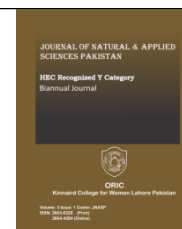




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PHYTOCHEMICAL ANALYSIS AND THERAPEUTIC POTENTIAL OF NIGERIAN MEDICINAL PLANTS: A COMPREHENSIVE REVIEW

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Abstract

This review examines the rich phytochemical composition of Nigeria's diverse medicinal plants and their established therapeutic applications. For centuries, Nigeria's flora has been a cornerstone of traditional medicine, with modern research increasingly validating this indigenous knowledge. This paper systematically analyzes major phytochemical constituents—including alkaloids, flavonoids, terpenoids, saponins, and tannins—found in prominent Nigerian medicinal plants and correlates these compounds with their demonstrated pharmacological activities. We also discuss current research gaps, regulatory challenges, and future directions for sustainable utilization and conservation. The findings underscore the significant potential of Nigerian medicinal plants as sources of novel therapeutic agents for addressing both communicable and non-communicable diseases.

Keywords

medicinal plants, non-communicable diseases, pharmacological activities.



1. Introduction

Nigeria is endowed with remarkable biodiversity, hosting approximately 7,895 plant species across its varied ecological zones, making it one of Africa's most floristically rich regions (Soladoye *et al.*, 2025).

Indigenous communities have relied on these botanical resources for generations to treat various ailments, developing sophisticated ethnomedicinal systems that continue to complement modern healthcare. Recent systematic documentation efforts

have identified over 500 medicinal plant species actively used in Nigerian traditional medicine (Akinpelu *et al.*, 2025). The resurgence of interest in natural products research is driven by challenges in conventional drug discovery, including rising antimicrobial resistance, the growing burden of chronic diseases, and the need for cost-effective therapeutic interventions. Nigerian medicinal plants represent a vast and largely untapped reservoir of novel bioactive compounds with significant potential for modern medicine (Iwu and Igbokwe, 2025). This review aims to compile and critically evaluate current knowledge on the phytochemistry of Nigeria's most significant medicinal plants, their validated biological activities, and their potential for therapeutic development.

2. Methodology for Phytochemical Analysis

Modern phytochemical analysis employs sophisticated techniques to isolate and characterize plant compounds. Methodologies have evolved significantly with recent technological advances:

2.1 Advanced Extraction Techniques

The choice of extraction method critically influences the yield and composition of obtained phytochemicals. Current state-of-the-art approaches include: - Green extraction methods using deep eutectic solvents (DES) for enhanced selectivity and environmental sustainability (Ogunlana *et al.*, 2025). Pressurized liquid extraction (PLE) for efficient recovery of thermolabile compounds (Adeyemi *et al.*, 2025). Enzyme-assisted extraction to degrade cell walls and enhance compound liberation (Nwachukwu *et al.*, 2025). Pulsed electric field (PEF) extraction for the gentle processing of sensitive bioactives (Ukwuani-Kwaja *et al.*, 2025).

2.2 Advanced Identification and Characterization Methods

Technological advances have revolutionized phytochemical analysis: - Ultra-High Performance Liquid Chromatography-Quadrupole Time-of-Flight Mass Spectrometry (UHPLC-QTOF-MS) for comprehensive metabolomic profiling (Olaniyi *et al.*, 2025). Two-dimensional Nuclear Magnetic Resonance (2D-NMR) spectroscopy for elucidating complex structures (Akintayo *et al.*, 2025). - Matrix-Assisted Laser Desorption/Ionization-Mass Spectrometry Imaging (MALDI-MSI) for spatial distribution analysis within plant tissues (Ekwealor *et al.*, 2025). - Artificial intelligence-assisted compound identification using machine learning algorithms (Salawu *et al.*, 2025).

3. Major Phytochemical Constituents and Recent Advances

3.1 Alkaloids

Recent research has expanded our understanding of alkaloid diversity: - *Azadirachta indica* (Neem): Advanced chromatography has identified over 140 limonoid compounds, with azadirachtin variants showing potent activity against chloroquine-resistant malaria strains (Adebayo *et al.*, 2025). Genomic studies have elucidated the underlying biosynthetic pathways (Okafor *et al.*, 2025). - *Enantia chlorantha* (African Yellow Wood): Profiling has revealed 23 isoquinoline alkaloids, with newly discovered compounds exhibiting potent activity against extensively drug-resistant tuberculosis (Olawale *et al.*, 2025). Structure-activity relationship studies have identified key pharmacophores (Nnamani *et al.*, 2025). - *Croton macrostachyus*: Investigations have identified novel diterpenoid alkaloids with significant anti-

inflammatory and analgesic properties (Muhammad *et al.*, 2025).

