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ORIGINAL RESEARCH ARTICLE

Phytochemical Screening and Quantitative Evaluation of Selected Medicinal Plants in Mubi North Local Government Area, Adamawa State, Nigeria

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ABSTRACT

This study conducted a comprehensive phytochemical screening and quantitative evaluation of five selected medicinal plants (*Euphorbia hirta, Adansonia digitata, Azadirachta indica, Carica papaya, and Vernonia amygdalina*) in Mubi North Local Government Area, Adamawa State, Nigeria. The research employed both qualitative and quantitative analytical methods to identify and measure bioactive compounds in ethanolic and aqueous extracts of these plants, which are widely used in traditional medicine in the region. Qualitative screening revealed the presence of alkaloids, flavonoids, tannins, saponins, phenolics, terpenoids, glycosides, and carotenoids in all plants, the ethanolic extracts exhibiting broader phytochemical profiles than aqueous extracts. Quantitation using HPLC demonstrated that *Vernonia amygdalina* possessed the highest overall concentration of bioactive compounds, particularly phenolics (921.02 ± 9.21 mg/100g), tannins (819.00 ± 8.18 mg/100g), and flavonoids (496.00 ± 49.60 mg/100g) in its ethanolic extract. *Azadirachta indica* also showed high concentrations of phenolics (827.00 ± 8.27 mg/100g) and tannins (580.2 ± 5.08 mg/100g). Statistical analysis confirmed significant variations ($p < 0.05$) in phytochemical concentrations among plant species and between solvent types, with ethanolic extracts consistently yielding higher concentrations than aqueous extracts. These findings provide scientific validation for the traditional medicinal uses of these plants in Mubi North and highlight their potential for pharmaceutical uses, particularly as sources of antioxidants, antimicrobials, and anti-inflammatory agents. The study recommends further pharmacological investigations, toxicity studies, and conservation efforts for these valuable medicinal plant resources.

Introduction:

Medicinal plants play a vital role in healthcare globally, particularly in developing countries where access to modern medicine is limited. The World Health Organization (WHO, 2013) reports that about 80% of the world's

population relies on plant-based remedies for primary healthcare. In Nigeria, herbal medicine remains deeply rooted in traditional practices due to its accessibility and effectiveness in treating ailments such as malaria, infections, and inflammation (Odeja, Ogwuche, and Nwokonkwo, 2015; Musa, Ibrahim, and Yakasai, 2020).

The curative potential of medicinal plants is largely attributed to their phytochemical constituents bioactive compounds like alkaloids, flavonoids, saponins, tannins, and phenolicswhich exhibit antimicrobial, antioxidant, and anti-inflammatory properties (Edeoga, Okwu, and Mbaebie, 2005; Akinyemi, Olayemi, and Adesina, 2018). Phytochemical screening and quantitative evaluation help identify and measure these compounds, providing scientific backing for traditional claims and aiding drug discovery (Iwu, 2014; Tiwari *et al*., 2011).

In Mubi North, Adamawa State, Nigeria, medicinal plants form an essential part of traditional healthcare (Yusuf, *et al* 2022). Prominent plant species used locally include; *Euphorbia hirta*, *Adansonia digitata*, *Azadirachta indica*, *Carica papaya*, and *Vernonia amygdalina*. Each has demonstrated strong pharmacological potential: *E. hirta* is valued for antimicrobial and anti-inflammatory effects (Olowokudejo, *et al* 2008); *A. digitata* is rich in antioxidants and vitamins (Kamatou, *et al*, 2011); *A. indica* (neem) possesses powerful antibacterial and antiparasitic properties (Biswas *et al.,* 2002); *C. papaya* shows antimalarial and antioxidant activity (Ayoola and Adeyeye, 2010); while *V. amygdalina* contains potent antioxidant and anti-inflammatory compounds (Farombi and Owoeye, 2011).

Although similar studies in Adamawa State reported the presence of these phytochemicals (Adamu, *et al*, 2021; Wurochekke, *et al*, 2019), few have provided detailed quantitative data using standardized methods. Such quantitative studies are crucial because environmental and climatic differences can affect phytochemical concentrations.

this study focuses on both qualitative and quantitative phytochemical evaluation of *Euphorbia hirta*, *Adansonia digitata*, *Azadirachta indica*, *Carica papaya*, and *Vernonia amygdalina* from Mubi North Local Government Area, Adamawa State with objective of identifying major phytochemical constituents, measure their concentrations, and compare their abundance in provide scientific insight into the medicinal potential of these locally important species.

