Discover Plants

Review

Pharmacological insights into *Flemingia grahamiana*: a comprehensive review

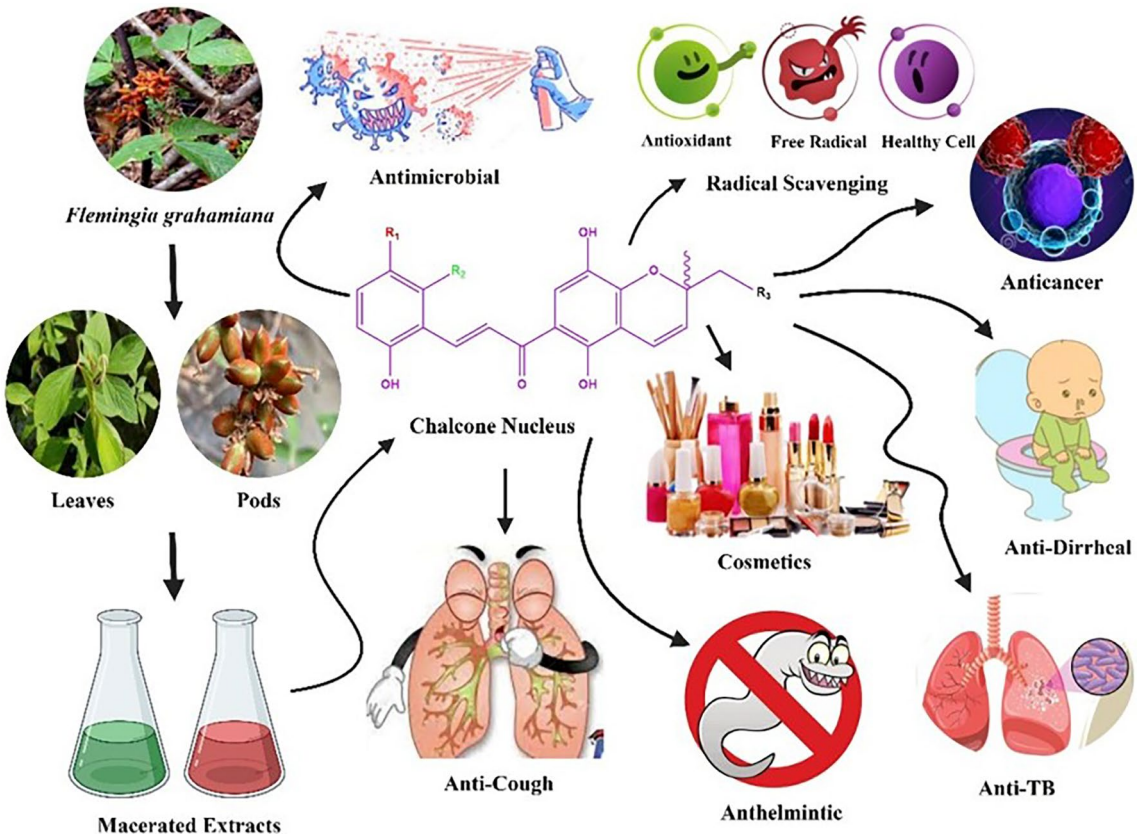
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Abstract
Flemingia grahamiana (*F. grahamiana*), a member of the Fabaceae family, is a plant of immense scientific significance. Its adaptability to tropical and subtropical climates, unique morphology, and a rich array of bioactive compounds like isoflavones, flavones, and chalcones make it a valuable candidate for drug discovery. With a history deeply rooted in folk medicine across diverse cultures and regions, *F. grahamiana* holds enduring therapeutic importance. This comprehensive analysis covers its botanical traits, taxonomic position within Fabaceae, traditional uses in folk medicine, and the chemical constituents responsible for its pharmacological effects. Its ability to thrive in diverse environments enhances its scientific relevance, shedding light on its evolutionary context within the Fabaceae family. The extensive ethnobotanical history underlines its potential in treating various medical conditions like antioxidants, cancer prevention, and antibiotics, shown in graphical abstract. In summary, *F. grahamiana*'s diversity, adaptability, and bioactive components make it a valuable resource for both traditional and modern medicine. This review's compilation of information provides a comprehensive understanding of its potential to advance contemporary drug research and conventional medical practices.

