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Ethnobotany and phytochemistry of medicinal plants used in Rwanda: implications for ethnopharmacology and pharmacy practice

Abstract

Background: Rwanda harbours exceptional botanical diversity within the Albertine Rift, and its population has relied on plant-based therapeutics for centuries. Despite this heritage, a comprehensive synthesis linking Rwandan ethnobotanical knowledge to modern pharmacy practice is lacking.

Objectives: This review critically synthesizes published ethnobotanical literature on Rwandan medicinal plants (1987–2025), with particular emphasis on phytochemical characterization, pharmacological validation, pharmaceutical formulation potential, regulatory developments, and research gaps relevant to clinical pharmacy and drug discovery.

Methods: A structured narrative review was conducted using PubMed/MEDLINE, Google Scholar, ScienceDirect, Web of Science, World Health Organization (WHO) databases, and Rwandan governmental and institutional reports. Search terms included combinations of Rwanda, ethnobotany, medicinal plants, traditional medicine, phytochemistry, pharmacology, and specific disease terms. The literature selection process was systematized and mapped using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow framework to detail study inclusion, exclusion, and information synthesis.

Results: Over 700 medicinal plant species have been documented in Rwanda, across therapeutic domains including gastrointestinal disorders, liver disease, malaria, cancer, skin conditions, and respiratory infections. Key species including *Vernonia amygdalina*, *Erythrina abyssinica*, *Tetradenia riparia*, and *Clerodendrum myricoides* demonstrate scientifically validated phytochemical profiles including flavonoids, alkaloids, tannins, sesquiterpene lactones, and terpenoids consistent with their traditional applications. Rwanda's pharmaceutical landscape is undergoing transformation through the National Industrial Research and Development Agency (NIRDA) Phyto Social Enterprise (POSE) project, Good Manufacturing Practice (GMP) facility upgrades, and the imminent launch of the country's first certified phytomedicines.

Conclusions: Rwanda's ethnobotanical heritage represents a significant pharmaceutical resource that remains insufficiently valorized. Bridging traditional knowledge with GMP-compliant formulation, pharmacovigilance, and clinical evidence generation is essential to reduce the country's 98% pharmaceutical import dependence and advance patient care.

Keywords: ethnobotany, Rwanda, medicinal plants, phytochemistry, pharmacy, traditional medicine, pharmacognosy, drug discovery, phytomedicine

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Introduction

Ethnobotany is the scientific study of the dynamic relationships between human societies and the plant kingdom, occupying a foundational position in the history of pharmaceutical science. The majority of drugs currently in clinical use, from aspirin (acetylsalicylic acid, derived from *Salix spp.*) to the anti-malarial artemisinin (derived from *Artemisia annua L.*), trace their origins to ethnobotanical observation and traditional therapeutic practice.[1] In sub-Saharan Africa, where conventional pharmaceutical supply chains remain constrained, this relationship between community botany and healthcare delivery remains acutely relevant rather than merely historical.

Rwanda, the "Land of a Thousand Hills," presents an ethnobotanical setting of exceptional richness. Positioned within the Albertine Rift, one of Africa's most biodiverse regions, the country encompasses a compressed altitudinal gradient from lowland savanna (~950 m) to Afromontane forest and the high-altitude slopes of the Virunga Massif (>4,500 m), supporting a correspondingly diverse flora estimated at over 2,500 vascular plant species.[2] Of these, research by the AGA Rwanda Network of traditional healers has estimated that over 700 possess recognized medicinal applications, though only a fraction has received rigorous phytochemical or pharmacological investigation.[3]

In the Rwandan healthcare system, the relevance of traditional botanical medicine is both epidemiological and economic. Approximately 60–80% of Rwandans consult traditional healers as a first point of care.[4] Meanwhile, Rwanda imported approximately 98% of its medicines as recently as 2019, spending nearly US$100 million annually — a structural vulnerability the government is now seeking to address partly through the valorisation of medicinal plant resources.[5] The WHO has itself acknowledged that over 40% of pharmaceutical formulations in use globally are derived from natural products, and that 11% of the 252 drugs on the WHO Essential Medicines List originate from plants.[6]

This review aims to provide a comprehensive and critically appraised synthesis of the ethnobotanical literature pertaining to Rwanda, with specific emphasis on the pharmaceutical implications

of documented plant use. It systematically addresses: (i) the scope and cultural context of Rwandan medicinal plant use; (ii) major disease categories and corresponding botanical remedies; (iii) the phytochemical and pharmacological evidence base for key species; (iv) traditional preparation methods and their pharmaceutical analogues; (v) conservation, sustainability, and supply chain challenges; (vi) the regulatory environment for phytomedicines; and (vii) research priorities for the pharmacy profession.