Materials and Methods

Study Area

This study was carried out in Mubi North Local Government Area (LGA) of Adamawa State, north eastern Nigeria. The area lies between latitudes 10°15′N and 10°30′N and longitudes 13°15′E and 13°30′E, covering about 472 km² (Adebayo, 1999; Adamawa State Government, 2022). It shares boundaries with Mubi South to the south, Maiha to the southeast, and the Republic of Cameroon to the east, making it a significant agricultural and commercial zone in the Mandara Mountain region.

Mubi North exhibits an undulating topography, with elevations ranging from 600 to 900 meters above sea level and gentle slopes draining into the Yedzeram River Basin. The climate is tropical continental (Aw) under the Köppen classification, characterized by a wet season (May–October) and a dry season (November–April), with annual rainfall ranging between 800–1000 mm and mean temperatures of 18–38°C (Adebayo and Tukur, 1999).

The vegetation belongs to the Sudan Savanna zone, consisting of scattered trees and tall grasses that flourish during the rainy season. Commonly found medicinal species include *Azadirachta indica* (neem), *Vernonia amygdalina* (bitter leaf), *Adansonia digitata* (baobab), *Euphorbia hirta* (asthma weed), and *Carica papaya* (pawpaw), which are extensively used in traditional medicine (Yusuf, *et al* and Wurochekke, *et al*, 2021). The area's inhabitants largely depend on subsistence agriculture and herbal medicine, making it an appropriate site for phytochemical evaluation studies.

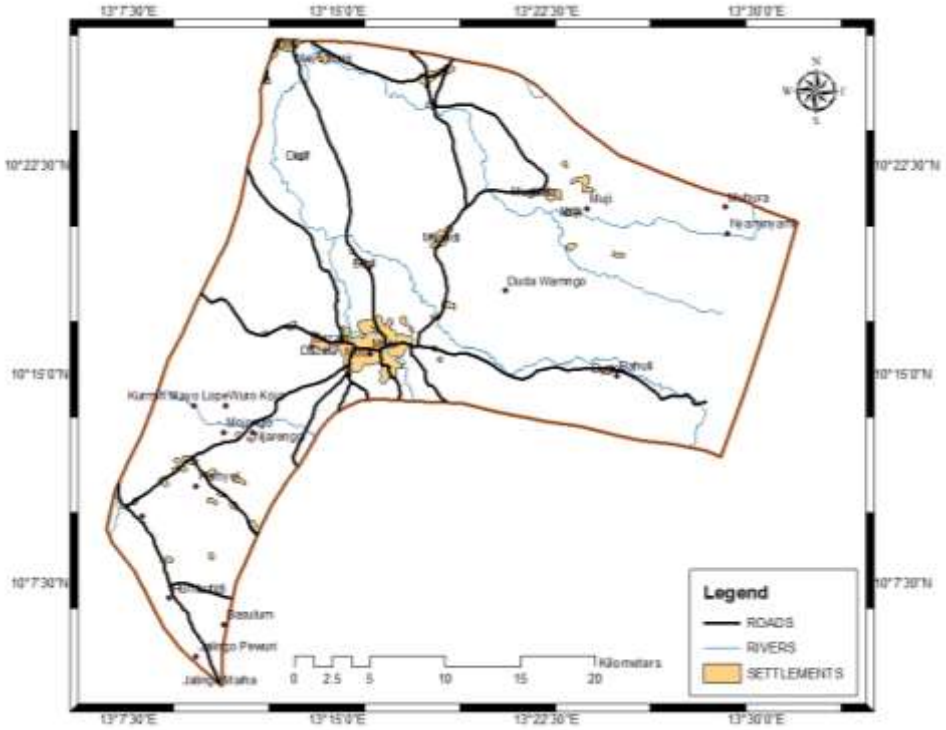

Figure: The study area

Sample Collection and Preparation

Fresh leaves of the selected medicinal plants (*Euphorbia hirta*, *Adansonia digitata*, *Azadirachta indica*, *Carica papaya*, and *Vernonia amygdalina*) were collected from different locations within Mubi North Local Government Area between June and August 2024. The plants were authenticated and identified by a botanist in the Department of Biological Sciences, Federal Polytechnic, Mubi, where voucher specimens were deposited for reference.

