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Review Article

A Comprehensive Review of the Botany, Phytochemistry, Bioactive Constituents and Therapeutic Potential of *Rauvolfia vomitoria* Afzel

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Abstract

Medicinal plants remain an essential part of traditional healthcare systems in Africa and their potential benefits are attracting significant attention in global scientific research. *Rauvolfia vomitoria*, a member of the Apocynaceae family, is widely used in African traditional medicine to treat various ailments, including neurological and cardiovascular disorders. Numerous scientific studies have validated its many uses, highlighting its potential as a therapeutic agent. This narrative review aims to summarize and critically analyze recent data on the botany, phytochemical profile and pharmacology of *R. vomitoria*, identifying research gaps that can be addressed to fully explore the plant's therapeutic potential. Relevant scientific literature was retrieved from major databases, including Google Scholar, Scopus, PubMed and SpringerLink, using appropriate keyword combinations. Only English-language studies focusing on the botany to explore the plant's therapeutic potential fully, traditional uses, phytochemistry and pharmacological activities of *Rauvolfia vomitoria* were considered for inclusion. Searches yielded several research articles and review papers. It appears that *R. vomitoria* contains diverse bioactive molecules, mainly indole alkaloids such as reserpine, ajmaline, ajmalicine, yohimbine and serpentine, as well as flavonoids, tannins and phenolic acids. These compounds have been reportedly linked to several pharmacological activities such as anti-hypertensive, anti-psychotic, anti-inflammatory and anti-cancer. *Rauvolfia vomitoria* is a valuable medicinal plant showing promising pharmacological potential, supported by traditional uses and pharmacological studies. Future research, especially on its safety and clinical efficacy, is needed to facilitate its development as a standardized herbal medicine.

Key words: *Rauvolfia vomitoria*, indole alkaloids, pharmacological activity, traditional medicine, conventional healthcare

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Medicinal plants play a central role in primary healthcare systems in Africa, where traditional remedies remain widely used. Throughout human history, communities across different regions have relied on plants for the prevention and treatment of diseases. Nowadays, scientific evaluation of traditional remedies is attracting growing global interest. *Rauvolfia vomitoria*, of the *Apocynaceae* family, is one of the most widely used plants in traditional African medicine. Native to the tropical regions of Africa and Asia, it is commonly known as ''African serpentwood'' or ''poison devil's pepper''[1]. The plant has long been traditionally used to manage several ailments such as hypertension, mental and neurological disorders, insomnia, fever, gastrointestinal problems, liver diseases and certain forms of cancer[2,3]. Its roots, bark, leaves and seeds are prepared in different forms such as decoctions, infusions and powders, depending on local therapeutic practices[4].

Phytochemical analyses on *R. vomitoria* have revealed the presence of a wide variety of secondary metabolites. These include alkaloids, tannins, saponins, flavonoids, steroids, terpenoids and cardiac glycosides[5]. Subsequent studies have reinforced their pharmacological interest by highlighting their anticancer potential[6,7]. Their antiplasmodial activity[8] and their positive influence on sexual performance and reproductive function in male rats has also been reported[9]. Additional studies have highlighted the plant's neuroprotective potential[10], antimicrobial activity[5] and hypolipidemic effects[11]. The pharmacological value of *R. vomitoria* has also been recognized for its potential as a source of bioactive compounds in modern drug discovery[12].

For more than two millennia, *R. vomitoria* has played a central role in African traditional medicine, particularly in the management of hypertension and neurological disorders. Recent scientific studies have justified its efficacy as an antipsychotic, antihypertensive and anti-inflammatory agent, as well as its ability to improve blood circulation and hematological parameters. As scientific research continues to reveal the potential of natural products in healthcare, *R. vomitoria* continues to be a subject of interest for its potential therapeutic applications[2,13].

A recent comprehensive review further strengthens current knowledge on the botany, ethnomedicinal uses, pharmacology, phytochemistry and clinical relevance of the species. underscoring the continued scientific interest in its therapeutic potential[14].

Given the extensive traditional applications of the plant and its rich chemical diversity, it is important to consolidate the growing knowledge and pharmacological evidence accumulated over the years. This will provide a comprehensive review of the traditional uses, phytochemistry and pharmacology of *R. vomitoria*, while also identifying existing research gaps and future directions to ensure its safe and effective use.

MATERIALS AND METHODS

This review summarizes current knowledge on the traditional medicinal uses of *R. vomitoria* and evaluates its therapeutic potential based on available scientific data. It also highlights research gaps related to its pharmacological properties, mechanisms of action and possible therapeutic applications.

Search strategy: A comprehensive literature search was conducted to identify relevant studies on *R. vomitoria*. The following Key search terms: "Traditional uses of *Rauvolfia vomitoria*", "Ethnopharmacology of *Rauvolfia vomitoria*", "Biological activities of *Rauvolfia vomitoria*", "Toxicological evaluation of *Rauvolfia vomitoria*", "Taxonomy of *Rauvolfia vomitoria*", "Pharmacological effects of *Rauvolfia vomitoria*", and "Phytochemical composition of *Rauvolfia vomitoria*", were introduced into major online databases such as PubMed, ScienceDirect, Google Scholar, SciFinder, SpringerLink and Wiley. Boolean search operators (AND, OR) were applied to refine and combine terms for better accuracy and coverage. Data collection was conducted between October 2023 and July 2025. Only peer-reviewed English-language publications were included.

Inclusion criteria:

- Studies on traditional uses and pharmacological properties of *R. vomitoria*
- Preclinical and clinical trials that evaluate his therapeutic effects
- Articles on his phytochemical composition or bioactive constituents
- Peer-reviewed publications in English and available up to the review date

Exclusion criteria:

- Studies unrelated to the plant's traditional uses, pharmacology, phytochemistry or Botanical description
- Non-English studies without available translations
- Non-original research articles

Data extraction and analysis: All relevant articles that met the inclusion criteria were reviewed and analyzed in their entirety. The information extracted from each study included the year of publication, country of study, part of the plant used, type of extract, main phytochemical constituents, experimental models, pharmacological activities and main conclusions. The data were classified into thematic categories based on traditional uses, phytochemistry, pharmacological effects and toxicity.

