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Review Article

A Review: Medicinal Uses, Phytochemistry and Pharmacological Properties of Plants from the *Hermannia Genus*

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ABSTRACT

Introduction: Medicinal plants play a pivotal role in treating illnesses and modern medicines are still being derived from plants. Hermannia genus is a significant traditional herbal medicine. This review evaluates the medicinal uses, phytochemistry and pharmacological properties of plants from the genus Hermannia genus based on available research. **Methods**: Studies accessed from online research databases were systematically selected and analysed to construct a comprehensive review of the medicinal uses, phytochemistry and pharmacological properties of plants from the genus. **Results**: Hermannia species are used in traditional medicine to treat or manage; respiratory conditions, gastrointestinal issues, skin conditions, sexually transmitted infections, and diabetes. Scientific findings also discovered promising pharmacological activities within members of the genus such as antimicrobial, anti-inflammatory, antioxidant, antidiabetic and anticancer activities. To date, over 30 types of secondary metabolites have been identified from the genus, including the 2 pure compounds that were isolated and tested for pharmacological activities. Further research must prioritize other unexplored species of the genus and efficacy and mechanism of action studies on isolated compounds. **Conclusion**: The genus Hermannia is important in the treatment of diseases of high public health concern. The pharmacological studies and presence of secondary metabolites and bioactive compounds further validates the traditional uses of the genus. Therefore, the findings suggest that the genus has species that may serve as candidates for novel drug discovery for the treatment of various illnesses. Efficacy and mechanism of action studies still need to be conducted on isolated compounds and other unexplored species of the genus.

Keywords: Hermannia, traditional medicine, phytochemistry, pharmacological activities, secondary metabolites, bioactive compounds, drug development.

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INTRODUCTION

The use of plants for medicinal purposes is a practice as old as humanity itself.[1] Evidence suggests that even in prehistoric times, humans understood the medicinal benefits of plants, learning through observation, experimentation, and self-medication. As civilisations developed, so did their understanding of plants as medicines.[2] The dawn of the early modern period introduced iatrochemistry, which developed an understanding of the chemical basis of medicinal properties in plants. This period was characterised by increased global exploration and trade of herbal medications, leading to the discovery and introduction of new medicinal plants from all around the globe, further enhancing the pharmacopoeia of the time.[1]

The 19th century was a turning point which introduced the identification and isolation of active compounds from plants, such as morphine from *Opium poppy* and digitoxin from *Digitalis purpurea*. This advancement paved the way for the discovery and development of synthetic drugs in the 20th century, resulting in the reclined use of plant-based medicines.[1] However, traditional medicine systems, deeply rooted in many cultures, continued to thrive, to date approximately 80% of the African population relies on them for primary healthcare.[3-4] In recent years, there has been a resurgence of interest in plant-based medicines. Factors increasing medicinal plant use include cultural beliefs in traditional practices, perceptions of plant-based remedies as natural and therefore safe, cost-effectiveness, perceived efficacy, self-medication tendencies, distrust towards modern medicine, extended wait times in hospitals, and widespread promotion.[4,3,5] Additionally, there is a growing awareness of the potential side effects of synthetic drugs, increasing antibiotic resistance, and the recognition of plants as a valuable source of novel drug leads.[6]

The genus Hermannia, also known as "doll's roses" or "*poprosie*" in Afrikaans, holds profound importance in traditional herbal medicine.[7] This genus represents a diverse group of plants classified within the Kingdom Plantae, Phylum Magnoliophyta, Class Magnoliopsida, Order Malvales, and Family Malvaceae. With an estimated 180 species globally Hermannia can be found in the United States, Mexico, Australia, Arabia tropical, East Africa, Northeast Africa and Madagascar. Nevertheless, in Africa, its predominant habitation is in in Southern African countries such as South Africa, Zimbabwe, Namibia, and Lesotho.[8-9] Hermannia species grow in diverse habitats, from the arid areas of the Karoo and Namibian deserts to the humid, summer-rainfall mountains of the Drakensberg and the sea-spray zones along Southern African coasts. This ecological versatility aligns with its extensive morphological diversity within the genus—the morphological variations from creeping herbs to thick-stemmed bushes and annuals.[9]

The Hermannia genus has diverse traditional medicinal uses that highlight its significance. Indigenous Southern African groups, including the

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Batswana, Bakwena, Basotho, Xhosa, and Zulus, have used the genus to treat many illnesses, such as respiratory diseases, heart conditions, gastrointestinal issues, skin conditions, sexually transmitted infections as well as epilepsy.[9, 10, 11, 12, 7] Furthermore, species of this genus have been scientifically investigated for their pharmacological properties such as antimicrobial, anti-inflammatory, antioxidant, anticancer and antidiabetic activities. The genus species that were studied and noted to possess significant therapeutic effects include *Hermannia depressa*, *Hermannia geniculata*, *Hermannia cuneifolia* and *Hermannia incana*.[13, 14, 15, 16, 17, 18, 19, 20]

This genus has a rich ethnobotanical history and significance in traditional medicine, especially within Southern Africa, underscoring the necessity for scientific phytochemical and pharmacological research because the genus could be a source of bioactive compounds for novel drug development. This review aims to determine the extent to which the genus has been studied focusing on phytochemistry, pharmacological activities, identified and isolated bioactive compounds and also to determine the existing gaps in literature.