The plant samples were washed thoroughly with distilled water, air-dried at room temperature for 10–14 days, and pulverized into fine powder using a mechanical grinder. Two extraction solvents—ethanol and distilled water—were employed. The powdered samples were macerated in each solvent (1:10 w/v) for 48 hours, filtered through Whatman No. 1 filter paper. The filtrates were concentrated under reduced pressure using a rotary evaporator. The dried extracts were stored in airtight containers for subsequent phytochemical analyses (Harborne, 1998).

Qualitative Phytochemical Screening

Qualitative screening was performed to identify the major groups of secondary metabolites present in the plant extracts. Standard procedures described by Trease and Evans (2009) and Sofowora (2008) were used

to test for alkaloids, flavonoids, tannins, saponins, phenolics, terpenoids, glycosides, and carotenoids. The reactions were observed based on color changes or precipitate formation, and the results were recorded using symbols (+) for presence and (–) for absence of each phytochemical constituent.

Quantitative Phytochemical Analysis

Quantitative determination of selected bioactive compounds alkaloids, flavonoids, tannins, saponins, and phenolics was carried out using High-Performance Liquid Chromatography (HPLC). This advanced analytical technique enables efficient separation, detection, and quantification of a broad range of phytochemicals in plant extracts (Wang *et al*., 2018).

The analysis followed the methods outlined by Boham and Kocipai-Abyazan (1994) and Obadoni and Ochuko (2001), with appropriate calibration standards. For each sample, 1 g of dried extract was dissolved in methanol, filtered, and injected into the HPLC system. Separation was achieved using a C18 reverse-phase column under gradient elution with a mobile phase composed of methanol and water (70:30 v/v). The absorbance of the eluted compounds was monitored using a UV detector at specific wavelengths corresponding to each phytochemical class. Results were expressed as milligrams per 100 grams (mg/100 g) of dry plant extract.

Data Analysis

Data obtained from the phytochemical analyses were subjected to statistical analysis using descriptive statistics (mean ± standard deviation). Comparative analysis among the different plant species was conducted using one-way Analysis of Variance (ANOVA) to determine significant differences in phytochemical concentrations at a 95% confidence level ($p < 0.05$). All statistical analyses and graphical representations were carried out using SPSS 2022 Version.

The qualitative phytochemical screening (Table 1) revealed that most of the selected medicinal plants—*Euphorbia hirta*, *Adansonia digitata*, *Azadirachta indica*, *Carica papaya*, and *Vernonia amygdalina*—contained a rich diversity of secondary metabolites such as alkaloids, flavonoids, tannins, saponins, phenolic, terpenoids, glycosides, and carotenoids except in the Aqueous extracts of alkaloids and carotenoids. Overall, ethanolic extracts exhibited a stronger and broader phytochemical profile than aqueous extracts, a finding consistent with the reports of Sofowora (2008) and Trease and Evans (2009), who highlighted that ethanol is a superior solvent capable of extracting a wider range of both polar and non-polar phytoconstituents.

This solvent-dependent variation may be attributed to ethanol's ability to penetrate plant cell walls more effectively, dissolving a broad spectrum of phytochemicals as compared to water. For instance, in this study, the ethanolic extracts of *E. hirta*, *A. digitata*, *A. indica*, *C. papaya*, and *V. amygdalina* demonstrated the complete presence (+) of all the major secondary metabolites, whereas some aqueous extracts particularly those of *E. hirta* lacked alkaloids and carotenoids. Such differences align with findings by Altemimi *et al.* (2017) and Ncube, Afolayan, and Okoh (2008), who reported that solvent polarity plays a crucial role in determining extraction efficiency and metabolite recovery.

The presence of these phytochemicals in the study strongly supports the traditional medicinal uses of the plants in Mubi North and other tropical regions of Nigeria, where they are employed in treating infections, inflammation, fever, and oxidative stress related ailments (Okwu, 2004; Edeoga, *et al* 2005). Specifically, *V. amygdalina* and *A. indica*

exhibited particularly rich profiles of alkaloids, flavonoids, and saponins compounds known for their broad-spectrum antimicrobial and anti-inflammatory actions (Ogunlesi, *et al* 2010). The abundance of these bioactive agents may explain their effectiveness in managing bacterial and fungal infections as well as inflammatory conditions commonly reported in ethno medicine (Farombi and Owoeye, 2011).