Synthesis and critical appraisal: The extracted data were analyzed qualitatively. The findings were synthesized to identify consistent patterns between traditional applications and experimentally validated pharmacological effects. Differences in extraction methods, dosages and experimental designs were critically examined to assess the reliability and reproducibility of reported outcomes. Limitations such as variability in study design, lack of clinical trials and insufficient mechanistic investigations were also discussed to provide a balanced and evidence-based evaluation of *R. vomitoria*'s therapeutic potential.

RESULTS AND DISCUSSION

Botanical overview: The genus "*Rauvolfia*", sometimes spelled "*Rauwolfia*", pays tribute to Leonhart Rauvolf, a 16th-Century German physician renowned for his numerous expeditions in medicinal flora collection. The epithet "*vomitoria*" attributed to the species refers to the bark's historical recognition for its emetic and purgative properties[15].

Taxonomy: The accepted scientific name of the species is now *Rauvolfia vomitoria* Afzel. It is commonly known in English as "Swizzle stick". Its EPPO code is "RAUVO"[16]. The plant's taxonomic classification is summarized in Table 1.

Morphology and reproductive biology: *Rauvolfia vomitoria* (*Apocynaceae*; 2n = 22, 66) is a perennial shrub or small tree native to the tropical regions of West Africa. It typically grows 2-4 m high, with glossy dark-green leaves and small fragrant white flowers arranged in terminal clusters[17]. The plant has an upright, glabrous stem with leaves that are broadly ovate to elliptic, measuring approximately 5 to 12 cm in length and 3 to 6 cm in width and arranged in whorled patterns along the stem. Its inflorescences form cymes, commonly grouped in fours, carrying small flowers that range from greenish to pale green in color. The corolla is subcylindrical, about 6 to 12 mm long, with an enlarged throat and a pubescent inner surface. Stamens are inserted at the corolla throat, forming a ring-like arrangement that is slightly shorter than the ovaries. The ovaries are separate and topped with slender styles that are hairy at the base and terminate in a fleshy pistil head. The fruit is a fleshy red drupe, sometimes occurring in pairs, oval to ellipsoid in shape and measuring roughly 0.8-1.4 cm in length and 6-9 mm in width. Flowering generally takes place from August to October, followed by fruiting between October and December[18].

Table 1: Taxonomic classification of *Rauvolfia vomitoria*[16]

Domain	*Eukaryota*
Kingdom	*Plantae*
Phylum	*Spermatophyta*
Subphylum	*Angiospermae*
Class	*Dicotyledonae*
Order	*Gentianales*
Family	*Apocynaceae*
Genus	*Rauvolfia*
Species	*Rauvolfia vomitoria*

Rauvolfia vomitoria is hermaphroditic, as each flower contains both male and female reproductive structures. Pollen is produced by five stamens, while the female organ consists of a superior ovary with two locules, each housing several ovules, connected to a slender style and stigma. Pollination is mainly insect-mediated, involving bees and butterflies attracted to the floral nectar. After fertilization, the ovary develops into a drupe that becomes dark purple to black at maturity and usually encloses one to four seeds. These seeds possess a hard, woody endocarp and are primarily dispersed by frugivorous animals, with additional dispersal facilitated by water owing to their buoyant nature. Germination often occurs after passage through an animal's digestive tract or following seed coat scarification. This reproductive cycle, characterized by insect pollination, fleshy fruits and animal-mediated seed dispersal, is typical of many tropical woody species[15-18]. Figure 1 shows a branch of *R. vomitoria* with its leaves, flowers and fruits.

Geographical distribution: *Rauvolfia vomitoria* is native to the tropical regions of West and Central Africa and is distributed across Nigeria, Benin, Ghana, Liberia, Côte d'Ivoire, Sierra Leone, the Democratic Republic of Congo, Cameroon, the Central African Republic, Gabon and the Republic of Congo. It thrives in Guinean-Congolian rainforests, often growing in association with palms, *Trema* and *Combretum* species. The plant has been introduced to tropical or subtropical regions of Southeast Asia and the Americas. It flourishes best in hot, moisture-rich climates where rainfall remains fairly consistent across the seasons. Optimal growth occurs in fertile,

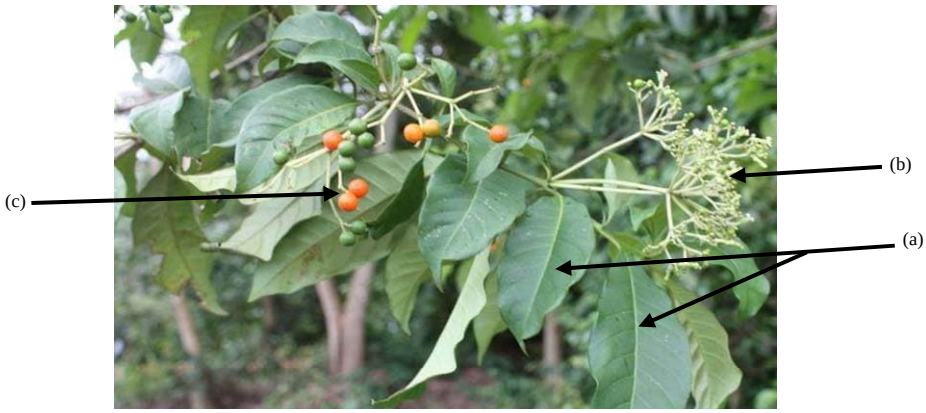


Fig. 1: *Rauvolfia vomitoria* (a) Leaves, (b) Flowers and (c) Fruits

well-drained organic-enriched loamy soils, with annual rainfall between approximately 1,000 and 2,500 mm and temperatures generally between 20°C and 30°C[17,18].