REVIEW METHODOLOGY

This review seeks to comprehensively evaluate and critically analyse the existing research on the genus Hermannia, focusing mainly on its phytochemistry, pharmacological potential and bioactive compounds. The literature search on the genus Hermannia was conducted through multiple electronic databases including Google Scholar, PubMed, Elsevier Science, Semantic Scholar,Taylor and Francis Online, Wiley Online Library, and Science Direct, using keywords such as "Hermannia", "traditional uses", "medicinal uses", "phytochemistry", "bioactive compounds", "biological activities" and "pharmacological activities ". As shown in Figure 1, a total of 26 studies that comprised 20 full text articles and 6 unpublished dissertations available online that report on the ethnobotanical uses, biological activities, and the screening, isolation and identification of bioactive compounds within the genus Hermannia were consulted to provide an up-to-date review of literature. The review includes studies conducted from 2005 to 2024. The studies that are accessible online and specifically mention the search terms in their content were incorporated. Excluded studies are those that did not meet the criteria of the search terms and Studies were excluded if they did not align with the search term criteria and those that that did not report on the medicinal uses, biological activities and the phytochemistry of the Hermannia plant species in relation to human diseases and illness.

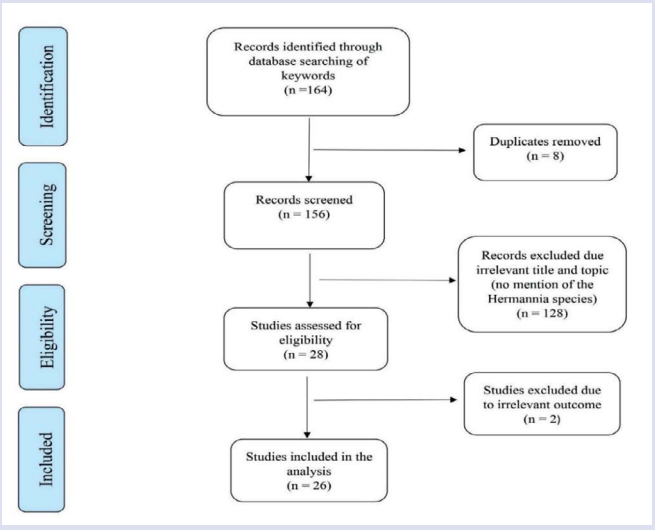

Figure 1: PRISMA flowchart of selected studies for the review

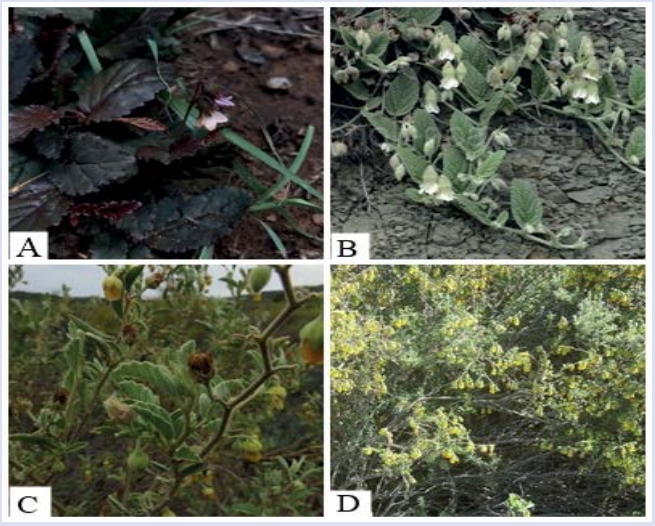

Figure 2: Hermannia species with their different morphological variations. Figure 2A – *H.depressa*, Figure 2B – *H.geniculata*, Figure 2C – *H. incana*, Figure 2D – *H. cuneifolia*.[21]

Botanical Characteristics of Hermannia

The genus Hermannia is capable of growing in a wide range of varied habitats and that explains its extensive morphological diversity. The growth forms range from low-growing, ground-hugging types to more erect and bushy species which may have woody or herbaceous stems. Low-growing and ground-hugging species such as *Hermannia depressa* and *Hermannia geniculate* (Figure 2A and Figure 2B) are widespread throughout the genus. The low-growing types are found in both summer- and winter-rainfall areas. The ground-hugging species can spread without rooting at nodes (procumbent), spread with raised terminal parts (decumbent) or have slight rooting at nodes (repent).[9]

Ascending growth forms include both sub-herbaceous and woody plants. Moreover, there are fewer erect single-stemmed species with branches, and they often exhibit a reseeding life strategy, typically in fire-prone areas, and are relatively short-lived.[9] Root types in Hermannia comprise three forms: a woody rootstock, a branched rootstock, and an erect rootstock; nevertheless, most species have a primary root with secondary adventitious roots radiating from it. Stems can range from thin and branch-like to robust and trunk-like forms, occasionally with a silvery waxy coating or resinous appearance as an anti-herbivory characteristic. Branching patterns are mostly alternate, though some species show unique forms like dichotomous branching.[9] Leaves of this genus exhibit substantial diversity in shape, size, margin, and indumentum. Most species have flattened leaves, with shapes ranging from narrow linear, lanceolate, and oblanceolate to broader elliptic, ovate, oblong, cuneate, and orbicular forms. Orbicular and cordate leaves are rare, appearing only in a few species from summer rainfall regions. Hermannia are flowering plants with inflorescences that consist of peduncles and pedicels with bracts and vary in calyx shape and lobe formation, adapting to different pollination strategies.[9]