Methods: Search strategy, selection criteria, and synthesis

This review was conducted according to the general principles of systematic literature synthesis, adapted for the ethnobotanical and ethnopharmacological scope of the subject. Literature research was performed across primary electronic databases including PubMed/MEDLINE, Google Scholar, ScienceDirect, and Web of Science. Regional and grey literature resources were accessed via the WHO African Office publications portal, Rwandan Ministry of Health (MoH) resources, and National Industrial Research and Development Agency (NIRDA) institutional documents.

The search strategy combined terms using Boolean operators: ("Rwanda") AND ("ethnobotany" OR "medicinal plants" OR "traditional medicine" OR "phytotherapy" OR "pharmacy" OR "pharmacology" OR "phytochemistry" OR "drug discovery" OR "herbal medicine"). Additional disease-specific iterations incorporated terms such as "diarrhoea", "malaria", "hepatitis", "cancer", "skin diseases", "tuberculosis", "respiratory infection", and "diabetes". Language restrictions were limited to English and French. The targeted publication timeline ranged from 1987 (marking Kayonga and Habiyaremye's foundational Centre Universitaire de Recherche sur la Pharmacopée et la Médecine Traditionnelle Africaine [CURPHAMETRA] report) to April 2026. To ensure structural transparency and methodological rigor, the study selection process followed a PRISMA-style workflow mapping the identification, screening, eligibility, and inclusion phases, as detailed in Figure 1.

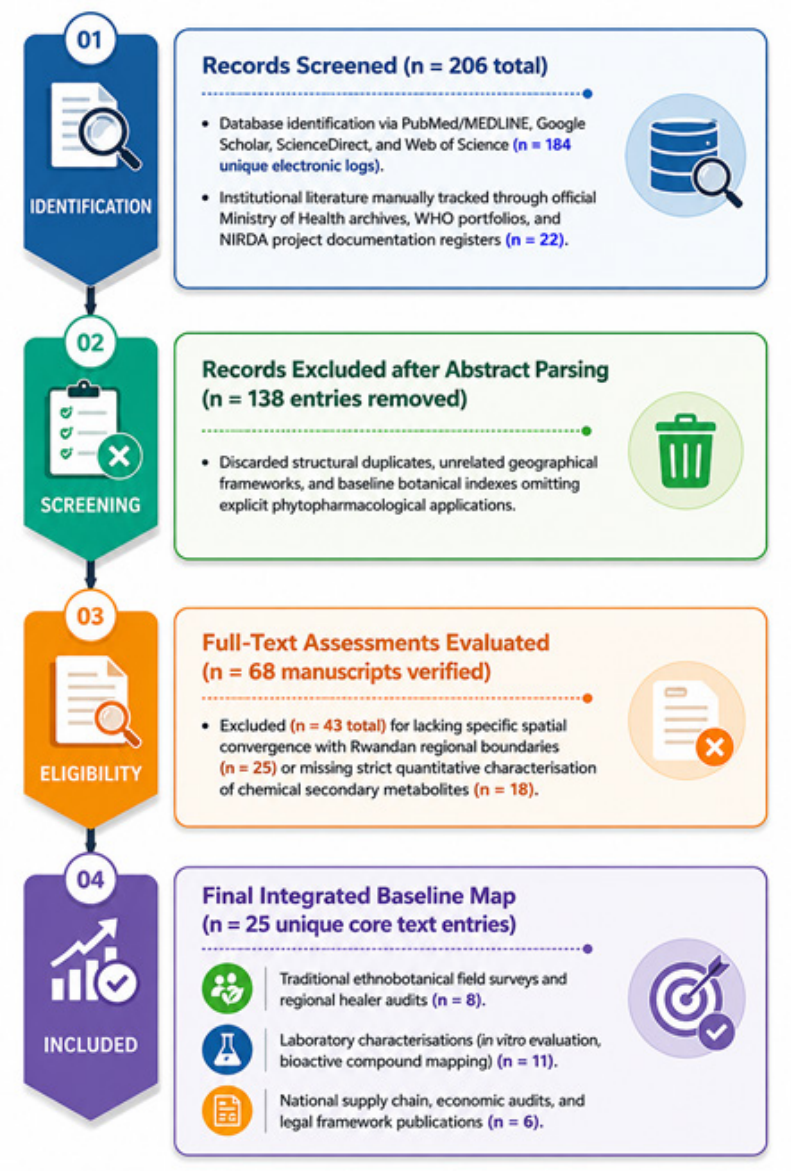

Figure 1 PRISMA flow matrix mapping structural search limits, validation partitions, and dataset inclusion boundaries.