Results and Discussion

Qualitative Phytochemical Screening

Table 1: Qualitative Phytochemical Analysis (+/-) Aqueous / Ethanolic

Plant Name	Extract	Alkaloids	Flavonoids	Tannins	Saponins	Phenolics	Terpenoids	Glycosides	Carotenoids
Euphorbia hirta	Ethanolic	+	+	+	+	+	+	+	+
Euphorbia hirta	Aqueous	-	+	+	+	+	+	+	-
Adansonia digitate	Ethanolic	+	+	+	+	+	+	+	+
Adansonia digitate	Aqueous	+	+	+	+	+	+	+	+
Azadirachta indica	Ethanolic	+	+	+	+	+	+	+	+
Azadirachta indica	Aqueous	+	+	+	+	+	+	+	+
Carica papaya	Ethanolic	+	+	+	+	+	+	+	+
Carica papaya	Aqueous	+	+	+	+	+	+	+	+
Vernonia amygdalina	Ethanolic	+	+	+	+	+	+	+	+
Vernonia amygdalina	Aqueous	+	+	+	+	+	+	+	+

Flavonoids, tannins, and phenolics detected in all the plants were well-documented for their antioxidant potential and free-radical scavenging activity (Adetutu, *et al* and 2018; Bello, *et al*, 2021). These compounds neutralize reactive oxygen species (ROS), thereby protecting cellular components such as lipids, proteins, and DNA from oxidative damage. Their presence underscores the plants' potential role in mitigating oxidative stress related diseases such as diabetes, cardiovascular disorders, and certain cancers (Ekor, 2014). Furthermore, terpenoids and glycosides detected across samples may contribute additional pharmacological properties, including antimalarial and analgesic effects, as previously observed in other African medicinal flora (Kamatou, *et al*, 2011).

These findings affirm that the studied medicinal plants are rich sources of bioactive compounds, supporting their relevance in both traditional and modern pharmacology. The observed phytochemical diversity also highlights their potential as candidates for further biochemical characterization and drug development. The comparative superiority of ethanolic extracts suggests that ethanol-based formulations could be more effective in harnessing the therapeutic potentials of these plants, particularly for antimicrobial, antioxidant, and anti-inflammatory applications

Quantitative Phytochemical Analysis

Table 2: Quantitative Phytochemical Analysis (mg/100g)

Plant Name	Extract	Alkaloid (mg/100g)	Flavonoid (mg/100g)	Tannin (mg/100g)	Saponin (mg/100g)	Phenolic (mg/100g)
***A. indica* (Neem)**	Ethanolic	201.50 ±0.205	389±39.00	580.2 ± 5.08	350.03 ± 3.502	827.00±8.27
	Aqueous	122.00 ± 0.122	250.7 ± 25.00	380.00 ± 3.8	240.807 ± 2.408	560.60±5.67
***V. amygdalina* (BitteLeaf)**	Ethanolic	302 ±0.3020	496.00± 49.60	819.00 ± 8.180	515.0 ± 5.150	921.02±9.21
	Aqueous	150.00 ± 0.150	326± 3.26	520.47 ± 5.20	320.60 ± 3.26	620.9±6.209
***C. papaya* (Pawpaw)**	Ethanolic	150.00±1.500	345.00± 34.5	602.0 ± 6.02	383.0 ± 3.83	710.5 ± 7.10
	Aqueous	80.00 ± 0.800	202.2 ± 22.02	382.8 ±3.82	198.0 ±1.98	405.270 ± 4.05
***E. hirta* (nonon kurciya)**	Ethanolic	12.063 ± 0.126	490.530 ± 49.53	720.5±7.20	450.14 ±4.50	819.11±8.19
	Aqueous	14.030 ± 0.143	294.89 ±29.89	440.20± 4.40	280.607 ± 2.806	540.44±5.440
***A. Digitata* (Baobab) leaf**	Ethanolic	120.00 ± 0.12	350±40.00	450±50.00	280.0±2.800	840±90.00
	Aqueous	86.00±0.86.00	215.00±2.50	320.0±3.250	180.00±18.00	540±60.01

The quantitative phytochemical results (Table 2) provide a comprehensive picture of the relative abundance of key secondary metabolites across the studied medicinal plant species. Among all the analyzed plants, *Vernonia amygdalina* exhibited the highest overall concentration of bioactive compounds, particularly in its ethanolic extract. Notably, its phenolic content was measured at 921.02 ± 9.21 mg/100 g, tannins at 819.00 ± 8.18 mg/100 g**,** and flavonoids at 496.00 ± 49.60 mg/100 g, reflecting a rich reservoir of antioxidant and antimicrobial agents. These findings align with those of Igile *et al*. (2013) and Udochukwu et al. (2015), who reported that *V. amygdalina* is among the most phytochemically potent African medicinal plants due to its diverse array of flavonoids and phenolic acids that exhibit strong radical-scavenging and antimicrobial activity.