Ethnobotanical and regional nomenclature: *Rauvolfia vomitoria* is widely used as a medicinal plant across Africa and is known by various local names. In Nigeria, it is called ''Oso'' and "Asofeyeje" among the Yoruba, ''Akanta'' among the Igbo, ''Wadda'' in Hausa and ''Utoenyin'' in Efik[19]. In Ghana, it is known as ''Kakapenpen'', in Côte d'Ivoire as "N'guma'', in the Democratic Republic of the Congo as "Lumbweny" among the Yanzi people and in Benin as "Letiwe" among the Fon and Goun communities. The genus includes several species, but *R. vomitoria* (African) and *R. serpentina* (Indian) are the best known. The rich ethnomedical history of *R. vomitoria* highlights its importance in traditional healing systems across these regions. The roots, leaves and bark are commonly used for this purpose.

Ethnomedicinal uses in various cultures: *Rauvolfia vomitoria* has been widely distributed in tropical regions of Africa and Asia, where it has an important place in folk medicine (Table 2). Its ethnomedicinal uses have been documented in several countries, such as Nigeria, Tanzania and China[12]. In these regions, the plant is traditionally employed to manage hypertension, venereal diseases, neuropsychiatric disorders, jaundice, gastrointestinal disturbances, sexual dysfunctions and others[2,8]. In Nigeria, traditional healers have long incorporated *R. vomitoria* into remedies used for psychiatric disorders, while its use against hypertension, insomnia, nervous disorders, jaundice, fever, gastrointestinal problems, skin infections, mental illnesses, intestinal worms and malaria has been reported. Its antiplasmodial activity, observed in several pharmacological studies, further supports its traditional application in malaria management. The plant is also used in different African regions for the traditional treatment of hypertension, diabetes, mental disorders and cardiovascular diseases[11,19]. Moreover, preparations made from *R. vomitoria* are applied externally or orally in the treatment of parasitic infections, including lice and scabies[20].

In the Democratic Republic of the Congo, *R. vomitoria* has historically been used for treating leprosy and improving male sexual performance and fertility[21]. Traditional applications of the plant also extend to treating fever, general weakness, liver disorders, pain, psychosis and cancer[2,6]. In Ghana, *R. vomitoria* is incorporated into herbal preparations such as amylin palmitate, which is used to relieve arthritis and inflammatory pain. Its inclusion in polyherbal formulations indicates possible synergistic effects when combined with other medicinal species[10].

Overall, the widespread and long-standing traditional use of *R. vomitoria* across African and Asian cultures underscores its ethnomedical importance. The isolation and characterization of its bioactive compounds, along with studies on its pharmacokinetic properties[13], together with broader reviews of the species' ethnomedicinal record[22], provide scientific support for its traditional applications and suggest promising avenues for modern therapeutic development.

PHYTOCHEMICAL CONSTITUENTS

Rauvolfia vomitoria has long attracted scientific interest due to its rich and diverse phytochemical profile. Numerous studies have investigated its bioactive components, identifying a wide range of secondary metabolites. Among these, alkaloids represent the predominant class of compounds, while polyphenols, tannins and flavonoids also occur in significant quantities[24].

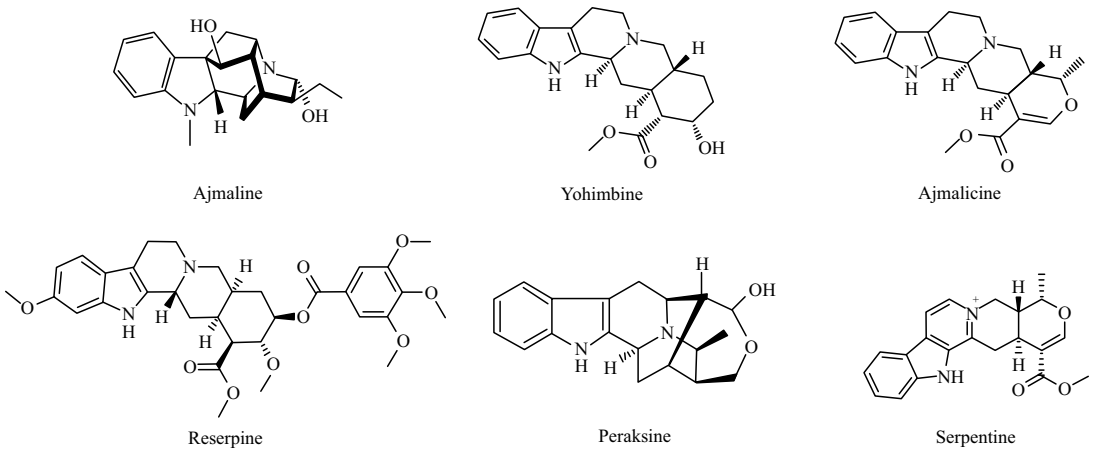


Fig. 2: Chemical structures of some alkaloids present in *R. vomitoria*[24]

Table 2: Some traditional medicinal recipes of *R. vomitoria*

Disorders	Plant part used	Treatment/Recipe	References
Hypertension	Root, Leaves	Roots and leaves are brewed as tea and taken for hypertension	Ukwubile *et al.*[23]
Diabetes	Root	Decoction of pounded root with *Citrus aurantifolia*	Zhan *et al.*[13]
Rashes, Chicken pox, Psoriasis, Scabies, Lice and leprosy	Root, Bark, Fruit	Pulped fruit and/or macerated and powdered roots are applied externally to the skin	Iwu[17]
Rheumatoid arthritis	Root	Root poultice is applied to the affected area	Iwu[17]
Snake bite and insect stings	Root	A poultice of the root is applied externally to the point of the sting	Iwu[17]
Uterine contraction	Root	Decoction of the roots is given during labour pains to increase uterine contraction	Iwu[17]
Tuberculosis	Root bark	Pulverized root bark is mixed with brandy and taken	Iwu[17]

Alkaloids: Alkaloids are naturally occurring nitrogenous compounds with diverse biological activities and important roles in plant defense mechanisms. They are primarily derived from amino acids containing nitrogen atoms and display structural variability and characteristic molecular properties. Their biosynthetic pathways are generally named after the amino acid precursors from which they originate. *Rauvolfia vomitoria* is particularly rich in indole alkaloids (Fig. 2), notably reserpine, which accounts for much of the plant's traditional medicinal use in India. Other monoterpenoid indole alkaloids identified in the plant include Rauvomines A and B, ajmaline, ajmalicine, serpentine, yohimbine, peraksine and alstoyunine A, all of which have been associated with significant pharmacological effects[2,25].