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Data synthesis and harmonization

Information from the 25 included studies was extracted into a standardised matrix categorised by botanical family, species, Kinyarwanda vernacular name, plant part utilised, preparation methodology, and targeted therapeutic domain. Quantitative data regarding species abundance and family distribution were cross-referenced to eliminate synonym overlaps. Qualitative information concerning ethnopharmacological preparation methods was mapped directly against modern pharmaceutical processing operations to identify direct operational analogues.

Cultural and historical context of medicinal plant use in Rwanda

Pre-colonial and colonial heritage

Documented Rwandan ethnomedical practice predates written records. The CURPHAMETRA, founded in Rwanda and referenced in regional pharmacopoeia literature since the 1980s, represents one of the earliest formal attempts to document and systematically evaluate Rwandan traditional healing plants.[7] Colonial-era accounts and post-independence compilations, including Kayonga and Habiyaremye's 1987 study of the Gisenyi prefecture flora, established a baseline catalogue of ethnomedicinal species, parts used, and methods of preparation that subsequent researchers have built upon.[8]

The introduction of Western biomedicine during the colonial period created a hierarchical relationship in which traditional healing was frequently marginalised or delegitimised. As one analysis of post-colonial Rwanda noted, colonial medicine systematically displaced indigenous therapeutic traditions, and much botanical knowledge was subsequently transmitted only through oral lineages, making it vulnerable to generational loss as elder healers pass away without formally trained successors.[9]

The role of traditional healers (Inanga / Umuvuzi)

Traditional healers in Rwanda, known locally as *inanga* (diviners) or *umuvuzi gakondo* (herbalists), function within a socio-medical framework that integrates empirical plant knowledge with community cosmology. African traditional medicine operates across three specialist levels: divination, spiritualism, and herbalism, with herbalism constituting the domain most directly relevant to pharmacognosy.[10] The AGA Rwanda Network currently counts over 3,000 registered traditional healers, against an estimated national total of approximately 14,000 practitioners, the vast majority of whom work outside any formal quality assurance framework.[3]

The transmission of botanical healing knowledge in Rwanda has historically occurred through oral apprenticeship within family lines. This oral tradition, while culturally embedded, creates significant pharmaceutical risks: undocumented dosing, variable preparation methods, lack of species verification, and an absence of pharmacovigilance. A pharmacist engaging with traditional medicine in Rwanda must understand this epistemological gap between the empirically refined but invalidated knowledge of the herbalist and the evidence standards required of a pharmaceutical product as the central challenge facing the field.

Disease categories and corresponding botanical therapeutics

Gastrointestinal disorders

Diarrhoeal disease constitutes the most extensively documented area of Rwandan ethnobotany, reflecting both the high burden of gastrointestinal illness driven by unsafe water, inadequate sanitation, and a high prevalence of enteric pathogens, and the pressing need for affordable alternatives to conventional antimicrobials in the context of rising antimicrobial resistance (AMR).[11] A landmark systematic review by Gahamanyi and colleagues (2021), published in *Antibiotics*, identified 63 plant species across 35 families used for diarrhoeal management in Rwanda, sourced from 17 published studies and specialized herbarium records.[11]

The most frequently reported anti-diarrhoeal species were *Vernonia amygdalina (Delile), Tetradenia riparia (Hochst.) Codd, Clerodendrum myricoides R. Br.,* and *Chenopodium ugandae* (Aellen).[11] Ramathal and Ngassapa (2001), in an earlier foundational study of Rwandese traditional healers' plant use conducted from refugee camps in northern Tanzania, documented 57 species addressing gastrointestinal, obstetric, febrile, and antiparasitic applications including decoctions of *Albizia adianthifolia* for diarrhoea and of *Entada abyssinica* for diarrhoea and poisoning.[12]