Uses of Hermannia in Traditional Medicine

Hermannia has a long-standing history of medicinal use among various cultural groups in Southern Africa and Europe. *H. depressa* also known as "*Seletjane*" in Sesotho[22] and "*Rooi-opslag*" in Afrikaans, is utilised as a protective charm to ward off relationship conflicts, applying it as an ointment on the body or placing it around their homes by the Zulu people.[7] As outlined in Table 1 decoctions of *H. depressa* are also utilised to relieve coughs, and the plant is combined with others to

address diarrhoea; additionally, it serves as an emetic, and the leaf sap mixed with water is used to treat stomach aches due to its purgative and diaphoretic properties.[23-24] Moreover, crushed leaves are applied in cancer treatment, while decoctions of its roots are used to treat gonorrhoea and other sexually transmitted infections.[25-10]

H. geniculata, referred to by the Basotho as "*kgwakgwa*," is a staple in traditional Basotho medicine, particularly for managing blood sugar disorders, where dried roots, when boiled in water and taken three times daily, help to control diabetes symptoms, treat colic, and alleviate heartburn and stomach disorders, including flatulence in pregnant women. [26-11] The root extract is also used for treating ulcers and skin conditions, showcasing its wide range of medicinal applications. Other Hermannia species, such as *Hermannia incana*, are also used medicinally. *H. incana* serves as an emetic, and its leaf sap is employed to treat stomach aches and diarrhoea. Decoctions of the entire plant are used to soothe coughs; among the Xhosa, the roots treat dysuria. Traditional ointments combining *H. incana* with *Lobostemon fruticosus* and *Psoralea decumbens* are used for erysipelas or eczema.[20]

Additionally, *Hermannia cuneifolia*, known as "*pleisterbos*" in Afrikaans has leaves used as plasters. Its leaves are also infused in tea to cleanse the blood, and a root infusion was historically used by European settlers for epilepsy. Additionally, a leaf lotion was applied to eczema and shingles.[7] Notably, in parts of Europe, *Hermannia althaeifolia* was cultivated and applied medicinally as a fragrant tea for treating syphilis.[11] Table 1 shows the documented medicinal uses and plant parts utilised. *Hermannia depressa* stands out as the most prominent for its use in traditional medicine, followed by *Hermannia geniculate*[9] as shown in Figure 3. Leaves, followed by roots, are the most frequently utilized plant parts of the genus as illustrated in Figure 4. While there are references to the use of the whole plant, existing literature does not document the medicinal utilisation of flowers. The diverse traditional uses of Hermannia species underscore their importance in ethnomedicine and emphasise the need for ongoing scientific investigation into their therapeutic properties.

PHARMACOLOGICAL ACTIVITIES OF GENUS HERMANNIA

Antimicrobial activity of the genus Hermannia

Antimicrobial testing evaluates the potential of plant extracts to inhibit the growth of pathogens. Notably, bacterial and fungal pathogens have been examined for susceptibility to Hermannia extracts far more extensively in comparison to viral infections. A conducted study where twelve Hermannia species were investigated for antibacterial; the species comprised *Hermannia althaeifolia, Hermannia cuneifolia, Hermannia flammula, Hermannia holosericea, Hermannia incana, Hermannia involucrate, Hermannia lavandufolia, Hermannia muricata, Hermannia saccifera, Hermannia salviifolia, Hermannia scabra* as well as *Hermannia trifurca*. The study found *all* 12 species possessing promising antimicrobial activity at varying degrees, strong inhibitors have minimum inhibitory concentrations (MIC) ranging from 0.5 to 0.0195 mg/mL and *H. saccifera* showed the most potent bactericidal activity, particularly against *Staphylococcus aureus*, *Bacillus cereus*, and *Enterococcus faecalis, Table 1 shows the specific antibacterial activities of the species.* [11]

Table 1: Documented traditional uses of Hermannia species.

Species	Plant part used	Use/diseases treated	Number of uses
H. depressa	Not specified	protective charm[22]	9
	leaves	emetic[23]	
	leaves	stomach-ache[23]	
	leaves	purgative[23]	
	leaves	diaphoretic[23]	
	leaves	soothe coughs[23]	
	leaves	cancer[25]	
	roots	Gonorrhoea[10]	
	roots	Unspecified STIs[10]	
H. geniculata	roots	blood sugar disorders[26-17]	8
	roots	Diarrhoea[26-17]	
	roots	Heartburn[26-17]	
	roots	stomach disorder[26-17]	
	roots	flatulency in pregnant women[26]	
	roots	colic[17]	
	roots	ulcer[17]	
	roots	skin diseases[26]	
H. incana	leaves	stomachache[20]	6
	leaves	diarrhoea[20]	
	leaves	purgative[20]	
	leaves	diaphoretic effects[20]	
	Whole plant	soothe coughs[20]	
	roots	Dysuria[11]	
H. cuneifolia	leaves	sores[11]	5
	leaves	used as plasters[7]	
	leaves	Blood cleansing[7]	
	leaves	eczema[7]	
	leaves	shingles[7]	
H. althaeifolia	Not specified	syphilis[11]	1
H. pinnata	roots	Diabetes mellitus[27]	1
H. salviifolia	roots	Convulsions[11]	1