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Graphical Abstract



Keywords *Flemingia grahamiana* · Antioxidant · Anticancer · Antibacterial

Abbreviations

F. grahamiana	*Flemingia grahamiana*
TB	Tuberculosis
DPPH	1,1-Diphenyl-2-picryl hydrazyl
MIC	Minimum Inhibitory Concentration
MRSA	Methicillin-Resistant *Staphylococcus aureus*
MABA	Microplate Alamar Blue Assay
LORA	Low Oxygen Recovery Assay
MCF-7	Michigan Cancer Foundation-7
MTT	(3-[4,5-Dimethylthiazol-2-yl]-2,5 diphenyl tetrazolium bromide)

1 Introduction

Flemingia grahamiana, a Fabaceae family member, is a scientifically significant plant with diverse phytoconstituents and potent pharmacological activities. Its adaptability to tropical and subtropical regions and unique morphological features aid in identification and traditional medicine practices [1]. The plant's bioactive compounds, including isoflavones, flavones, aurones, anthraquinone, emodin, and Chalcones like Flemingin A, B, C, G, H, and O, etc. make it an attractive resource for drug discovery [2]. Further research may lead to novel medicines derived from *F. grahamiana*, advancing herbal medicine and modern drug discovery.

A systematic search on databases such as Google Scholar, ResearchGate, PubMed, and Springer, etc. was used to perform a full review of *F. grahamiana* The study concentrated on phytoconstituents, pharmacological activity, traditional applications, bioactive substances, and traditional medicine. Articles published in English between the earliest accessible date and the most recent date were included, with no limitation on publication year. Exclusion criteria maintained quality and relevance by rejecting irrelevant, non-English, duplicate, and inadequate studies. Inclusion criteria assured the reliability of investigations by examining relevance, original research, publication type, and language. The search generated a significant number of articles, which were screened using the requirements. Relevant full-text papers were chosen for data extraction and analysis, providing significant data about *F. grahamiana* and its possible therapeutic applications. The combined data benefits the scientific community and stimulates further research.

Flemingia grahamiana, a member of the Leguminosae (Fabaceae) family, is a captivating plant with a rich history of traditional use in folk medicines across different parts of the world. Belonging to a botanical genus comprising approximately 30–50 species, primarily found in tropical and subtropical regions, *F. grahamiana*, commonly known as 'Warrus', stands out as an intriguing species within this diverse family [1, 3]. Its botanical characteristics, taxonomic classification, and geographical distribution have been subjects of interest, along with its vital role in traditional medicine, where it is used to address various health conditions.

This review article aims to provide a comprehensive overview of *F. grahamiana*, consolidating existing knowledge from various sources. The plant's unique features, including its erect herb or sub-shrub structure with tomentose young shoots and deep roots, occasionally exhibiting tuberous growth, add to its visual allure. Noteworthy are the digitately 3-foliate leaves, auxiliary inflorescence, densely fasciculate racemes, and distinctive yellow-white or pink corollas of its bisexual flowers. The inflated oblong pods, often adorned with red viscous glands, further contribute to its intriguing botanical attributes [4–6].

Although native to Africa, *F. grahamiana* has a wide distribution, extending to various regions in Asia, such as India, Laos, Myanmar, Vietnam, and Yemen. It thrives in diverse ecological niches, including open and wooded savanna, riverine vegetation near water bodies, hill slopes, termite mounds, and road edges. The plant's adaptability to varying environments has undoubtedly contributed to its popularity as a subject of interest for researchers and scientists worldwide [4].

The Leguminosae family, to which *F. grahamiana* belongs, is renowned for its ethnobotanical uses in traditional medicines across the globe. Members of this family have been recognized for their effectiveness in treating diverse ailments, ranging from stomach problems, diarrhea, dysentery, chest pain, and coughs to serving as aphrodisiacs, purgatives, and anti-helminthic agents, and even as antidotes for snake bites. Furthermore, many of these plants have additional applications, such as food sources, vegetables, and fodder, contributing significantly to nitrogen fixation and soil conservation [7–9].