Reserpine: Reserpine ($C_{33}H_{40}N_2O_9$) or 3,4,5-trimethoxybenzoate methyl reserpate is an indole alkaloid isolated from the root bark of *R. vomitoria*. It was first purified in 1952 and became one of the earliest plant-derived antihypertensive agents. It is a weak tertiary base with established therapeutic applications in the treatment of hypertension, cardiovascular diseases and neurological disorders. Reserpine affects central and peripheral nervous systems by interacting with neurotransmitter storage vesicles, especially those responsible for storing norepinephrine, serotonin and dopamine. This interaction results in a progressive reduction of catecholamine levels, suppression of sympathetic nervous activity and relative enhancement of parasympathetic tone, leading to lowered blood pressure and sedative effects[24]. Because of its calming properties and its role in modulating neurotransmission pathways, it is the subject of numerous physiological and pharmacological studies.

Rauvomines A and B: Rauvomine A ($C_{18}H_{19}ClN_2O$) and Rauvomine B ($C_{18}H_{18}N_2O$) are monoterpenoid indole alkaloids isolated from the aerial parts of *R. vomitoria*. These alkaloids are increasingly investigated for anti-inflammatory activity. Although their exact mechanisms of action remain to be fully elucidated, the current findings suggest that they may act by modulating inflammatory signaling pathways[2].

Ajmaline: Ajmaline ($C_{20}H_{26}N_2O_2$) is an indole alkaloid from the *Apocynaceae* family with well-established antiarrhythmic properties. Pharmacologically, ajmaline exerts its antiarrhythmic effect by blocking cardiac potassium channels,

notably Kv1.5 and Kv4.3[26]. In clinical practice, it is primarily employed as a diagnostic agent in pharmacological challenge tests for Brugada syndrome, an inherited cardiac condition associated with characteristic electrocardiographic abnormalities[26]. Ajmaline shares a biosynthetic pathway with other indole alkaloids such as sarpagine and macroline[25] and its effects on systemic and pulmonary blood pressure are comparable to those of serpentine.

Ajmalicine: Ajmalicine ($C_{21}H_{24}N_2O_3$), also known as raubasine, is another indole alkaloid identified in *R. vomitoria*. It acts as an alpha-adrenergic antagonist, explaining its ability to lower blood pressure and promote vasodilation. Its biosynthesis begins with tryptophan, passing through intermediates such as secologanine, strictosidine and catenamine and the final step requires NADPH and tryptophan decarboxylase; a pathway broadly conserved across monoterpenoid indole alkaloid-producing *Apocynaceae* species[25]. The pharmacological activities of ajmalicine, in particular its antihypertensive and adrenergic blocking properties, make it a molecule of therapeutic interest.

Yohimbine: Yohimbine ($C_{21}H_{26}N_2O_3$) is an adrenergic α-receptor antagonist widely studied for its neuropharmacological and physiological effects. It acts on several neurotransmitter systems, including dopamine D and multiple serotonin (5-HT) receptor subtypes. This compound has also been reported to interfere with Tumor Necrosis Factor alpha (TNFα), a key cytokine involved in neuroinflammation, oxidative damage and cell death within the central nervous system[27]. It has also been shown to reduce blood glucose levels and lower blood pressure, effects attributed to its antagonism of α_2A-adrenergic receptors. Taken together, these properties make yohimbine a valuable molecule for studying the biological pathways underlying stress, anxiety and addiction[24].

Serpentine: Serpentine ($C_{21}H_{21}N_2O_3$) is an indole alkaloid from *Rauvolfia* species that lowers blood pressure by depleting monoamine neurotransmitters. It lowers blood pressure by depleting monoamine neurotransmitters and has demonstrated hypotensive, antipyretic, anti-inflammatory, antibacterial and antimuscarinic activities. Serpentine also functions as a topoisomerase II inhibitor, contributing to its antipsychotic and antimicrobial effects. It is biosynthetically formed through the peroxidase (PER)-catalyzed oxidation of ajmalicine within vacuoles, resulting in the production of this bisindole alkaloid[28].

Phenolic constituents: In *R. vomitoria*, important quantities of phenolic compounds like rutin, chlorogenic acid, gallic acid and kaempferol have been identified using HPLC analysis[28]. Complementary studies on the leaves of *R. vomitoria* indicate that flavonoids constitute the dominant class of phenolic compounds present in the plant[29]. Flavonoids in *R. vomitoria* have shown strong antioxidant and enzyme inhibitory properties[28], which mainly support its traditional use in the treatment of erectile dysfunction.

Saponins: Saponins have also been identified in the leaves of *R. vomitoria*. These amphiphilic compounds are characterized by their ability to produce foam in aqueous solutions, induce hemolysis and bind cholesterol. Owing to their natural antimicrobial properties, saponins are recognized as promising candidates for treating fungal infections. They function as natural antibiotics, supporting the body's defense mechanisms against microbial pathogens and other invasive agents[24].