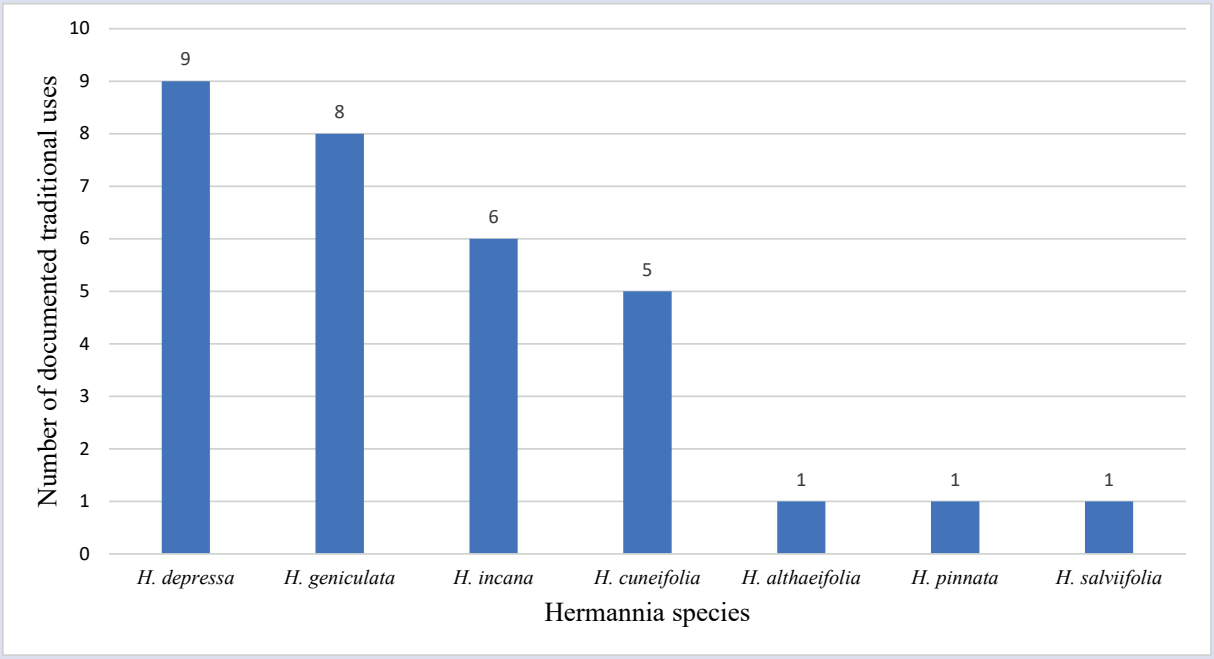

Figure 3: Comparison of Hermannia species based on documented traditional uses

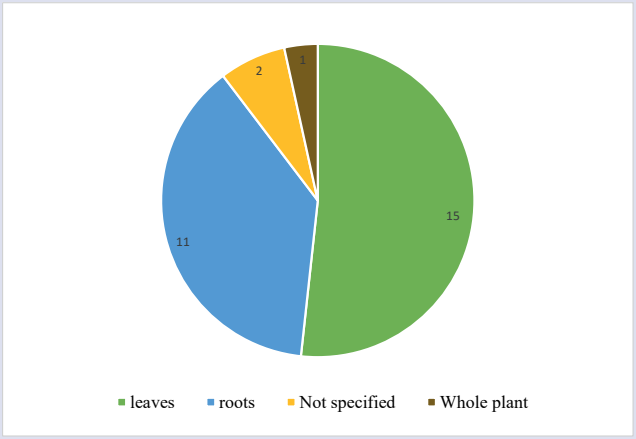

Figure 4: Comparison of frequently used plant parts from Hermannia genus

Reid et al. (2005) document the antibacterial activity of *H. depressa* where ethanolic and ethyl acetate extracts from its roots, leaves and stems showed efficacy against pathogens such as *Bacillus subtilis, Escherichia coli, and Klebsiella pneumoniae*; demonstrating potent antibacterial activity against *Bacillus subtilis*. Moreover, Hlongwane noted good antimicrobial activity of *H. depressa* extracts against *Mycobacterium tuberculosis*. [13] *H. depressa* methanol and acetone extracts showed antimicrobial activity against 13 microorganism including *Candida albicans*, *Candida krusei*, *Candida parapsilosis*, *Bacillus cereus*, *Clostridium perfringens*, *Enterococcus faecalis*, *Escherichia coli*, *Neisseria gonorrhoeae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus pneumoniae* and *Streptococcus pyogenes*, nonetheless the highest inhibitions were observed in *Candida albicans* and *Bacillus cereus* with MICs as low as 0.1 and 0.3 mg/mL respectively.[19] *H. geniculata* has been minimally screened for antimicrobial potential as compared to *H. depressa* however isolates from *H. geniculata* have shown antimycotic against *Candida albicans*.[14] Another species of this genus that has been studied is *H. cuneifolia*, and the results showed inhibition of strains of *Bacillus cereus*, *Staphylococcus aureus*, *Klebsiella oxytoca* and *Acinetobacter species*.[28] Plants from the Hermannia genus have great potential agents in the treatment of infectious diseases mainly caused by various bacteria and fungi. Therefore, more members of the genus need to be screened for antimicrobial activity extensively.