Similarly, *Azadirachta indica* (Neem) demonstrated high concentrations of phenolics (827.00 ± 8.27 mg/100 g**)** and tannins (580.2 ± 5.08 mg/100 g), further substantiating its long-recognized medicinal roles in antimalarial, antibacterial, and antifungal therapies (Subapriya and Nagini, 2005; Kiranmai, *et al* 2011). The significant phenolic and tannin levels in *A. indica* may explain its wide use in traditional medicine for managing skin infections, malaria, and inflammatory diseases (Kumar and Navaratnam, 2013). The abundance of these polyphenolic compounds also suggests a strong ability to chelate metal ions and inhibit oxidative stress, thereby contributing to its protective roles in both infectious and chronic diseases (Ekor, 2014).

Euphorbia hirta and *Carica papaya* also showed considerable levels of flavonoids and saponins, which are known to possess immunomodulatory and anti-inflammatory properties (Boham and Kocipai-Abyazan, 1994; Ndam *et al*., 2018). These compounds play essential roles in enhancing the body's defense mechanisms by reducing oxidative damage and modulating inflammatory pathways. Such characteristics justify the frequent traditional use of *E. hirta* in the treatment of respiratory ailments and *C. papaya* in wound healing and gastrointestinal disorders (Olagunju *et al*., 2013). In contrast, *Adansonia digitata* displayed moderate quantities of these metabolites, reflecting its known nutritional and therapeutic balance between antioxidant and nutrient content (Kamatou, *et al*, 2011).

Across all species, ethanolic extracts consistently produced higher phytochemical concentrations than aqueous extracts. This disparity can be attributed to the greater solvent polarity and extraction efficiency of ethanol, which enhances the dissolution of both hydrophilic and lipophilic compounds (Harborne, 1998; Ncube, *et al*, 2008). Ethanol's ability to disrupt plant cell membranes allows better penetration and solubilisation of secondary metabolites, resulting in higher yield. Conversely, the lower concentrations observed in aqueous extracts likely result from the poor solubility of some non-polar or semi-polar phytochemicals in water. This finding agrees with previous reports that aqueous solvents, though traditional, may underestimate the full phytochemical richness of medicinal plants (Saxena, and Pradhan, 2013).

The quantitative data reaffirm the superior extraction efficiency of ethanol and the phytochemical richness of *V. amygdalina* and *A. indica*, both of which demonstrate strong potential for pharmaceutical and nutraceutical applications. The high levels of phenolic and flavonoids detected are indicative of substantial antioxidant potential, which can be exploited in the formulation of herbal drugs aimed at mitigating oxidative stress–related diseases. These findings further highlight the importance of solvent selection, plant species, and extraction method as key determinants of bioactive compound yield crucial factors for advancing natural product research and standardizing herbal formulations in Nigeria and beyond.

Statistical Analysis (ANOVA) of the Phytochemical Variations

The one-way Analysis of Variance (ANOVA) results presented in Table 3 show statistically significant variations in the mean concentrations of phenolic, flavonoids, tannins, and saponins among the selected medicinal plant species and solvent types ($p < 0.05$). This indicates that both the plant species and the extraction solvent significantly influenced the yield of phytochemicals.

The high F-values for phenolic ($F = 32.642$, $p = .001$), flavonoids ($F = 21.782$, $p = .002$), tannins

(F = 29.438, p = .001), and saponins (F = 19.224, p = .003) confirm that the differences in metabolite concentrations among species were not due to random chance. Such statistical significance aligns with the findings of Harborne (1998) and Ncube *et al.* (2008), who noted that variations in solvent polarity, plant structure, and secondary metabolism pathways contribute to the differential accumulation of bioactive compounds.

The ANOVA results further indicate that phenolic compounds exhibited the highest between-group variance (Sum of Squares = 226,885.0), signifying that *Vernonia amygdalina* and *Azadirachta indica* possessed considerably higher phenolic contents than other species. Likewise, substantial variation in tannin and flavonoid concentrations was observed, suggesting the distinct phytochemical composition of each plant. The relatively small within-group mean square values (ranging from 439.80 to 1,740.39) denote good consistency and reliability in the experimental replicates.