Mineral composition: *Rauvolfia* species contain a wide spectrum of macro and micro-nutrients, with calcium being the spredominant macronutrient. The high calcium content may contribute to the plant's traditional use in promoting blood coagulation and wound healing[24]. Additional investigations have shown that *R. vomitoria* contains a range of important mineral elements, including potassium, manganese, magnesium, iron, sodium and, zinc present at different levels. Among these, zinc is of particular interest due to its role in glucose regulation, which supports the traditional use of the plant in diabetes care. Phytochemical evaluation of different parts of the plant has identified many other compounds associated with the species (Table 3).

OVERVIEW OF PHARMACOLOGICAL STUDIES ON *R. VOMITORIA*

Pharmacological investigations on *R. vomitoria* have revealed multiple therapeutic properties that support its traditional medicinal uses. These studies highlight a broad range of activities attributed largely to its rich alkaloid content and other secondary metabolites.

Antihypertensive activity: Several studies have identified reserpine as one the principal bioactive antihypertensive compounds in *R. vomitoria*. This compound reduces blood pressure by blocking the release of norepinephrine at sympathetic nerve endings, which decreases sympathetic activity and produces a sustained antihypertensive response.

Table 3: Some compounds obtained from *R. vomitoria* extracts and their pharmacological effects

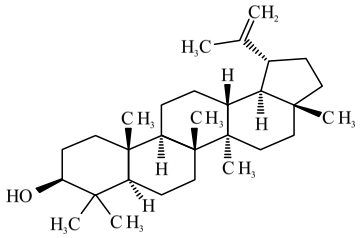
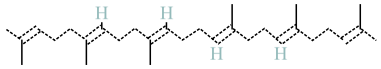
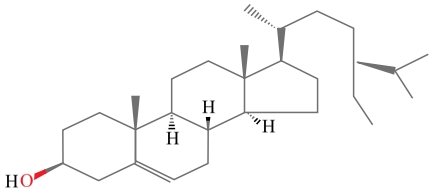
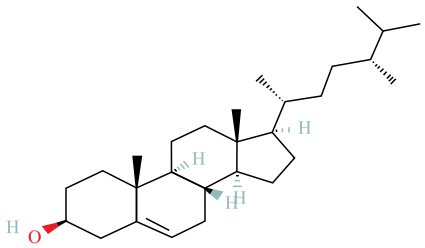
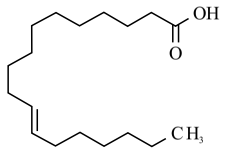
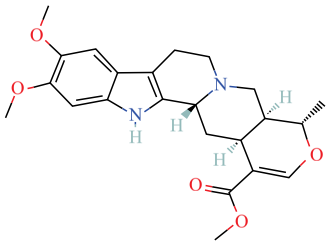
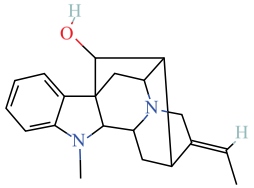
Compound	Molecular formula	Plant parts	Structure	Pharmacological effects	References
Lupeol (Fagarsterol)	$C_{30}H_{50}O$	Leaves		Anti-inflammatory, anticancer	Gaoue *et al.*[24]
Squalene	$C_{30}H_{50}$	Leaves		Reduces skin damage by ultra violet radiation, reduces cholesterol level in the blood and prevents cardiovascular diseases, antitumor; anticancer against ovarian, breast, lungs and colon cancer	Gaoue *et al.*[24]
Phytol	$C_{20}H_{40}O$	Leaves		Schistosomiasis drug, antimicrobial, antioxidant, anti-inflammatory	Gaoue *et al.*[24]
ɣ-sitosterol	$C_{29}H_{50}O$	Leaves		Improving benign prostatic hyperplasia, reduces the risk of cancer and prevent coronary heart disease	Gaoue *et al.*[24]

Table 3: Continue

Compound	Molecular formula	Plant parts	Structure	Pharmacological effects	References
Campesterol	$C_{28}H_{48}O$	Leaves		Balance cholesterol level in the body, anti-inflammatory, used to treat benign prostate hyperplasia, fibromyalgia, allergies and sinusitis	Gaoue *et al.*[24]
Vaccenic acid	$C_{18}H_{34}O_2$	Leaves		Useful in the treatment of cardiovascular diseases, cancer, inflammations and to enhance immune functions	Gaoue *et al.*[24]
Reserpiline	$C_{23}H_{28}N_2O_5$	Root and Leaves		Antipsychotic, antigastric secretion, antihypertension	Yu *et al.*[6]
Tetraphyllicine	$C_{20}H_{24}N_2O$	Root		Myocardial stimulation	Yu *et al.*[6]

Other alkaloids from this plant species, such as ajmaline, ajmalicine and yohimbine, may also contribute to blood pressure regulation through vasodilation and relaxation of vascular smooth muscle[12]. Results from experimental models confirm these effects. In hypertensive rats, treatment with *R. vomitoria* extracts led to a significant reduction in blood pressure, partly due to the suppression of angiotensin-converting enzyme (ACE), an important modulator of vascular tone[23]. Comparable results have been reported with aqueous extracts, which lowered blood pressure in hypertensive animals, while studies in normotensive rats observed a decrease in systolic and diastolic pressure as well as a reduction in heart rate. These effects were proposed to occur via calcium-channel inhibition[4,23]. Overall, *R. vomitoria* exhibits antihypertensive activity through multiple mechanisms, including ACE inhibition, vasodilation, sympatholytic effects, diuresis and antioxidant actions. These pharmacological properties highlight its potential in the management of hypertension and related cardiovascular disorders.