Anti-inflammatory activity of genus Hermannia

Hermannia extracts demonstrated consistent anti-inflammatory activities across different in vitro studies where techniques such as Cyclooxygenase-1 (COX-1) inhibition, 5-lipoxygenase inhibition and nitric oxide (NO) inhibition assays were employed as shown in Table 1. *H. depressa* dichloromethane extracts portrayed 81% COX-1 inhibition, the highest compared to the five other Sterculiaceae species screened in a study by Reid et al., .[16-23] Ngobeni et al. assessed the production of NO of lipopolysaccharide-stimulated RAW 264.7 macrophages treated with *H. depressa* acetone and methanol extracts and both extracts showed strong anti-inflammatory activity, in addition, their findings suggest that acetone extract is slightly more effective than the methanol.[19]

H. geniculata also demonstrated significant anti-inflammatory properties through various pharmacological studies. Hermannol a compound isolated from *H. geniculata* showed strong anti-inflammatory properties through potent inhibition of 5-lipoxygenase.[17] Another study also found flavonoid and phenol extract of *H. geniculata* with potent inhibition of 5-lipoxygenase.[29] Furthermore, another study was also in agreement with the findings where flavonoid extract exhibited significant inhibition of the 5-LOX enzyme, even better than the standard drug indomethacin.[30]

Furthermore, in a study that screened 12 Hermannia species for anti-inflammatory activity, eleven of the twelve species portrayed moderate activity against the 5-lipoxygenase enzyme, and *H. cuneifolia* showed a more potent anti-inflammatory activity.[31] The potential of the genus in the development of new, safe, and effective treatments for inflammatory diseases is therefore undeniable and further research is necessary, with a higher focus on the less explored in-vivo experimentations

Antioxidant activity of genus Hermannia

Hermannia species possess notable antioxidant activity. Most studies utilised the DPPH (2,2-diphenyl-1-picrylhydrazyl), the ABTS (2,2-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid) radical scavenging assays, metal ion chelation assays and the ferric reducing antioxidant power (FRAP) to evaluate their antioxidant potential. [15, 11, 19] In a study by Essop et al. (2008)[11], ten of twelve Hermannia species, including *H. althaeifolia, H. cuneifolia, H. flammula, H. holosericea, H. incana, H. involucrate, H. lavandufolia, H. muricata, H. saccifera and H. scabra* portrayed good free radical scavenging activity and *H. cuneifolia* exhibited the strongest antioxidant activity.[11] Moreover, several studies document that aqueous, methanol and acetone extracts of *H. depressa* exhibit significant antioxidant activity.[19-15] Ngobeni et al. (2024) also notably added that methanol and acetone extracts of *H. depressa* exhibited superior antioxidant capacity compared to standards like ascorbic acid and Trolox.

Furthermore, ethyl acetate extract leaves and flavonoids isolated from the roots of *H. geniculata* have demonstrated significant antioxidant properties in vitro. For instance, ethanolic and hydro-ethanolic extracts of the roots showed remarkable free radical scavenging abilities across different assays, including DPPH, ABTS, hydroxyl radicals, and superoxide anions, in some cases outperforming standard antioxidants like silymarin.[29-14] The flavonoid and phenolic compounds also displayed significant antioxidant activity, underscoring the potential of *H. geniculata* as a rich source of natural antioxidants. Similarly, Hermannol, a xanthene derivative isolated from the roots, was discovered to possess strong antioxidant properties, potentially through both radical scavenging and metal-chelating mechanisms.[17] These findings suggest that the Hermannia genus is a valuable candidate for developing effective natural antioxidant therapies, contributing to its pharmacological relevance.

Toxicity studies on genus Hermannia

The toxicity studies on *H. geniculata* roots have provided insights into its safety and pharmacological properties. In an evaluation involving Wistar rats, the administration of an aqueous root extract at doses showed no significant toxic effects on vital organs like the liver, kidneys, lungs, and heart over however, a reduction in white blood cell count was observed, hinting at potential long-term impacts on immunity.[26] Cytotoxicity studies using *H. geniculata* roots and flavonoid extraction demonstrated an agreement in findings that this plant has low toxicity towards Vero cells and RAW 264.7 macrophages, indicating it is not harmful to normal cells. However, it demonstrated high toxicity towards HepG2 cancer cells, suggesting potential anti-cancer properties.[30] These findings are promising and can drive research on *H. geniculata* in developing safe treatments, although further detailed studies are necessary to understand its therapeutic applications and biosafety profile extensively.

Studies by Molefe and Ngobeni et al have a consensus indicating that *H. depressa* has no significant toxicity to normal cells in their research. Ngobeni et al utilised the 3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyltetrazolium bromide (MTT) assay, treating the African green monkey kidney cells with *H. depressa* acetone, methanol and aqueous extracts. Acetone and methanol showed some moderate decrease in cell viability; in contrast, the aqueous extracts showed no toxicity. [19] Molefe conducted the MTT assay using the Madin-Darby bovine kidney cell (MDBK) lines, lactate dehydrogenase (LDH) and the brine shrimp lethality assay (BLSA) assays. *H. depressa* extracts exhibited low in-vitro cytotoxic effects on MDBK cells, especially for the acetone extract, which even stimulated cell growth. Nonetheless, the in vivo BLSA showed significant toxicity, especially for higher concentrations of water and acetone extracts, indicating potential toxic constituents requiring further investigation.[32] *H. depressa* has limited cytotoxicity studies, and the recommendation is that further in vivo studies are crucial to confirm these findings and determine safe doses for potential therapeutic applications.[32-19]