The phytochemistry of *Flemingia* species, including *F. grahamiana*, has been a subject of interest, revealing various compounds such as isoflavones, chalcones, flavanones, and others. The isolation and characterization of these compounds have shed light on the plant's potential pharmacological activities and therapeutic significance. Notably, the presence of compounds with antioxidant, anticancer, and antibacterial properties in *F. grahamiana* offers exciting prospects for further exploration in drug discovery and development [2, 3, 10, 11].

By synthesizing information from various sources, this review article aims to shed light on the medicinal value of *F. grahamiana* and its potential as a valuable resource for both traditional and modern medicine. We will delve into its phytochemical constituents and explore their potential pharmacological activities, encompassing antioxidant, anticancer Michigan Cancer Foundation-7 (MCF-7), antibacterial, and cytotoxic properties. The wealth of knowledge accumulated through this exploration may pave the way for future research, ultimately leading to the development of novel therapeutic agents derived from this remarkable plant species [3, 10, 11].

1.1 Botanical information

Flemingia is a genus of 30–50 species found in tropical and subtropical climates. *Flemingia* is a synonym for Moghania, an altered variety of Maughania [1].

Up to 1.8 m tall, *F. grahamiana* is an erect plant or subshrub (Fig. 1) with tomentose young shoots and deep (sometimes tuberous) roots. Digitately three-foliate, its stipules are lanceolate or elliptic-lanceolate and around 1 cm long. The plant bears an additional inflorescence that is densely fasciculate, raceme-shaped, and has imbricate bracts on rachises that are 1 to 5 cm long. Flowers are bisexual and have a 2-mm long pedicel, a 1.5-cm long tubular calyx, and an oblong, standard-length corolla that is either yellow-white or pink. The inflated, rectangular, 2-seeded, hairy, and frequently coated in red viscous glands pods are 1 cm in length [4].



Fig. 1 Morphology of *Flemingia grahamiana Wight & Arn. defining* Leaves and pods

It is found throughout tropical Africa from Ethiopia to Cameroon, Ghana to South Africa, and grows in termite mounds, open and wooded savannas, often close to water in riverine vegetation, and along roadside edges. In addition to Southern Arabia (Yemen and Oman), the plant is also widespread in South Western Asia, including India (Karnataka, Tamil Nadu), Laos, Myanmar, and Vietnam [4, 12–14].

M. Mosango conducts extensive investigation of *F. grahamiana* by drying the leaves at 60 ℃. The analysis aimed to determine the following constituents: Ash content (4.0%), Nitrogen (3.28 ± 0.02), Carbon (54.3 ± 3.72%), Cellulose (28.1%), Hemicellulose (6.3%), and Lignin (18.9%). Furthermore, the research encompassed the evaluation of the Active fraction content (42.7%) and the computation of the L/N ratio (5.8) and C/N ratio (16.6). This thorough analysis offers insightful information on the biology and features of *F. grahamiana*. [15]

1.2 Taxonomic classification [16]

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Leguminosae (Fabaceae)
Subfamily: Papilionoideae (Faboideae)
Genus: *Flemingia*
Species: *grahamiana*

1.3 Ethnobotanical uses

Worldwide, traditional medicines employ plants from the Leguminosae family to treat a wide range of illnesses. They are used to cure a variety of conditions, such as coughs, chest pain, diarrhea, dysentery, and syphilis. They are employed as aphrodisiacs, purgatives, laxatives, anti-helminthics, and snake bite antidotes [7–9].

Numerous members of this family of plants are employed as food and vegetable producers, as well as livestock feed for soil conservation. Some are utilized in live and dry fences, particularly those that have thorns and spines [7]. *F. grahamiana* is widely used in traditional medicine in different parts of the world, as summarized in Table 1.