From a pharmaceutical sciences perspective, the AMR context is particularly compelling. Undiagnosed diarrhoea treated empirically with broad-spectrum antimicrobials, particularly ciprofloxacin, whose overuse has been implicated in resistance emergence, creates the epidemiological pressure that makes plant derived anti-infectives especially relevant. Several Rwandan medicinal species have demonstrated in vitro antimicrobial activity against diarrhoea-causative bacteria including *Escherichia coli*, *Salmonella spp*., and *Shigella spp*., lending scientific credibility to ethnobotanical selection.[11]

Liver disease and Hepatoprotective plants

Liver disease constitutes the ninth most common cause of morbidity in Rwanda, with viral hepatitis and its complications (cirrhosis, hepatocellular carcinoma) accounting for an estimated 80% of all hepatic pathology at the University Hospital of Butare.[13] The limited therapeutic arsenal available within the formal healthcare system — vaccines, interferon, and hepatoprotective agents such as silymarin from *Silybum marianum* has created a significant niche for traditional botanical hepatotherapy.[13]

A detailed phytotherapy survey of Southern Rwanda by Mukazayire and colleagues (2011), published in the Journal of Ethnopharmacology, engaged 56 traditional health practitioners (each the legal representative of an official healer association) and identified 86 herbal species from 34 families used in hepatitis treatment, across 68 multi-component and 65 single-component recipes.[13] This study stands as the most rigorous ethnobotanical investigation of hepatoprotective plant use in Rwanda to date, and its findings directly inform the pharmacognostic agenda for liver protective drug discovery in the region.

Malaria and antiparasitic applications

Malaria remains a leading cause of morbidity in Rwanda, with *Plasmodium falciparum* responsible for most clinical cases. Ethnobotanical surveys consistently identify *Vernonia amygdalina* as the preferred plant for malaria treatment among Rwandan traditional healers.[14] This preference is pharmacologically coherent: the species contains sesquiterpene lactones—structurally related to the sesquiterpene class from which artemisinin is derived and has demonstrated antiplasmodial activity in multiple in vitro studies.[15]

The emergence of artemisinin partial resistance in Rwanda, documented through surveillance of Pfkelch13 mutations (particularly A675V), intensifies the urgency of identifying new antiplasmodial leads from the national flora.[16] Ethnobotanical data provide a rational, culturally validated starting point for such discovery efforts, representing an efficient pre-screening strategy for the pharmacologist compared to random compound library screening.

Cancer and anticancer ethnobotany

Ethnobotanical documentation of plant use in cancer treatment in Rwanda and the adjacent Kivu region (Democratic Republic of the Congo [DRC]) is less mature but rapidly growing. Marhegeko and colleagues (2016) conducted a field survey of traditional healers

in the Bukavu area; a region sharing flora with eastern Rwanda; documenting plant remedies targeting blood, breast, uterine, lung, liver, and skin cancers, administered as decoctions, infusions, fresh juices, and cataplasms.[17] The authors noted that approximately half of the species cited matched published scientific studies on anticancer activity, providing preliminary ethnopharmacological validation.[17]

Skin disorders and wound healing

A distinctive contribution of Rwandan ethnobotanical research is the pharmacognostic investigation of plants used in voluntary depigmentation, a culturally specific therapeutic goal. The survey by Niyigena and colleagues (2013), published in the Journal of Ethnopharmacology, documented 190 plant species in 61 families and 152 genera used for diverse health conditions in Rwanda, with Fabaceae as the dominant family (14% of documented species).[19] The application of High Performance Liquid Chromatography (HPLC) guided fractionation to skin active plant extracts in this study, identifying an A-type proanthocyanidin from *Litchi chinensis* roots with anti-tyrosinase activity, exemplifies the transition from ethnobotanical observation to pharmaceutical lead isolation that more Rwandan plant studies should pursue.[14]

Key medicinal species: Phytochemistry and pharmacological evidence

Table 1 summarizes the most pharmacologically significant medicinal plant species documented in the Rwandan ethnobotanical literature. The following subsections provide detailed analyses of the most critically important species.