Antidiabetic Activity of genus Hermannia

H. geniculata is the most studied member of the genus on antidiabetic properties and these findings led to promising but varied potential in managing hyperglycaemia. The ethanolic root extract showed potent inhibition of α-glucosidase, while α-amylase inhibition was milder.[18] Meanwhile, Hermannol, a xanthene derivative isolated from the roots, demonstrated moderate inhibitory activity against α-amylase.[30] Furthermore, the flavonoid and phenol extracts exhibited significant α-glucosidase inhibition but were less effective against α-amylase. Notably, the ethyl acetate extract, particularly the isolated compound 1,3-dibutyl-2,8-dihydroxy-9H-xanthen-9-one, showed strong α-amylase inhibitory activity and significant α-glucosidase inhibition, surpassing acarbose in effectiveness.[14] These findings suggest that various extracts and isolated compounds from *H. geniculata* possess anti-diabetic properties, particularly through the inhibition of key carbohydrate-catabolizing enzymes, highlighting its potential for managing diabetes; however, there is a clear gap in the literature on the antidiabetic effects of the other members of the genus Hermannia.

PHYTOCHEMISTRY OF GENUS HERMANNIA

Plants produce secondary metabolites, which are organic compounds resulting from secondary metabolic processes. Secondary metabolites are categorised based on their structural diversity, biosynthesis, and functions, resulting in the identification of over 214,000 secondary metabolites in the scientific literature.[33] These compounds are classified into various groups, including alkaloids, terpenoids, steroids, polyphenols, fatty-acid-derived compounds, non-ribosomal polypeptides, and enzyme cofactors. The plants' phytochemicals have notable pharmacological applications because of their antimicrobial, antiviral, antioxidant, anti-inflammatory, anticancer, and cardioprotective properties.[34, 35, 33, 36] The genus Hermannia has been used for many traditional medicine purposes, which may be attributed to the present bio-active compounds.

H. depressa is utilised in various traditional medicinal practices and has demonstrated significant pharmacological potential. Techniques utilised for phytochemical screening range from older standard qualitative methods such as the froth test and the ferric chloride test to the advanced modern techniques that can be both qualitative and quantitative such as vacuum liquid chromatography (VLC), thin layer chromatography (TLC), high-performance liquid chromatography (HPLC) and Liquid Chromatography with tandem mass spectrometry (LC-MS/MS).[32-19] Phytochemical screening has identified the presence of tannins, saponins, phenols, terpenoids and cardiac glycosides in extracts of *H. depressa* and these metabolites contribute to its therapeutic potential.[23, 37, 12, 32] Utilising LC-MS/MS analysis, Ngobeni et al. (2024) identified alkaloids and flavones, such as Waltherione D, quercetin, and tricin, in aqueous and acetone extracts. Methanol extracts showed the presence of steroids, fatty acids, and lignans. Identified compounds are outlined in Table 2 [19] The quantitative phytochemical analysis of *H. depressa* was conducted utilising the Folin-Ciocalteu method for phenolic content and Aluminium colourimetric for flavonoid content. The highest phenolic content was observed in acetone extracts at 8.45 mg gallic acid equivalent per gram (GAE/g), while flavonoid content was notably high in aqueous extracts, recorded at 0.97 mg quercetin equivalent per gram (QE/g).[19]

Meanwhile, qualitative and semi-quantitative screening of phytochemicals in *H. geniculata* root extracts using standard methods showed the presence of saponins, phenols, flavonoids, anthraquinones, alkaloids, tannins, triterpenes and phytosterols as well as traces of while

Table 2: Hermannia species with noteworthy biological activities.