Antidiabetic activity: Multiple studies have demonstrated the antidiabetic potential of *R. vomitoria* extracts. In streptozotocin-induced diabetic rats, treatment with leaf extracts resulted in marked reductions in blood glucose levels and significant increases in plasma insulin, suggesting enhanced regeneration of pancreatic islets and improved insulin secretion[30]. Earlier research showed that ethanolic extracts of the root (without bark) produced hypoglycemic effects in normoglycemic rats and antihyperglycemic effects during glucose tolerance tests. Phytochemical investigations have identified phytol in the plant's leaves, a compound known for antidiabetic activity. Pharmacokinetic studies on the alkaloids yohimbine, ajmaline and ajmalicine derived from the plant have confirmed their antidiabetic effects in experimental models of diabetes[19]. Collectively, available evidence suggests that *R. vomitoria* may exert antidiabetic effects through multiple mechanisms such as hypoglycemic effects, stimulation and sensitization of insulin secretion, inhibition of gluconeogenesis and anti-inflammatory and antioxidant mechanisms. The complementary nature of these actions enhances its potential in the management of diabetes and associated metabolic complications.

Mental illness: Several studies have demonstrated the therapeutic potential of *R. vomitoria* extracts in the management of mental health disorders. The plant exhibits notable neuroprotective properties, as shown by findings that rats treated with the extract retained near-normal hippocampal cytoarchitecture[10]. This protective effect suggests possible benefits in conditions involving neuronal injury or dysfunction. In Addition, *R. vomitoria* has shown anticonvulsant activity[31], supporting its potential use in epilepsy. Phytochemical investigations provide further support for its neurotherapeutic potential. Oyeniran *et al.*[29] demonstrated that phenolic-rich extracts of *R. vomitoria* leaves inhibit monoamine oxidases, lipid peroxidation and cholinesterases while exhibiting strong antioxidant activity, effects that, taken together, suggest benefits in neurodegenerative conditions. A recent narrative review similarly highlights the breadth of central nervous system effects associated with the species' principal alkaloids[22]. Overall, the neurological benefits of *R. vomitoria* are thought to involve multiple mechanisms, including regulation of neurotransmitters, reinforcement of antioxidant systems, suppression of inflammation, neuronal protection and attenuation of epileptic activity. Continued research is essential to fully characterize its therapeutic applications in neurology.

Anticancer activity: Alkaloids and other bioactive constituents of *R. vomitoria* have demonstrated significant anticancer potential. Extracts of the plant exhibit anti-prostate cancer activity in both *in vitro* and *in vivo* models, with gene expression analyses indicating effects on DNA damage response and cell-cycle regulatory pathways[6]. Other studies showed that *R. vomitoria* improve the anticancer efficacy of carboplatin against ovarian cancer, while β-carboline-enriched extracts of the plant demonstrated pronounced activity against pancreatic cancer, both alone and in combination with gemcitabine [7]. Additional evidence supports its protective and chemopreventive actions. A study showed that *R. vomitoria* extract represses colorectal cancer cell autophagy and promotes apoptosis suggesting that the plant might be a potent therapeutic agent of colorectal cancer. Indeed, *R. vomitoria* exhibits anticancer activity through various mechanisms like cytotoxicity, cell cycle arrest, apoptosis induction, angiogenesis inhibition, antioxidant effects, anti-inflammatory actions and immunomodulation[13]. Despite these promising findings, further research is needed to clarify its clinical potential and optimize therapeutic formulations.

Anti-inflammatory and antioxidant effects: The *R. vomitoria* is traditionally used in African medicine to treat inflammatory diseases and recent studies provide scientific support for these applications. Because oxidative stress plays a critical role in inflammation, research has extensively investigated the plant's anti-inflammatory and antioxidant properties. Other mechanistic studies indicate that their anti-inflammatory

Table 4: Pharmacological properties of some biomolecules isolated from *R. vomitoria*

Compound name	Parts of the plant use	Pharmacological effects	References
Tetrahydroalstonine	Leaves	Alpha-adrenergic receptor antagonist for antihypertension activity, inhibiting the reuptake of serotonin and dopamine THA-mediated autophagy regulation through the Akt/mTOR pathway	Zhan *et al.*[13]
Peraksine	Leaves, Stems	Anti-inflammatory and acetylcholinesterase inhibitory activities.	Zhan *et al.*[36]
Normacusine B	Leaves	Hypotensive effect by decrease the peripheral vascular resistance, mainly due to the a-1-adrenergic blockade	Zhan *et al.*[13]
Methenamine	Leaves	It is used to treat urinary tract infections; it decomposes at an acidic pH to produce formaldehyde, which has bactericidal properties enhanced by mandelic acid	Zhan *et al.*[13]
1-pentanol,4-amino	Root	Increase aromatic amino acid decarboxylase activity	Zhan *et al.*[13]
Cyclohexan-1,4,5-triol-3-one-1-carboxylic acid	Root	Acidifier, inhibit production of uric acid, urinary acidulant	Zhan *et al.*[13]
2-Propenoic acid, 1-methyl in decyl ester	Root	Arachidonic acid inhibitor, Increase aromatic amino acid decarboxylase activity, inhibit production of uric acid, urinary acidulant	Zhan *et al.*[13]
4-((1E)-3-Hydroxy-1-Propenyl)-2-methoxyphenol	Root	Anticancer, antidote (emetine), cytochrome-P4502E1 inhibitor, EDRF promoter, elastase inhibitor, endothelium-derived relaxing factor promoter, enteromotility enhancer, ethanol-absorption inhibitor, fertility enhancer, entero parasiticide, memory enhancer,	Zhan *et al.*[13]
Cyclopentaneundecanoic acid, methyl ester	Root	Increase aromatic amino acid decarboxylase activity, inhibit the production uric acid, arachidonic acid inhibitor	Zhan *et al.*[13]
Undecanoic acid	Root	Acidifier, inhibit production of uric acid, urinary acidulant	Zhan *et al.*[13]
1-Adamantanemethylamine, a-methyl-	Root	Catechol-O-methyl-transferase inhibitor, methyl donor, methyl-guanidine inhibitor	Zhan *et al.*[13]

effects may also be related to their membrane-stabilizing properties, their ability to inhibit phospholipase A2 activity and their ability to prevent albumin denaturation and block protease action[32]. Peraksine derivatives isolated from the plant's stems further support its anti-inflammatory potential[13].