Table 1 Region-wise ethnobotanical applications of *Flemingia grahamiana* used by the localites

Sr. No	Plant species	Disease treated/used as (plant part)	Place
01	*Flemingia grahamiana*	'Warrus'—Cosmetic, dye, anthelmintic, and anticough (pods) [13, 17, 18]	Arabia and India
02		'Warrus'—Cosmetic and dye (fruits and flowers) [5, 6, 13, 19]	Uganda, Malawi, and Zimbabwe
03		Skin diseases and as a purgative (leaves and stems) [13, 15, 20]	India and West Africa
04		Diarrhea and dysentery (roots) [13]	Zimbabwe and Malawi

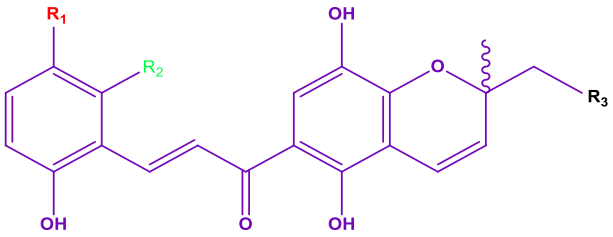


Fig. 2 Chalcone nucleus defining abundant active phytoconstituent Flemingins from *Flemingia grahamiana*

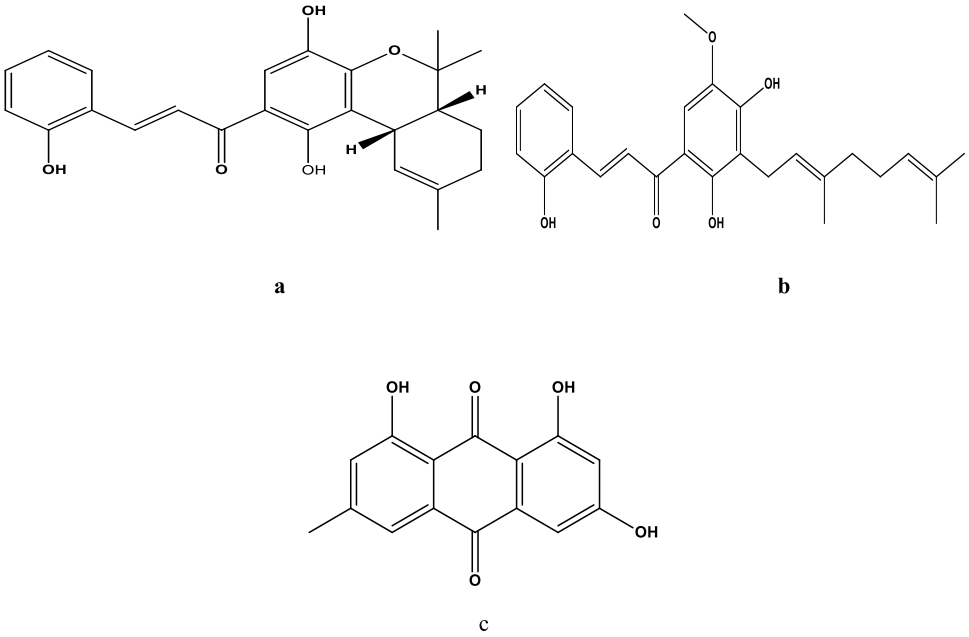


Fig. 3 Chemical structures of other phytoconstituents from *Flemingia grahamiana* **a** Flemingin O, **b** Deoxyhomoflemingin, and **c** Emodin

1.4 Phytochemistry

The *Flemingia grahamiana* has been linked to a variety of chemicals. These include isoflavones, chalcones (including the nine newly discovered Flemingins G-O and the known Flemingins A-C), flavanones, along with deoxyhomoflemingin and emodin, which were extracted from *F. grahamiana* leaf extract. It was discovered that the isolated chalcones had a geranyl substituent changed into a chromene ring with a residual chain [2, 5, 10, 21–23].

The chemical structures for Flemingins, Deoxyhomoflemingin, and Emodin are shown with the Chalcone nucleus for Flemingins and their associated substitutes in Figs. 2 and 3, and Table 2 respectively.

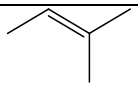
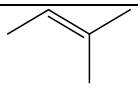
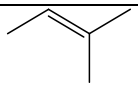
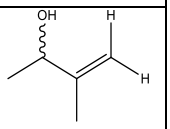
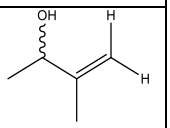
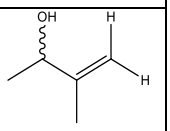
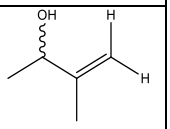
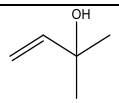
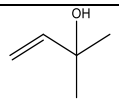
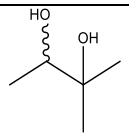
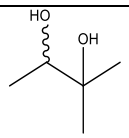
1.5 Pharmacological activities

Graphical representation of pharmacological activities is shown in Fig. 4.