Biological activity	Species	Extract/ Compound	Description	Reference
Antimicrobial activity.	*H. depressa*	Ethanolic extract	0.195 mg/ml MIC against *B. subtilis*	[23]
		methanolic extract	1.25 mg/mL MIC against *B. cereus* and *C. albicans* being the most inhibited.	[19]
		acetone extract	1.25 mg/mL MIC against *C. albicans* 0.5 mg/ml MIC against *E. faecalis*	[19-24]
	H. geniculata	1,3-dibutyl-2,8-dihydroxy-9H-xanthene-9-one compound (isolated from ethyl acetate extracts)	3.25 mg/mL MIC against Candida albicans (HO321 and HO325 strains) 6.5 mg/mL MFC MIC against Candida albicans (HO321 and HO325 strains)	[14]
	H. cuneifolia	acetone extract	0.5 mg/mL MIC against *C. neoformans*	[11]
	H. involucrata	acetone extract	0.5 mg/mL MIC against *C. neoformans*	[11]
	H. muricata	acetone extract	0.5 mg/mL MIC against *C. neoformans*	[11]
	H. saccifera	acetone extract	0.0195 mg/ml MIC against both *S. aureus and B. cereus and* 0.125 mg/ml MIC against *E. faecalis*.	[11]
	H. salviifolia	acetone extract	0.5 mg/mL MIC against *P. aeruginosa*	[11]
	H. scabra	acetone extract	0.5 mg/ml MIC against *P. aeruginosa* and *C. neoformans*	[11]
	H. cuneifolia	Methanol extract	0.05 mg/ml MIC against *B. cereus* strains 0.19 mg/ml MIC against both *S. aureus* (ATCC 4330) 0.09 mg/ml MIC against both *S. aureus* (ATCC 867716) 0.19 mg/ml MIC against MRSA	[28]
		Acetone extract	0.05 mg/ml MIC against *B. cereus* strains 0.19 mg/ml MIC against *S. aureus* 0.09 mg/ml MIC against MRSA 0.78 mg/ml MIC against *K. oxytoca*	
Anti-inflammatory activity	*H. depressa*	acetone extracts	77.5% NO production inhibition from oligosaccharide (LPS)-activated malignant macrophage cell line RAW264.7	[19]
		dichloromethane extracts	78% (stem) and 81% (root) COX-1 inhibition	[23]
			3.64 ± 0.123 mg/mL IC_{50} value for inhibition of NO production	[30]
	H. geniculata	Ethanol (Hermannol)	0.67 ± 0.042 mg/mL IC_{50} 5-lipoxygenase enzyme inhibition.	[17]
		Ethanol	0.14±0.06 mg/mL lowest IC_{50} value for 5-LOX enzyme inhibition	[30]
		acetone extracts	56.53%. 5-lipoxygenase enzyme inhibition.	[11]
Antioxidant activity	*H. depressa*	aqueous	0.24±0.691 µg/ml IC50 value DPPH inhibition	[15]
		methanol	0.23±0.37 µg/ml IC50 value DPPH inhibition	[15]
		Acetone	0.003576 ± 0.00044 mg/mL lowest DPPH inhibition and IC_{50} values	[19]
		ethyl acetate	0.199 µg / mL IC50 value for DPPH inhibition IC50 of 0.077 µg/mL IC50 value for ABTS inhibition	[14]
		1,3-dibutyl-2,8-dihydroxy-9H-xanthen-9-one compound (isolated from ethyl acetate extracts)	0.474 µg/mL IC50 value for Hydroxyl radical inhibition	[14]
	H. geniculata	Ethanol	0.111 µg/mL IC50 value for ABTS inhibition	[14]
		hexane	IC50 of 0.021 µg/mL IC50 value in hydroxyl radical inhibition	[14]
		acetone	0.056 µg/mL IC_{50} value in hydroxyl radical inhibition	[14]
		Ethanol (Hermannol)	0.29± 0.011 mg/mL DPPH inhibition IC_{50} value 0.28 ±0.07 mg/mL metal chelation IC50 value	[17]
			10.26 ± 0.29 µg /ml IC50 in DPPH inhibition	[11]
			10.32 ± 0.34 µg /ml IC50 value for ABTS+ inhibition.	[11]
Antidiabetic activity	*H. geniculata*	Ethanol (Hermannol)	0.59 ± 0.086 IC50 for α-amylase inhibition. 0.04 ± 0.002 IC50 for α-glucosidase inhibition.	[17]

Table 3: Compounds identified from the genus.

Hermannia species	Source (Plant part)	Extract	Type	Compound	Molecular formula	References
H. depressa	leaves	Ethanol	Fatty Acid	Lauric acid	$C_{12}H_{24}O_2$	23-39
			Fatty Acid	Myristic acid	$C_{14}H_{28}O_2$	23-40
			Fatty Acid	Palmitic acid	$C_{16}H_{32}O_2$	23-41
			Fatty Alcohol	Stearyl alcohol	$C_{18}H_{38}O$	23-42
			Alkaloid	Waltherione D	$C_{22}H_{22}NO$	
			Alkaloid	Isomer of Waltherione D	$C_{22}H_{22}NO_4$	
			Alkaloid	Waltherione C	$C_{22}H_{21}NO_3$	
		Aqueous	Accridone alkaloid	Buxifoliadine D	$C_{23}H_{23}NO_3$	19
			Flavonoid	Quercetin	$C_{15}H_{10}O_7$	
			Flavone	Tricin	$C_{17}H_{14}O_7$	
			Flavone	Gramrione	$C_{17}H_{14}O_7$	
			Alkaloid	Waltherione D	$C_{22}H_{22}NO_4$	
				8-Dihydroantidesmone	$C_{19}H_{31}NO_3$ Na	
				Hibtherin A	$C_{22}H_{36}O_3$	
				2-Methoxy-5-octylaniline	$C_{15}H_{26}NO$	
			Steroid	2-Methoxyestradiol	$C_{15}H_{10}O_7$	
		Acetone	Flavonoid	4'-Methoxynaringenin	$C_{15}H_{10}O_6$	
			Carbohydrate	Hexose or glucose	$C_6H_{12}O_6$	
			Flavonoid	Jaceosidin	$C_{17}H_{14}O_7$	
			Fatty acid	Docosahexanoic acid	$C_{22}H_{32}O_2$	19
			Fatty acid	Vernolic acid	$C_{18}H_{32}O_3$	
			Phenolic	6-Gingerol	$C_{17}H_{26}O_4$	
			Polyphenolic	4-O-Caffeoylquinic acid	$C_{16}H_{18}O_9$	
			Lignans/Polyphenol	Matairesinol	$C_{16}H_{22}O_9$	
			Lignan/Polyphenol	Pinoresinol	$C_{16}H_{22}O_9$	
		Methanol	Lignan/ Polyphenol	Medioresinol	$C_{21}H_{24}O_7$	
				7-Methoytaxifolin-3-glucoside	$C_{21}H_{22}O_{12}$	
			Caffeic Acid [43]	Yunnaneic acid F	$C_{29}H_{26}O_{14}$	
			flavonoid [44]	Salvigenin	$C_{20}H_{24}O_4$	
			keto acids	2-keto-butyric-acid	$C_4H_6O_3$	30-45
				2,2-Bis(4-nitrobenzyl)-1- phenylbutane-1,3-dione	$C_{24}H_{20}N_2O_6$	30
			Alkane	n-Undecane	$C_{11}H_{24}$	30-46
	roots	ethanolic		1,4,5,8-tetrathiadelin	$C_6H_{10}S_4$	30
				Imidazo (1,5-a) pyrimidine	$C_6H_5N_3$	30
				9-(7 methyl octyl)- 9H-xanthene-2,3-diol	$C_{22}H_{27}O_3$	17
	leaves	ethyl acetate		1,3-dibutyl1-2,8-dihydroxy-9H-xanthene-9-one	$C_{21}H_{26}O_4$	14