Beyond inflammation, *R. vomitoria* is recognized for its potent antioxidant activity. Its extracts neutralize free radicals and reactive oxygen species (ROS), preventing oxidative damage to cellular components. They also enhance endogenous antioxidants such as superoxide dismutase (SOD) and catalase. Polyphenolic compounds such as rutin, chlorogenic acid and kaempferol may play a key role in the plant's antioxidant activity[28]. It is also indicated that *R. vomitoria* exhibits anti-inflammatory and antioxidant actions with potential for the development of therapies for conditions related to inflammation and oxidative stress. Further research is still needed to better define effective dosages, safety profiles and underlying molecular pathways.

Antimicrobial activity: Several studies have explored the antimicrobial properties of *R. vomitoria* to demonstrate its effectiveness against various pathogenic organisms. Emencheta *et al.*[20]. evaluated methanol-extracted fractions from the leaves, bark and roots against isolates of *Salmonella typhi*, *Escherichia coli*, *Candida albicans*, *Aspergillus niger*, *Microsporon canis* and *Trichophyton rubrum*, confirming its traditional use in treating gastrointestinal and skin infections. Similarly, ethanolic and aqueous leaf extracts exhibited activity against clinical strains of *Staphylococcus aureus*, *Salmonella typhi*, *Klebsiella pneumoniae*, *Escherichia coli* and *Pseudomonas aeruginosa*[33]. These findings highlight the plant's antimicrobial potential and support its possible therapeutic applications in infection treatments.

Other pharmacological studies: Beyond its well-documented activities, *R. vomitoria* has been shown to exert several additional pharmacological effects. Studies on male reproductive function revealed that the ethanolic extract improved sexual behavior parameters such as erectile quality and ejaculation latency[21]. Complementary research suggests its aphrodisiac potential may be linked to modulation of neurotransmitters, hormonal activity and improve blood flow to reproductive organs[9], a mechanism also implicated in the species' reported benefits for benign prostatic hyperplasia[34]. The plant also demonstrates anti-arthritic effects. *R. vomitoria* extracts reduced markers of inflammation like C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), rheumatoid factor (RF) and cytokines such as TNF-α, IL-1β and IL-6 in adjuvant-induced arthritic rats[35].

Another pharmacological study highlights the plant's broad therapeutic applications. The plant antiplasmodial activity has been widely reported *in vitro* to support its traditional use in malaria management[8]. Moreover, aqueous extracts of the leaves demonstrated anticonvulsant properties. This validates the plant's traditional use in the treatment of epileptic seizures[31]. Table 4 summarizes selected biological activities of major bioactive compounds identified in *R. vomitoria*.

TOXICOLOGICAL CONSIDERATIONS AND POTENTIAL SIDE EFFECTS

Toxicological investigations indicate that while *R. vomitoria* possesses significant therapeutic potential, excessive doses or prolonged use may lead to adverse effects. The reported side effects, such as hypotension, bradycardia and sedation, could largely be attributed to its depressant effects on the cardiovascular and central nervous systems[15,17]. In addition, alkaloids such as reserpine may induce gastrointestinal disturbances like nausea, vomiting and diarrhea[15]. Experimental studies also raise concerns regarding reproductive and developmental toxicity. Studies conducted on rats have shown that reserpine can have toxic effects on both mothers and their foetuses, raising questions as to whether the physiological responses observed are due to the compound itself or to general systemic toxicity. Furthermore, evidence indicates that exposure to the plant during pregnancy could disrupt normal foetal cardiac development. Hepatocellular dysregulation and impaired renal function were observed following the administration of ethanolic leaf and root extracts at 524 mg/kg for seven days, with root extracts producing more pronounced toxicity. A comparative evaluation of toxicity has shown that low-dose, long-term use of leaf and root extracts is generally tolerated by vital organs such as the liver, kidneys and brain, whereas short-term exposure to higher doses may result in adverse effects[37]. While several studies report acceptable safety within defined dosage rangess[9], other evsidence suggests that prolonged or repeated administration could lead to toxic effects. Consistent with these concerns, a recent subchronic toxicity evaluation of the root bark extract reported dose-dependent hepatotoxic changes over a 90-day exposure period, reinforcing the need for caution at higher or prolonged dosing[34].

Globally, these results highlight the necessity of dose control and standardized preparations. Further studies, particularly long-term toxicological and clinical evaluations, are needed to clarify safety margins and guide appropriate therapeutic applications.

POTENTIAL FUTURE DIRECTIONS OF RESEARCH ON *R. VOMITORIA* TO IMPROVE THEIR USE IN TRADITIONAL AND MODERN MEDICINE

Rauvolfia vomitoria has been the subject of numerous studies aimed at understanding its medicinal properties and potential therapeutic applications. To further improve its safe and effective use in traditional and modern medical practices, future research could focus on several key areas:

Phytochemistry: Continued isolation and structural characterization of bioactive molecules from *R. vomitoria* may uncover additional therapeutic candidates beyond those currently known. The study of synergistic interactions between its phytochemical compounds could also help explain the plant's various pharmacological effects and improve the rationale for polyherbal formulations.

Anticancer potential: While several studies point to the anticancer potential of *R. vomitoria*, more research is required to clarify the molecular mechanisms underlying the activity of its bioactive components. Studying how these compounds might work synergistically with standard chemotherapeutic drugs could also pave the way for the development of combination therapies that offer improved efficacy and reduced toxicity.

Neuroprotective and neurotherapeutic properties: Given the neuroprotective effects already observed in this plant, it would be appropriate to conduct in-depth research to evaluate its possible applications in the treatment of neurological and neurodegenerative diseases such as Parkinson's and Alzheimer's[10].

Formulation development: Improvement in bioavailability, stability and therapeutic efficacy of *R. vomitoria* compounds requires the development of appropriate formulations and delivery systems. Exploring advanced pharmaceutical technologies such as nanoemulsions, microencapsulation, solid lipid nanoparticles and optimized extraction and purification methods could help overcome challenges related to solubility, targeted delivery and controlled release of active ingredients[21].