Table 1 Key medicinal plant species in Rwandan ethnobotany and their pharmaceutical relevance

Family	Species	Kinyarwanda	Therapeutic use	Key phytochemicals	Part used
Asteraceae	*Vernonia amygdalina Delile*	Umubirizi	Diarrhoea, malaria, fever, diabetes	Sesquiterpene lactones, flavonoids, alkaloids	Leaf
Asteraceae	*Bidens pilosa L.*	Umusunsuri	Wound healing, anti-infective	Flavonoids, polyacetylenes, terpenes	Leaf
Fabaceae	*Erythrina abyssinica Lam.*	Umurinzi	Diarrhoea, malaria, inflammation, HIV	Flavonoids, alkaloids, terpenoids	Bark
Fabaceae	*Albizia adianthifolia W.F.Wight*	Umusange	Diarrhoea, fever	Saponins, tannins	Leaf, Bark
Lamiaceae	*Tetradenia riparia (Hochst.) Codd*	Umuravumba	Diarrhoea, respiratory infections	Saponins, tannins, terpenoids	Leaf
Lamiaceae	*Clerodendrum myricoides R. Br.*	Umushashati	Diarrhoea, dysentery	Tannins, flavonoids, alkaloids	Leaf
Chenopodiaceae	*Chenopodium ugandae (Aellen)*	Umugombe	Diarrhoea, intestinal parasites	Terpenes, sterols, saponosides, flavonoids	Leaf
Euphorbiaceae	*Euphorbia tirucalli L.*	Inshuke	Skin disorders, antimicrobial	Diterpene esters, triterpenoids	Latex
Moraceae	*Ficus thonningii Blume*	Umugumo	Gastrointestinal, wound healing	Tannins, flavonoids	Bark
Asparagaceae	*Dracaena afromontana Mildbr.*	Isekera	Diarrhoea, malaria	Steroidal saponins	Leaf
Myrtaceae	*Psidium guajava L.*	Amapera	Diarrhoea, antimicrobial	Tannins, flavonoids, triterpenoids	Leaf

Sources: Gahamanyi, et al;[11] Ramathal & Ngassapa;[12] Mukazayire, et al;[13] Niyigena, et al;[14] Ugbogu, et al;[15] Obakiro SB, et al.[18]

***Vernonia amygdalina (Delile)* (Asteraceae)—Umubirizi**

Vernonia amygdalina, commonly known as bitter leaf, is arguably the most pharmacologically scrutinized medicinal plant in the Rwandan ethnobotanical corpus. Used across East, Central, and West Africa for gastrointestinal complaints, fever, malaria, diabetes, and antimicrobial indications, it represents a global convergence of ethnobotanical knowledge around a single species.[15]

Phytochemical profiling has identified a complex secondary metabolite profile: sesquiterpene lactones (vernodalin, vernolide, hydroxyvernolide), flavonoids (luteolin, luteolin-7-O-glucoside), alkaloids (steroidal and indole classes), saponins, glycosides, cyanogenic glycosides, tannins, and phenolic compounds.[15] The sesquiterpene lactones are of particular pharmaceutical interest, having demonstrated cytotoxic activity against cancer cell lines and antiplasmodial activity consistent with their structural analogy to artemisinin. The flavonoid fraction contributes to the validated antioxidant, anti-inflammatory, and hepatoprotective activities documented in animal studies.[15]

From a pharmacy formulation standpoint, *V. amygdalina* presents both opportunities and challenges. Its broad-spectrum bioactivity profile including hypoglycaemic, antimalarial, hepatoprotective, and antimicrobial properties makes it a candidate for multi-indication phytomedicine development. However, the cyanogenic glycoside content necessitates careful processing controls during manufacturing to prevent hydrolytic release of hydrogen cyanide, highlighting the non-trivial toxicological considerations that distinguish phytomedicine development from simple extract preparation.[15]

***Erythrina abyssinica Lam.* ex DC. (Fabaceae)—Umurinzi**

Erythrina abyssinica is a socio-culturally prominent tree in Rwanda, used ceremonially in addition to its medicinal applications. It is harvested by traditional practitioners across East, Central, and Southern Africa for indications including bacterial and fungal infections, tuberculosis, malaria, Acquired Immunodeficiency Syndrome (AIDS)/HIV, diarrhoea, cancer, meningitis, inflammatory disorders, urinary tract infections, wound management, diabetes, and dermatological conditions.[18]

The pharmacological breadth of *E. abyssinica* extracts and isolated phytochemicals encompassing anti-inflammatory, antibacterial, antioxidant, antiplasmodial, antiproliferative, antifungal, antimycobacterial, antidiarrhoeal, anti-HIV-1, antidiabetic, and

antiobesity activities reflects its rich flavonoid, alkaloid, and terpenoid chemistry.[18] The alkaloid fraction is of particular interest to pharmaceutical chemistry, as Erythrina alkaloids (erythraline, erysotrine) possess Central Nervous System (CNS)-active properties and have been investigated as pharmacophore templates.