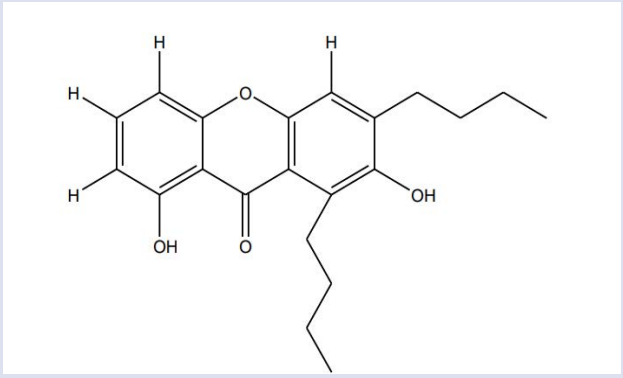

Figure 5: 9-(7-methyl octyl)-9H- xanthene2, 3-diol (hermannol).[17]

anthraquinones and phytosterols.[38-14] Moreover, Mojau isolated a pure bioactive compound utilising analytical techniques TLC and column chromatography (CC) and characterised it using Nuclear Magnetic Resonance (NMR) and then confirmed NMR results using Fourier Transform Spectroscopy (FTIR) from the ethyl acetate extract of *H. geniculata*. The isolated compound was determined as 1,3-dibutyl1-2,8-dihydroxy-9H-xanthen-9-one (Figure 5).[14] Further analysis was conducted to examine its pharmacological properties, and it was found to possess strong antidiabetic and antioxidant activities and moderate antifungal effects against *C. albicans*.[14]

Hermannol (7-methyl octyl)-9H-xanthene2, 3-diol) (Figure 5) was also isolated from ethanol extracts of *H. geniculata* roots using column chromatography, preparative TLC, and characterised by NMR, Mass Spectrometry, Infrared Spectroscopy, and Ultraviolet spectroscopy. Furthermore, the pharmacological properties identified for the compound included significant antioxidant, antidiabetic, and anti-inflammatory activities, with inhibitory effects on α-glucosidase and 5-lipoxygenase enzymes. In addition, cytotoxicity assays demonstrated selective antiproliferative effects on HepG2 liver cancer cells.[17]

The conducted research has unravelled the extraordinary medicinal potential of the Hermannia genus, however, a notable gap in the phytochemical analysis of other members of Hermannia was observed, especially relating to the isolation, elucidation and determination of biological activities of pure bioactive compounds from the genus.

CONCLUSION

The genus Hermannia has over 30 documented traditional medicinal uses. The medicinal uses of the species from the genus are validated by the discovered biological activities in scientific research, which include antimicrobial, anti-inflammatory, antioxidant, antidiabetic anticancer and toxicity activities. This genus is a rich source of bioactive compounds with over 30 identified from different classes, which include alkaloids, flavonoids, phenolics, terpenoids, fatty acids and many more. These compounds are the foundation of the potent biological activities of the genus. 1,3-dibutyl1-2,8-dihydroxy-9H-xanthene-9-one and hermannol (9-(7-methyl octyl)-9H- xanthene2, 3-diol) are 2 pure compounds that were isolated, elucidated and discovered to possess potent pharmacological properties.

Despite the increasing number of studies of the genus, *H. depressa* and *H. geniculate* remain the most studied species by far and the phytochemical and pharmacological statuses of the other species remain under-explored. The most used parts of the plants in this genus are the roots followed by the leaves and stems, consequently leaving the phytochemical profiling and pharmacological characterisation of the flowers under-explored, this may be because flowers are seasonal and short-lived due to grazing of animals. Moreover, the potential of the genus in terms of isolation and characterisation of pure compounds also remains substantially untapped.

Hermannia genus is a promising source of bioactive compounds for novel drug discovery, particularly in the treatment of bacterial infections, inflammatory conditions, oxidative stress, cancer and management of diabetes. Therefore, rigorous research on the genus is imperative, and future research should prioritise phytochemical screening and pharmacological evaluations screening of a more under explored plant species, isolation and elucidation of more pure bioactive compounds, their mechanisms of action and biosafety evaluation. This will fuel therapeutic products development from the genus, thus contributing to health and wellbeing of communities.

AUTHOR CONTRIBUTION

Mfundisi Nhlapo searched the literature, collected the data, and drafted the manuscript; Brian Ngobeni contributed to the data analysis, drafting and reviewing the manuscript. Idah Manduna contributed to the literature search and comments and corrections to the final version of the manuscript

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CONFLICT OF INTEREST

The authors declare no conflict of interest

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