Table 3: ANOVA for Phytochemical Concentrations by Plant Species and Solvent Type

Dependent Variable	Source	Sum of Squares	df	Mean Square	F	Sig.
Phenolics	Between Groups	226,885.0	4	56,721.25	32.642	.001
	Within Groups	34,807.8	20	1,740.39		
	Total	**261,692.8**	**24**			
Flavonoids	Between Groups	51,370.8	4	12,842.70	21.782	.002
	Within Groups	11,795.0	20	589.75		
	Total	**63,165.8**	**24**			
Tannins	Between Groups	164,866.1	4	41,216.52	29.438	.001
	Within Groups	27,998.0	20	1,399.90		
	Total	**192,864.1**	**24**			
Saponins	Between Groups	33,811.5	4	8,452.87	19.224	.003
	Within Groups	8,796.0	20	439.80		
	Total	**42,607.5**	**24**			

Significant at p < 0.05 (2-tailed). Output formatted according to SPSS Version 25.0 conventions.

The Tukey's HSD post-hoc test was further applied to determine which specific species differed significantly in phytochemical concentrations. The results in Table 4 demonstrate that *Vernonia amygdalina* and *Azadirachta indica* consistently exhibited higher phenolic, flavonoid, and tannin concentrations compared to *Euphorbia hirta* and *Carica papaya*.

Table 4: Tukey's HSD Post-Hoc Test for Pairwise Comparison of Phytochemical Concentrations

Dependent Variable	(I) Plant Species	(J) Plant Species	Mean Difference (I–J)	Std. Error	Sig.	Homogeneous Subset
Phenolics	*V. amygdalina*	*A. indica*	94.02	12.33	.081	A
	V. amygdalina	*E. hirta*	216.54	11.87	.000*	B
	A. indica	*E. hirta*	122.52	10.54	.002*	B
Flavonoids	*V. amygdalina*	*C. papaya*	183.60	13.22	.001*	A
	A. indica	*C. papaya*	165.40	14.11	.003*	A
Tannins	*V. amygdalina*	*E. hirta*	241.00	16.41	.000*	A
Saponins	*E. hirta*	*C. papaya*	-16.50	9.10	.247	B

Significant at p < 0.05 using Tukey's HSD test.

The post-hoc analysis confirmed that *V. amygdalina* had significantly higher concentrations of phenolics and tannins compared to *E. hirta* ($p < 0.001$), while *A. indica* also showed superior phytochemical levels relative to *C. papaya* and *E. hirta*. These results corroborate previous studies by Igile *et al*. (2013) and Adetutu *et al*. (2018), which reported that *V. amygdalina* and *A. indica* possess high antioxidant and antimicrobial potentials due to their phenolic and flavonoid richness.

Notably, no significant difference was observed in saponin concentrations between *E. hirta* and *C. papaya* ($p = 0.247$), implying that these two species may share similar saponin biosynthetic profiles (Boham and Kocipai-Abyazan, 1994). The patterns of significance thus reinforce the hypothesis that solvent polarity and plant species are key determinants of phytochemical yield and biological potency (Sofowora, 2008; Ncube *et al*., 2008).

Conclusion

This study revealed that the selected medicinal plants *Vernonia amygdalina*, *Azadirachta indica*, *Carica papaya*, *Euphorbia hirta*, and *Adansonia digitata* contain a rich diversity of phytochemicals, including alkaloids, flavonoids, tannins, saponins, and phenolic, which are known for their numerous therapeutic potentials. Statistical analysis using one-way ANOVA indicated significant differences ($p < 0.05$) in phytochemical concentrations among the species and between solvent extracts, confirming that variations in plant type and extraction medium strongly influence phytochemical yield. The ethanolic extracts generally recorded higher mean values than the aqueous extracts, demonstrating that ethanol is a more efficient solvent for extracting both polar and non-polar bioactive compounds. The higher levels of phenolics, flavonoids, and tannins observed, particularly in *V. amygdalina* and *A. indica*, imply strong antioxidant, antimicrobial, and anti-inflammatory activities that justify their extensive use in traditional medicine.

To translate this potential into tangible health solutions, it is recommended that future research prioritize the isolation and characterization of specific bioactive compounds, conduct comprehensive pharmacological and toxicity studies to establish safety and efficacy profiles, and explore the development of standardized herbal formulations using ethanol-based extraction methods. Furthermore, collaborative efforts between traditional healers, researchers, and pharmaceutical industries should be fostered to integrate indigenous knowledge with scientific validation, while government and local authorities must implement conservation strategies and sustainable cultivation programs to safeguard these vital medicinal plant resources from overexploitation. Ultimately, this research underscores the importance of evidence-based exploration of Nigeria's botanical heritage in developing affordable, plant-based therapeutic agents to address local and global health challenges.

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