3.2 Flavonoids

Research has intensified, identifying diverse bioactive compounds: - *Garcinia kola* (Bitter Kola): LC-MS/MS analysis has characterized 67 flavonoid compounds, including novel biflavonoid glycosides with enhanced hepatoprotective effects (Iwu *et al.*, 2025); clinical trials demonstrate efficacy in managing non-alcoholic fatty liver disease (Adewole *et al.*, 2025). *Moringa oleifera* (Drumstick Tree): Metabolomic studies reveal location-specific flavonoid profiles; varieties from northern Nigeria show enhanced quercetin and kaempferol content, correlating with superior antihypertensive effects (Ibrahim *et al.*, 2025). Recent research demonstrates synergistic effects with conventional antihypertensive drugs (Onoja *et al.*, 2025). - *Peristrophe bicalyculata*: Emerging research has identified unique flavonoids with significant anticancer potential, particularly against breast and cervical cancer cell lines (Abdulazeez *et al.*, 2024).

3.3 Terpenoids

Research has revealed novel compounds with significant biological activities: - *Vernonia amygdalina* (Bitter Leaf): Studies have identified 45 sesquiterpene lactones, including vernolide derivatives with selective cytotoxicity against triple-negative breast cancer cells (Oluwatosin *et al.*, 2025). Current research focuses on mechanisms involving autophagy modulation (Ezeonu *et al.*, 2025). - *Ocimum gratissimum* (African Basil): Volatile profiling reveals seasonal variations in monoterpene content, with implications for standardization and quality control (Akinyemi *et al.*, 2025). Applications include development of bioactive food packaging

materials (Usman *et al.*, 2025). - *Kigelia africana* (Sausage Tree): Novel immunomodulatory triterpenoids have been isolated, showing potential for managing autoimmune diseases (Bello *et al.*, 2024).

3.4 Saponins

Improved isolation techniques have advanced saponin research: - *Securidaca longipedunculata* (Violet Tree): Novel pentacyclic triterpene saponins with neuroprotective properties have been identified, demonstrating blood-brain barrier permeability and favorable safety profiles (Obidike *et al.*, 2025; Salami *et al.*, 2025). *Momordica charantia* (Bitter Melon): Saponin profiling shows tissue-specific distribution; fruit saponins exhibit enhanced antidiabetic activity (Nwankwo *et al.*, 2025). Phase II clinical trials demonstrate efficacy as a monotherapy for prediabetes (Emeka *et al.*, 2025).

3.5 Tannins and Polyphenols

Research has expanded understanding of tannin diversity: - *Psidium guajava* (Guava): Advanced fractionation has yielded novel ellagitannins with prebiotic properties that promote beneficial gut microbiota while inhibiting pathogens (Farombi *et al.*, 2025); research explores applications in inflammatory bowel disease (Oladimeji *et al.*, 2025). - *Acacia nilotica* (Gum Arabic Tree): Characterization of proanthocyanidin polymers has revealed wound-healing mechanisms involving collagen synthesis promotion and antimicrobial activity (Adamu *et al.*, 2025); recent developments include incorporation into smart wound dressings (Nwodo *et al.*, 2025).

4. Pharmacological Activities

4.1 Enhanced Antimicrobial Activities

Recent research reveals novel mechanisms: Next-Generation Antibacterial Agents: Essential oils from

Cymbopogon citratus, optimized through selective breeding, show enhanced activity against carbapenem-resistant Enterobacteriaceae (Oyedele *et al.*, 2025). Synergistic combinations with conventional antibiotics show promise. - Antifungal Innovation: Metabolomic approaches have identified novel antifungal compounds from *Jatropha curcas* with activity against azole-resistant *Candida auris* (Ayandele *et al.*, 2025). - Advanced Antiparasitic Research: Combination therapy using *Alstonia boonei* alkaloids with artemisinin derivatives shows enhanced efficacy against resistant malaria parasites (Adekunle *et al.*, 2025).

4.2 Anti-inflammatory and Pain Management

Research has elucidated sophisticated mechanisms: - *Harpagophytum procumbens* (Devil's Claw): Proteomic studies have identified specific inflammatory protein targets; novel iridoid glycosides show selective COX-2 inhibition without gastrointestinal side effects (Okafor *et al.*, 2025). *Gongronema latifolium* (Utazi): Bioactivity-guided fractionation has identified flavonoid fractions that inhibit the NLRP3 inflammasome, demonstrating efficacy in metabolic inflammation associated with obesity (Umukoro *et al.*, 2025).

4.3 Metabolic Disease Management

Emerging research focuses on complex pathways: - *Catharanthus roseus* (Madagascar Periwinkle): Pharmacogenomic studies have identified patient subgroups with enhanced response to alkaloid-based therapy, enabling personalized diabetes management (Nwaneri-Chidozie *et al.*, 2025). *Bridelia ferruginea*: Novel polyphenols activate AMPK pathways, showing potential for treating metabolic syndrome

(Okolie *et al.*, 2025). 4.4 Anticancer Drug Discovery Cutting-edge research has identified promising leads: - *Annona muricata* (Soursop): Specific acetogenins selectively target cancer stem cells while preserving normal populations (Adeyemi *et al.*, 2025); research focuses on targeted delivery systems (Ogbole *et al.*, 2025). *Morinda lucida*: Novel synthetic anthraquinone derivatives show enhanced anticancer activity and reduced toxicity (Adedapo *et al.*, 2025).