***Tetradenia riparia (Hochst.) Codd* (Lamiaceae)—Umuravumba**

Tetradenia riparia is among the top-cited anti-diarrhoeal plants in Rwanda, with saponins and tannins identified as the primary bioactive fractions.[11] Its aromatic essential oil fraction has also attracted attention for potential antimicrobial and antiplasmodial activities. The species is widely cultivated in Rwandan homegardens as both a culinary and medicinal plant — an example of the food-medicine continuum that characterises much of Rwandan ethnobotany and has implications for nutraceutical as well as pharmaceutical development.

***Psidium guajava L.* (Myrtaceae) — Amapera**

Guava (*Psidium guajava*) represents a species where global pharmacological evidence robustly supports its Rwandan traditional use in diarrhoeal management. The tannin and flavonoid content of guava leaves have been mechanistically linked to anti-secretory and anti-motility effects in multiple pre-clinical models, and clinical evidence from other regions lends credibility to its therapeutic potential.[11] Its wide availability in Rwanda and known safety profile make it a high-priority candidate for phytomedicine formulation and clinical evaluation.

Preparation methods and pharmaceutical analogues

The methodologies of traditional Rwandan herbal preparation map onto established pharmaceutical processes in ways that carry direct implications for quality assurance, standardization, and formulation development. Table 2 presents the primary preparation methods documented in the Rwandan ethnobotanical literature alongside their pharmaceutical equivalents.

Table 2 Traditional preparation methods and their pharmaceutical analogues

Preparation method	Characteristics	Pharmacological relevance	Pharmaceutical equivalent
Aqueous decoction	Boiling of plant parts in water; most common (>60% of preparations)	Extracts water-soluble polyphenols, flavonoids, tannins; antimicrobial activity demonstrated	Aqueous extract; basis for standardised oral phytomedicines
Cold infusion	Soaking in cold water; used for sensitive volatile-compound-rich species	Preserves heat-labile constituents (e.g., essential oils, labile alkaloids)	Analogous to cold maceration in pharmacopoeial extraction
Fresh juice	Mechanical pressing of leaves or stems; applied topically or ingested	Retains unstable enzymes and direct-acting phenolics; rapid onset	Corresponds to expressed juice preparations (succus) in herbal pharmacopoeia
Topical cataplasm	Ground fresh plant material applied directly to skin	Direct contact delivery of anti-inflammatory and wound-healing compounds	Analogous to poultice/ointment dosage forms; basis for NIRDA skin ointments
Multi-herb compound recipe	Combination of 2–10+ plant species in a single preparation	Potential synergistic phytochemical interactions; complexity increases toxicological assessment challenge	Corresponds to polyherbal formulations; requires multi-constituent quality control

Sources: Gahamanyi, et al;[11] Ramathal & Ngassapa;[12] Marhegeko, et al;[17] NIRDA.[5]

The predominance of aqueous decoctions (>60% of documented preparations) is pharmacologically significant: boiling in water selectively extracts water-soluble secondary metabolites — polyphenols, flavonoids, tannins, water-soluble alkaloids, and polar saponins — while concentrating heat-stable bioactive fractions. This mirrors the aqueous extraction processes used in standard pharmacopoeial preparation of herbal medicines, providing a rational basis for process validation and scale-up.[11] However, traditional decoctions lack critical quality attributes required in registered pharmaceutical products: no standardized active constituent concentration, no validated shelf-life, no batch reproducibility data, and no sterility testing.

Multi-herb compound recipes, documented extensively in the hepatitis study of Mukazayire et al. (2011),[13] present the greatest formulation challenge and scientific opportunity simultaneously. Polyherbal preparations may exhibit pharmacological synergy (additive or potentiating interactions between constituent active compounds) or pharmacokinetic enhancement (one plant constituent improving the absorption or bioavailability of another's active components). Conversely, herb-herb interactions may produce antagonism or potentiate toxicity. No systematic study of polyherbal interaction among Rwandan traditional recipes has yet been published — a significant gap that pharmaceutical scientists at the University of Rwanda are positioned to address.