1.5.1 Radical scavenging activity

To evaluate the radical scavenging ability of crude extracts made from *F. grahamiana*'s roots and leaves, *Ivan Gumula* studied the DPPH test. Table 3's findings revealed that the leaf extract had a high ability to scavenge free radicals. It was previously believed that the Flemingin's extraordinary capacity to scavenge free radicals was due to the 2′, 5′-para dihydroxylation present in the B-ring, which resulted in the production of a stable quinone after radical scavenging processes described in Fig. 5 [2, 24].

Table 2 R_1, R_2, R_3 substituents of chalcone nucleus outlining various structural derivatives of Flemingins

Sr. No.	Flemingin	R_1	R_2	R_3
1	**A**	H	H	
2	**B**	H	OH	
3	**C**	OH	H	
4	**G**	OH	H	
5	**H**	H	OH	
6	**I**	H	H	
7	**J**	H	H	
8	**K**	OH	H	
9	**L**	H	H	
10	**M**	H	H	
11	**N**	H	H	

1.5.2 Anti-TB activity

Flemingin A demonstrated strong activity against *Mycobacterium tuberculosis* in the Low Oxygen Recovery Assay (LORA) test, moderate activity in the Methicillin-Resistant *Staphylococcus aureus* (MABA) test, and strong cytotoxicity against

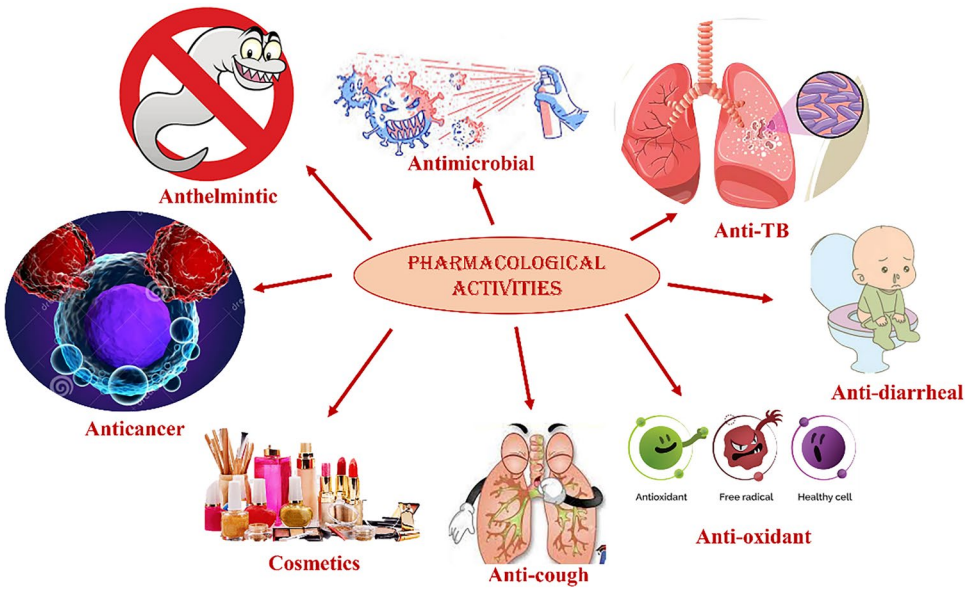


Fig. 4 Graphical representation of various pharmacological activities of *Flemingia grahamiana*

Table 3 Radical scavenging Activity and Anti-TB Activity of selected compound

Test & parameters		Test compound				Standard	
Radical scavenging activity		F A	F B	F C	*FG* Leaves	Quercetin	
ED_{50} (µg/mL)		1.8	3.28	2.5	5.9	0.76	
Activity index		1.76	3.08	2.35	–	1	
Anti-TB activity		F A				Rifampicin	Isoniazid
MIC (%Inh. at high Conc.)	MABA	14.5 µM				0.06 µM	0.17 µM
	LORA	25.8 µM				1.8 µM	> 128 µM (63%)
Cytotoxicity (Vero Cell) IC_{50}		11.6 µM				183.8 µM	Not Tested