Clinical trials: Well-structured clinical studies are essential to determine the safety, effectiveness and therapeutic potential of *R. vomitoria* in human populations. These researchers could focus on its main traditional applications, including hypertension, diabetes, neurological disorders and sexual dysfunction. Conducting randomized, controlled trials will provide the solid evidence needed for its acceptance and use in conventional medicine.

Safety optimization via advanced extraction and purification techniques: Due to documented reports of toxicity associated with *R. vomitoria* and its active alkaloid reserpine[15,17], future research must also focus on minimizing adverse effects while maintaining therapeutic efficacy. This includes assessment of advanced extraction techniques such as accelerated solvent extraction, supercritical fluid extraction,

pressurized solvent extraction and microwave-assisted extraction to optimize yields of beneficial compounds while reducing toxic constituents. Purification strategies such as bioassay-guided fractionation, chromatographic separation and membrane filtration can selectively isolate therapeutic molecules and eliminate harmful components. The use of novel solvents and targeted purification approaches could facilitate the production of standardized extracts enriched in desired alkaloids and secondary metabolites, ultimately to improve safety and clinical potential.

This review consolidates current evidence on the ethnomedicinal uses, phytochemical composition, pharmacological activities and toxicological profile of *R. vomitoria*, a plant widely used in African traditional medicine. Many of its traditional uses particularly in the management of hypertension, neurological disorders, infectious diseases and inflammatory conditions are supported by experimental data[2]. The strong correlation between traditional uses and scientific study results demonstrates the importance of *R. vomitoria* as a promising source of bioactive compounds.

The plant's therapeutic potential is largely attributed to its diverse phytochemical constituents. Indole alkaloids such as reserpine, ajmaline, ajmalicine, yohimbine and serpentine demonstrate a wide range of pharmacological effects like antihypertensive, neuroprotective, antidiabetic, anticancer and antimicrobial activities[5,19]. Phenolic compounds like rutin, chlorogenic acid and gallic acid are known to have antioxidant and anti-inflammatory activities, which partly explains the traditional use of the plant in the management of cardiovascular, metabolic and neurological disorders[28]. This evidence makes the plant a valuable candidate for drug development.

However, interpretation of current research remains problematic. Much of the available data comes from preclinical experiments and only a few clinical studies have been conducted to validate safety and therapeutic efficacy in humans. Moreover, studies differ considerably in terms of extraction protocols, plant materials, choice of solvents and doses administered, which limits comparisons between studies and complicates the establishment of standardized therapeutic guidelines[4,23]. The other challenge is the use of crude extracts rather than purified metabolites, which makes it difficult to attribute specific pharmacological actions to individual molecules or synergistic interactions[2,25].

Moreover, data from toxicological studies indicate the need for caution when using the plant. Although some studies report acceptable safety profiles at controlled doses[9], others highlight dose-dependent toxicity like cardiovascular depression, neurobehavioral changes, reproductive toxicity, hepatocellular injury and renal impairment[37]. The adverse effects associated with reserpine including hypotension, sedation, gastrointestinal disturbances and foetal toxicity remain a major concern[15]. These results highlight the need for standardization of doses, purification strategies and long-term safety assessments.

LIMITATIONS OF THE REVIEW

This review provides an updated synthesis of the traditional uses, phytochemical composition and pharmacological properties of *R. vomitoria*. However, several limitations should be acknowledged. First, the review is based primarily on studies published in English, which may exclude relevant findings reported in other languages. Additionally, although multiple scientific databases were searched, the reliance on available published data means that unpublished studies or local ethnobotanical knowledge may not be fully represented. The review presents a wide variety of studies. These range from *in vitro* tests to animal trials, with a few limited clinical evaluations. This diversity makes it difficult to compare results. It also prevents clear conclusions from being drawn. Much of the research uses crude extracts. These extracts are not standardized, which complicates the identification of the compounds responsible for the observed effects. In addition, there is a lack of data on long-term toxicity, as well as information on pharmacokinetics and clinical efficacy. This limits the possibility of direct applications of results. Overall, these limitations highlight the need for more rigorous, standardized and clinically oriented research to fully validate the therapeutic potential of the plant.

CONCLUSION

This review showed a correlation between the rich bioactive constituents of *R. vomitoria* and its traditional applications in various parts of the world, namely: antihypertensive, neuroprotective, antidiabetic, antimicrobial and anti-inflammatory properties. Nevertheless, documented toxicity concerns, especially those associated with reserpine, highlight the need for strict dose regulation, formulation standardization and comprehensive safety evaluation. Future studies should prioritize optimizing extraction and purification strategies to enhance therapeutic efficacy while reducing adverse effects. In addition, well-designed clinical trials and in-depth mechanistic studies are essential to support evidence-based guidelines for safe use in humans. Bridging traditional knowledge with modern scientific approaches will be essential to promote the responsible integration of *R. vomitoria* into contemporary healthcare and to facilitate the development of new plant-derived therapeutic agents.

SIGNIFICANCE STATEMENT

Rauvolfia vomitoria Afzel. has a long-standing history in traditional African medicine for treating a wide array of neurological, metabolic and cardiovascular disorders. While its primary alkaloid, reserpine, has historically served as a foundational antihypertensive agent, modern clinical transitions demand a unified, rigorous evaluation of the plant's broader therapeutic matrix. This narrative review synthesizes recent botanical, phytochemical and pharmacological data to bridge historical ethnomedicinal practices with contemporary evidence-based medicine. By critically appraising preclinical evidence, mechanisms of action and systemic toxicities, such as dose-dependent hepatotoxicity and central nervous system depression, this work explicitly highlights critical research gaps. Ultimately, it provides a crucial roadmap for future randomized controlled trials and advanced purification techniques aimed at optimizing safe, standardized, plant-derived therapeutic agents.

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