Safety, toxicology, and pharmacovigilance

Safety assessment of traditional plant medicines is among the most critical and most neglected areas of Rwandan ethnopharmacology. The published literature consistently identifies the absence of toxicity and posology data as a primary limitation.[11] This gap is not merely academic: plant-derived phytochemicals can cause significant organ toxicity, herb-drug interactions, and developmental harm if used without appropriate characterization.

Potential sources of toxicity in traditionally prepared Rwandan medicines include: (i) intrinsically toxic phytoconstituents such as tropane alkaloids, cardiac glycosides, and pyrrolizidine alkaloids in certain species; (ii) route-of-administration and dose-dependent effects; (iii) contaminants introduced during harvesting and processing; (iv) misidentification of botanical species, particularly among morphologically similar taxa; and (v) herb-drug interactions in patients concurrently using conventional pharmaceuticals.[19]

Rwanda has developed a National Pharmacovigilance and Medicine Information System, with specific provisions for safety monitoring of herbal medicines integrated into the framework. The Rwanda Food and Drug Authority (FDA) Guidelines for Pharmacovigilance and Medicine Information include a dedicated section on herbal medicine safety surveillance, encompassing spontaneous adverse event reporting and active surveillance mechanisms.[20] However, the

extension of these systems to encompass the informal traditional medicine sector — where most of the plant-based therapeutic activity occurs — remains an ongoing challenge.

The WHO has identified 70% of Rwanda's population as users of traditional medicine, a prevalence that demands integration of traditional medicine pharmacovigilance into the national health information system.[21] Pharmacists, as medication safety experts, are ideally positioned to lead this integration, educating both traditional healers and patients about adverse event recognition and reporting, and advocating for the inclusion of herbal medicine use in routine medication history-taking.

Conservation, biodiversity, and sustainable supply chains

The pharmaceutical potential of Rwandan medicinal plants is inseparable from their ecological viability. The AGA Rwanda Network has documented that over 700 medicinal plant species face decline due to anthropogenic pressure: agricultural land conversion, deforestation, settlement expansion, and unsustainable wild harvesting.[3] Among the most at-risk pharmacologically important species is *Prunus africana* (Hook.f.) Kalkman, whose bark is used for urological and anti-inflammatory indications and is globally traded, making it particularly vulnerable to over-exploitation in the Rwandan Afromontane zone.[11]

From a pharmaceutical supply chain perspective, wild harvesting of medicinal plant material introduces quality variability that is incompatible with pharmaceutical standardization. Seasonal variation in phytochemical content, ecotypic differences between collection sites, post-harvest processing variability, and the absence of certified Good Agricultural and Collection Practices (GACP) all compromise the consistency of the raw material upon which dosage form development depends. The WHO guidelines for GACP in medicinal plants (2003) provide the international standard against which Rwandan cultivation programmes should be benchmarked.

NIRDA's earmarking of 100 hectares for the cultivation of medicinal plants, together with the establishment of a botanical garden at the Huye Research Centre and a training programme for farmers cultivating species including *Plantago lanceolata, Capsicum frutescens,* and *Calendula officinalis,* represents Rwanda's most tangible step toward GACP-compliant supply chain development.[4] These cultivated botanical resources will provide the traceable, standardized raw material required for GMP-compliant phytomedicine manufacturing.

The regulatory and pharmaceutical industry landscape

Policy framework

Rwanda has developed a national policy on traditional, complementary, and alternative medicine, and has integrated traditional medicine considerations into its national health policy and strategic plans.[21] The WHO African Region guidelines for the Registration of Traditional Medicines provide the continental regulatory framework within which Rwanda's national legislation is positioned, proposing minimum requirements for pharmaceutical quality, safety, and efficacy across categories of traditional medicine products.[22]

NIRDA and the POSE project

The National Industrial Research and Development Agency (NIRDA) is the primary government actor in Rwanda's phytomedicine industrialization effort. A NIRDA audit of the existing herbal medicine sector exposed critical deficiencies: no enterprise in Rwanda met GMP standards, the majority operated entirely manual processes without automation, quality control was absent, and product standardization was non-existent.[5]