* F Flemingin, *FG Flemingia grahamiana*

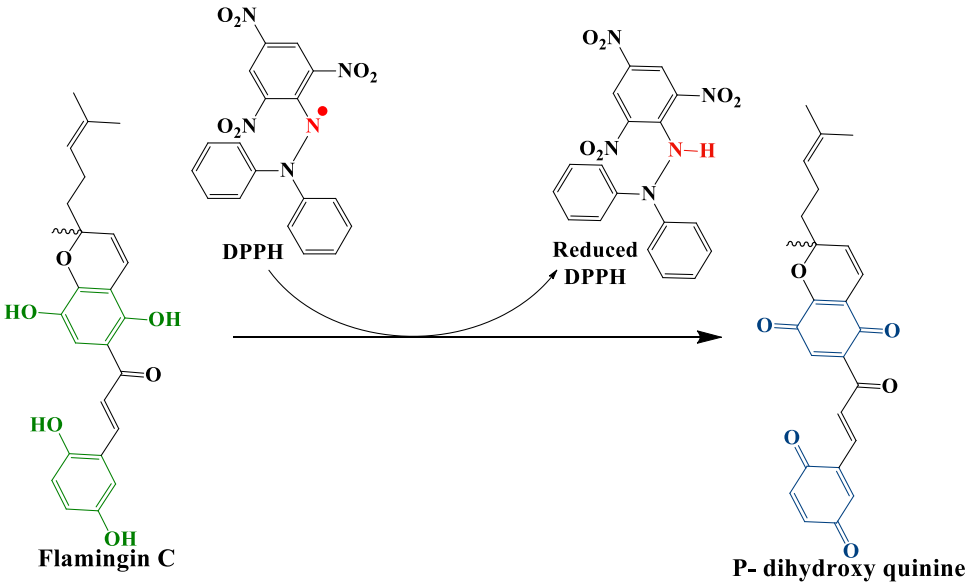


Fig. 5 Chemical conversion of *P*-dihydroxy chalcones into quinones by DPPH explaining the antioxidant potential of Flemingin C

Vero cells, as reported in Table 3. This highlights the efficacy of Flemingin A in the treatment of renal and malignancies associated with the kidney [2].

1.5.3 Antioxidant activity

A study was conducted by *Latifa Nasser* et al. to investigate the antioxidant activities of methanol and aqueous extracts made from *F. grahamiana* warrus pods. The researchers evaluated the antioxidant activity using the 1, 1-Diphenyl-2-picryl hydrazyl (DPPH) technique. A link between the antioxidant properties of both extracts and their concentration was seen. The IC_{50} values for *F. grahamiana* Warrus extracts were 3.95 µg/ml and 0.71 µg/ml for methanol and aqueous extracts, respectively. Notably, the standard ascorbic acid's IC_{50} value was determined to be 3.35 µg/ml [3].

1.5.4 Anticancer activity

Gumula et al. isolated *F. grahamiana* leaf fractions using methanol and dichloromethane, then assessed the leaf fractions' cytotoxicity against MCF-7 cells. When compared to other flemingin derivatives, their research showed that flemingin A and C had the highest cytotoxic potencies, with IC50 values of 8.9 and 7.6 µM, respectively. Additionally, *Abdulqawi* et al. investigated the extracts of *F. grahamiana*'s anticancer potential against MCF-7 cells. They discovered that substantial anticancer effects were shown by both methanol and water extracts, however significant inhibition required concentrations higher than 25 µg/ml. The combined results highlight the potential effectiveness of *F. grahamiana* and its derivatives against human breast cancer cells [10, 24, 25].

1.5.5 Antibacterial activity

The antibacterial potential of methanolic and aqueous crude extracts obtained from *F. grahamiana* was the topic of a research investigation carried out by *Abdul Qawi* et al. The researchers tested the extract's effectiveness against six common bacterial infections in Aurangabad, India, using the Well-diffusion method in vitro. These pathogens included *Escherichia coli* (ATCC25922), *P. mirabilis, K. pneumoniae* (clinical samples), *S. aureus, and P. aeruginosa*. Different concentrations of the extracts (2.5, 5, 7.5, and 10 mg/well) were studied [11].