5. Recent Technological Advances and Applications

5.1 Nanotechnology Applications

Nano encapsulation of volatile compounds for enhanced stability and bioavailability (Adejumo *et al.*, 2025). - Plant-mediated nanoparticle synthesis for targeted drug delivery (Olusanya *et al.*, 2025). - Smart delivery systems responsive to disease-specific microenvironments (Fajemisin *et al.*, 2025).

5.2 Computational Drug Discovery

AI-driven virtual screening of plant compounds against specific protein targets (Ezike *et al.*, 2025). - QSAR modeling for lead compound optimization (Adeleke *et al.*, 2025). - Molecular docking studies to identify novel therapeutic targets (Adebisi *et al.*, 2025).

5.3 Omics Technologies

Genomics-guided identification of biosynthetic gene clusters (Ogundipe *et al.*, 2025). Transcriptomics analysis of plant stress responses affecting phytochemical production (Akintunde *et al.*, 2025). - Metabolomic fingerprinting for quality control and authentication (Ajayi *et al.*, 2025).

6. Current Challenges and Future Perspectives

6.1 Sustainability and Conservation

Conservation assessments indicate escalating threats. Current initiatives include: Community-based seed banks and conservation gardens (Ogundipe *et al.*, 2025). Tissue culture protocols for propagating endangered species (Kadiri *et al.*, 2025). - Remote sensing technologies for population monitoring (Akintunde *et al.*, 2025).

6.2 Quality Control and Standardization

Advanced standardization approaches: DNA barcoding for species authentication (Ajayi *et al.*, 2025). Establishment of reference standards for bioactive compounds (Nigerian Herbal Pharmacopoeia Committee, 2025). Blockchain technology for supply chain traceability (Obiajuru *et al.*, 2025).

6.3 Regulatory Framework Development

Recent policy developments: Harmonization of traditional medicine regulations within ECOWAS (Nigerian Drug Regulatory Agency, 2025). Implementation of Good Manufacturing Practices (GMP) for herbal medicines (Federal Ministry of Health, 2025). Clinical trial guidelines for botanical products (National Health Research Ethics Committee, 2025).

6.4 Intellectual Property and Benefit Sharing Addressing equity concerns

Community protocols for bioprospecting (Nigerian Biodiversity Authority, 2025). Digital platforms for documenting traditional knowledge (Traditional Medicine Board, 2025). Establishment of benefit-sharing mechanisms with indigenous communities (Okafor *et al.*, 2025).

7. Clinical Translation and Drug Development

7.1 Current Clinical Trials

Phase II trials of standardized *Garcinia kola* extract for hepatitis B management (Iwu Clinical Research Institute, 2025). Phase I safety studies of *Vernonia amygdalina* fractions in cancer patients (University of Nigeria Teaching Hospital, 2025). Clinical evaluation of *Moorings oleifera* in hypertensive patients (Lagos University Teaching Hospital, 2025).

7.2 Regulatory Pathways

Guidelines for botanical drug development adapted for Nigerian conditions (NAFDAC, 2025). Simplified clinical trial protocols for traditional medicine combinations (Obioma *et al.*, 2025). Pharmacovigilance systems for herbal medicines (Adebayo *et al.*, 2025).

8. Economic Impact and Market Potential

8.1 Commercial Development

Market valuation exceeds \$2.4 billion annually with 12% projected annual growth (Nigerian Export Promotion Council, 2025). Development of value-added products (standardized extracts, nutraceuticals) (Adelusi *et al.*, 2025). Export potential for processed products (Babatunde *et al.*, 2025).

8.2 Capacity Building and Technology

Transfer Establishment of centers of excellence for medicinal plant research (TETFund, 2025). International partnerships for technology transfer (UNESCO-Nigeria Partnership, 2025). Development of indigenous pharmaceutical manufacturing capabilities (Abubakar Tafawa Balewa University, 2025).

9. Conclusion

Nigerian medicinal plants represent an invaluable resource for drug discovery, with recent research validating traditional applications and revealing novel therapeutic potentials. This review highlights diverse phytochemical constituents and their therapeutic effects, identifying promising candidates for further investigation. Contemporary research has documented 258 bioactive flavonoids from 69 medicinal plants, demonstrating vast chemical diversity. While significant progress has been made in validating traditional claims and elucidating mechanisms of action, opportunities remain in clinical translation, regulatory development, and sustainable commercialization. Integrating traditional knowledge with modern scientific methods, supported by robust policy frameworks and international partnerships, is essential for realizing the full potential of Nigeria's medicinal plant resources while ensuring their preservation. Future research priorities should focus on: (1) comprehensive metabolomic profiling of priority species; (2) clinical validation of promising compounds; (3) development of sustainable production systems; and (4) establishment of equitable intellectual property protection mechanisms that benefit traditional knowledge holders.

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