In response, NIRDA launched the Phyto Social Enterprise (POSE) Project in partnership with FXB-Rwanda in February 2023. The project has upgraded Rwanda's Phytomedicine Facility to GMP standards, incorporating certified production processes, laboratory testing (purity, efficacy, stability), and compliance with Rwanda FDA, Rwanda Standards Board (RSB), and WHO requirements.[4,5] Three products are approaching commercial launch: an anti-inflammatory wound and burn ointment, an anti-rheumatic ointment, and an expectorant herbal syrup for respiratory infections — Rwanda's first domestically produced and certified phytomedicines.[4]

The pharmaceutical significance of this milestone cannot be overstated. Certified phytomedicines, distributed through licensed pharmacies, subject to post-market surveillance, and manufactured under GMP, represent a qualitative transformation from artisanal herbal production to regulated pharmaceutical products. The Pharmacy Department at the University of Rwanda has identified local production as foundational to supply security and cost reduction — aligning with Rwanda's broader "Made in Rwanda" pharmaceutical policy.[4]

Import dependence and economic rationale

Rwanda's 98% pharmaceutical import dependence — representing approximately US$100 million in annual expenditure as of 2019 — creates both vulnerability and opportunity.[5] The global herbal medicine market is projected to grow from US$205.2 billion (2024) to US$533.6 billion by 2033, at a compound annual growth rate (CAGR) of 11.2%.[23] Rwanda, positioned as an emerging economy within an East African Community (EAC) market of over 300 million people, has a realistic opportunity to develop phytomedicine exports alongside domestic supply — provided it establishes the quality infrastructure required for regional and international market access.

Research gaps and priorities for pharmacy and pharmaceutical sciences

The synthesis of available literature reveals the following priority research needs for the pharmacy profession in Rwanda:

1. Systematic Toxicological Characterization: Evaluate the 63 anti-diarrhoeal species identified by Gahamanyi et al.,[11] prioritizing acute and subacute oral toxicity, organ-specific toxicity (hepatic, renal), and genotoxicity assays as a prerequisite for clinical application.
2. Pharmacokinetic Studies: Investigate the most cited therapeutic species to establish bioavailability, plasma half-life, metabolic pathways, and protein binding data currently absent from the Rwandan ethnopharmacological literature.
3. Randomised Controlled Trials (RCTs): Perform clinical testing for the most pharmacologically validated species (*V. amygdalina, P. guajava*) in their primary therapeutic indications (anti-diarrhoeal, antidiabetic), to generate the clinical evidence required for Rwanda FDA registration as pharmaceutical-grade products.
4. Polyherbal Interaction Studies: Assess the safety and potential synergy of the multi-component recipes documented in the hepatitis and diarrhoea literature to open translational pharmacological research avenues.
5. GACP Implementation Research: Conduct agronomic studies on yield optimization, harvest timing, and post-harvest processing for key medicinal species to establish reproducible phytochemical profiles suitable for pharmaceutical standardization.
6. Curriculum Integration: Embed ethnobotanical and pharmacognostic training into the University of Rwanda's pharmacy curriculum, with dedicated modules on phytomedicine regulation, quality control, and clinical evidence evaluation.
7. Pharmacovigilance Extension: Develop community-based adverse event reporting mechanisms specific to herbal medicine use, fully integrated into Rwanda's existing health information framework.

Conclusion

Rwanda's ethnobotanical heritage represents one of the country's most underutilized pharmaceutical assets. This review has demonstrated that the published literature, while growing, remains insufficient relative to the documented diversity of medicinal plant use, with rigorous phytochemical, pharmacological, and clinical evidence available for only a small fraction of the species in traditional therapeutic use.

The interface between ethnobotany and pharmacy in Rwanda is simultaneously a challenge and an opportunity: a challenge because the quality, safety, and efficacy standards of modern pharmacy practice are currently unmet by most traditional preparations; an opportunity because the ethnobotanical evidence provides rational, culturally embedded therapeutic leads that, subjected to appropriate scientific scrutiny and pharmaceutical development, could substantially reduce Rwanda's pharmaceutical import dependence while improving health access and outcomes.

Rwanda's regulatory and industrial trajectory, exemplified by the POSE project, GMP facility upgrades, NIRDA's botanical garden, and the imminent commercial launch of the country's first certified phytomedicines, signals that this opportunity is now being structurally grasped. The pharmacy profession, through research, education, clinical practice, and regulatory engagement, has an indispensable role in ensuring that Rwanda's botanical wealth is translated into safe, effective, and affordable medicines for its population.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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