The findings of this antimicrobial evaluation showed that *F. grahamiana* methanol extracts demonstrated considerable inhibitory effects, especially at a dosage of 10 mg/well. With significant zone sizes of 25.2 mm and 25.7 mm, respectively, *Proteus mirabilis* and *Staphylococcus aureus* were the two pathogens most strongly affected by these effects. However, neither *Klebsiella pneumonia* nor *Escherichia coli* (ATCC 25922) displayed any inhibitory zones in response to these extracts [11].

The study examined the Minimum Inhibitory Concentration (MIC) over a range of concentrations from 25 mg/ml to 0.781 mg/ml to better understand the potency of the extracts. The MIC of *F. grahamiana*'s methanolic extract was 0.781 mg/ml against MRSA and *Staphylococcus aureus*, while that of the aqueous extract was 0.781 mg/ml exclusively against MRSA [11].

Nadia Hassan Al-Asbahi et al.'s study emphasizes how important it is to look into the antibacterial qualities of natural extracts and improve extraction techniques for possible medicinal uses. According to this viewpoint, the study assessed the antibacterial activity of many extracts, including *F. grahamiana* glandular hairs of the pods, against *Staphylococcus aureus*. At 2.5 mg, 5 mg, and 10 mg of extract, the methanolic extract of *F. grahamiana* displayed inhibition zones with diameters of 10 ± 0.29 mm, 10 ± 1 mm, and 12 ± 1.73 mm, respectively; at no tested dosage, the aqueous extract did not demonstrate any inhibition zones. These results highlight the *F. grahamiana* glandular hairs' modest antibacterial activity in a methanolic extract. As an antibacterial agent, *F. grahamiana* seeds are typically ineffective [26, 27].

1.5.6 Other activities

In Zimbabwe and Malawi, the plant's root decoction is used to treat diarrhea and dysentery. In India, the plant is also used internally as a purgative and to treat colds in addition to being used externally to treat skin conditions [13, 28].

2 Conclusion

The fascinating plant *F. grahamiana*, a member of the Fabaceae family, has enormous potential for use in both conventional and modern medicine. This article gives a thorough summary of its pharmacological effects, ethnobotanical uses, and botanical characteristics. Multiple databases were included in the systematic search technique, which produced a

lot of data. Researchers are drawn to *F. grahamiana* because of its capacity to adapt to a variety of habitats and its distinctive morphological features. The bioactive components of the plant, such as isoflavones, flavones, and chalcones, offer intriguing possibilities for therapeutic development. *F. grahamiana* has been used in traditional medical practices around the globe to treat a range of medical issues. The review emphasizes the adaptability, distribution, and previous uses of the plant. Potential therapeutic uses are made possible by the phytochemistry of the plant, particularly by substances with antioxidant, anticancer, and antibacterial properties. The significance of *F. grahamiana* in bridging the gap between conventional methods and contemporary drug development is highlighted by this review. Future improvements in medicine are possible thanks to *F. grahamiana*, which combines historical knowledge with modern research.

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Data availability The data collected and reported in the review has been cited accordingly as per the ethics.

Declarations

Ethics approval and consent to participate Not Applicable.

Consent for publication Not Applicable.

Competing interests Authors declares no competing interests.

