides, and condensed tannins (Ammari *et al.*, n.d.). This contrasts with the moderate yields of the *Combretaceae* species *Guiera senegalensis* (32.00%) and *Anogeissus leiocarpa* (34.70%), which fall within the typical 28–36% range for hydrolyzable tannins and methoxylated flavonoids (Ojong *et al.*,

2026). Conversely, the suppressed recovery observed in *Vachellia nilotica* (12.80% ethanolic; 5.15% aqueous) and *Parkia biglobosa* (18.80% ethanolic; 6.10% aqueous) reflects patterns documented by Usman *et al.* (2023).

The physical appearance of the extracts reflected these chemical differences. Ethanolic extracts retained hydrophobic pigments such as chlorophylls and carotenoids, along with viscous terpenoids, yielding dark green to amber gummy pastes. Aqueous extracts dried to hygroscopic granules or powders enriched in free sugars and hydrophilic tannic salts (Green & Usman, 2022).

Phytochemical profiling revealed distinct taxon-specific metabolic strategies across the evaluated species. *Lepidium sativum*, *Z. spina-christi* and *Piliostigma reticulatum* tested positive for all nine metabolite classes, consistent with the rich alkaloid, glycoside and tannin content reported for arid-adapted flora (El-Ghani *et al.*, 2021). *G. senegalensis* and *A. leiocarpa* showed nearly complete profiles, dominated by hydrolyzable tannins and methoxylated flavonoids (Chomini *et al.*, 2021; Umma *et al.*, 2023). Cardiac glycosides were absent from *Annona senegalensis*, *S. singueana*, *V. nilotica* and *P. biglobosa*, which may point to tannin or anthraquinone-based chemical defences instead (Sabir *et al.*, 2025). The absence of lipophilic steroids and terpenoids in *Ricinus communis* is likely due to tissue- and environment-related variation (Green & Usman, 2022). *Boswellia odorata* showed the resin profile typical of Burseraceae, rich in triterpenic acids and volatile terpenes rather than tannins (Truong *et al.*, 2019).

Among the sixteen extracts screened, the ethanolic extracts of *Senna nigricans* (GZ ET) and *Ziziphus spina-christi* (MY ET) exhibited the strongest cytotoxicity (7.16 and 7.66 µg/mL, respectively), followed closely by the aqueous extract of *Piliostigma reticulatum* (KLG AQ= 9.50 µg/ml). This corroborates research in which *Senna singueana* leaf extract has separately been shown to inhibit HeLa cervical cancer cell proliferation via p53- and Bax-mediated intrinsic apoptosis, with its most active (chloroform) fraction exhibiting an LC50 of 20 µg/mL (Pantagada *et al.*, 2025). *Ziziphus spina-christi* is robustly established in existing literature as a source of cytotoxic dammarane-type saponins (christinins) (Bozicevic *et al.*, 2017). These specialized compounds exhibit low micromolar activity against lung, glioblastoma, breast, and colorectal cancer cell lines (Elmaidomy *et al.*, 2023). Conversely, their corresponding aqueous fractions were remarkably less potent or entirely non-toxic (1445.77 µg/ml for *Z. spina-christi*). This contrast conforms to recent pharmacological consensus that lower-polarity organic solvents like ethanol are exceptionally efficient at solubilising and concentrating lipophilic or semi-polar secondary metabolites such as cytotoxic alkaloids, terpenoids, and methoxylated flavonoids, which are largely left behind or degraded in purely aqueous systems (Abubakar & Haque, 2020).

Piliostigma reticulatum was the only exception to the solvent trend. Its aqueous extract was highly toxic (9.50 µg/mL), whereas its ethanolic extract was far less potent (116.07 µg/mL). This reversal suggests that the active constituents are polar, water-soluble compounds, such as saponins or tannin salts, that ethanol extracts poorly (Naczek & Shahidi, 2004). The aqueous fractions of *Senna singueana* and *Moringa oleifera* also gave no determinable LC50, which shows how strongly the choice of extraction solvent shapes the toxicity profile of traditional medicinal plants (Sultana *et al.*, 2009).

Conclusion

This study comprehensively evaluated the morphological features, extraction yields, qualitative phytochemical profiles, and acute cytotoxic potentials of sixteen medicinal plant species traditionally used in cancer management across Northern Nigeria. Across all evaluated species, ethanolic extraction consistently demonstrated superior recovery yields and a broader, more robust profile of secondary metabolites compared to aqueous extraction. Phytochemical screening confirmed the widespread presence of flavonoids, phenols, saponins, tannins, and steroids across both solvents. At the same time, lower-polarity classes such as anthraquinones and terpenoids were preferentially concentrated in ethanolic extracts. This highlights their promising potential for bioassay-guided fractionation, testing on human cancer cell lines, and safety profiling.

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