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References

1. Kenicer G. Legumes of the World. In: Lewis G, Schrire B, MacKinder B, Lock M (eds). Royal Botanic Gardens, Kew: 2006.
2. Gumula I. Phytochemical investigation of three leguminosae plants for cancer chemopreventive agents. Nairobi: University of Nairobi; 2014.
3. Abdul Qawi LNA, Quadri SA. Antioxidant activity of yemini plants, Myrtus communis L. and Flemingia grahamiana Wight & Arn. Int J Pharm Pharm Res. 2020;17(4):805–11.
4. Gillett JB, Polhill RM, Verdcourt B. Flora of Tropical East Africa: Leguminosae, Subfamily Papilionoideae, Part 1. Crown Publishing Group Agents for Overseas Governments & Administrations: 1971.
5. The 14th NAPRECA symposium and AAMPS Ethnoveterinary medicine symposium Nairpobi 2011
6. Jansen PCM. *Flemingia grahamiana*, Wright and Arn. In PROTA 3: Dyes and Tannins/Colorants et Tannins [CD-ROM]; 2005.
7. Kokwaro JO. Medicinal plants of East Africa. 2nd ed. Nairobi: Kenya Literature Bureau; 1993.
8. Katende, Birnie, Tengnas. Useful Trees and Shrubs for Uganda (Technical Handbook No. 10); Regional Land Management Unit, RELMA/Sida, ICRAF House, Gigiri: 2000.
9. Rickard PP, Cox PA. Use of derris as a fish poison in Guadalcanal Solomon Islands. Econ Bot. 1986;40(4):479–84. https://doi.org/10.1007/BF02859661.
10. Gumula I, Alao JP, Ndiege IO, Sunnerhagen P, Yenesew A, Erdélyi M. Flemingins G-O, Cytotoxic and antioxidant constituents of the leaves of *Flemingia grahamiana*. J Nat Prod. 2014;77(9):2060–7. https://doi.org/10.1021/np500418n.
11. Abdul Qawi LNA, Quadri SA. In-vitro antibacterial activities of extracts of yemeni plants *Myrtus communis L*. and *Flemingia grahamiana* Wight and arn. Int J Pharm Sci Res. 2021;12(2):956–62. https://doi.org/10.13040/IJPSR.0975-8232.12(2).
12. Lackey JA. Chromosome numbers in the Phaseoleae (Fabaceae:Faboideae) and their relation to taxonomy. Am J Bot. 1980;67(4):595–602. https://doi.org/10.1002/j.1537-2197.1980.tb07689.x.
13. Ghazanfar, S. A., & Kogan, L. (2022). A Botanical and Etymological Approach to Plant Names in Southern Arabia. Bloomsbury Advances in Ecolinguistics Series Editors, 119.

14. Lekhak MM, Nandikar MD, Yadav SR. Karyomorphology of Flemingia nilgheriensis (Baker) Wight ex T. cooke: an endemic from Western Ghats. Cytologia. 2011;76(3):243–8. https://doi.org/10.1508/cytologia.76.243.
15. Mosango, Chemical Characteristics of Six Woody Species for Alley Cropping M. Notes Techniques Technical Notes. Tropicultura 1998–99, 16–17, 2, 93–95.
16. *Flemingia grahamiana* (PROTA). Plantuse English. https://uses.plantnet-project.org/e/index.php?title=Flemingia_grahamiana_(PROTA)&oldid=198776. Accessed 25 Aug 2023.
17. Ghalot K. Phytochemical and pharmacological potential of *Flemingia* Roxb. ex W.T. Aiton (Fabaceae). Int J Phytomed. 2011;3:294–307.
18. Thacker KD, Gavade SK, Lekhak MM, Gondaliya AD, Rajput KS. Comparison of petiole anatomy in Flemingia and its potential for delimitation of species. Flora. 2021;278:151790. https://doi.org/10.1016/j.flora.2021.151790.
19. Cardillo G, Merlini L, Mondelli R. Natural Chromenes—III. Tetrahedron. 1968;24(1):497–510. https://doi.org/10.1016/0040-4020(68)89049-0.
20. Sornay PD, Flattely FW. Green manures and manuring in the tropics, including an account of the economic value of leguminosæ as sources of foodstuffs, vegetable oils, drugs, &c. London: J. Bale, Sons Danielsson Ltd; 1916. https://doi.org/10.5962/bhl.title.22569.
21. Cardillo B, Gennaro A, Merlini L, Nasini G, Servi S. New natural chalcones from ham. Tetrahedron Lett. 1970;11(49):4367–8. https://doi.org/10.1016/S0040-4039(00)89487-3.
22. Cardillo B, Gennaro A, Merlini L, Nasini G, Servi S. New Chromenochalcones from *Flemingia*. Phytochemistry. 1973;12(8):2027–31. https://doi.org/10.1016/S0031-9422(00)91528-0.
23. Zhou K, Yang S, Li SM. Naturally occurring prenylated chalcones from plants: structural diversity, distribution, activities and biosynthesis. Nat Prod Rep. 2021;38(12):2236–60. https://doi.org/10.1039/d0np00083c.
24. Yenesew A, Gumula I, Erdélyi M, Patrick AJ, Isaiah Omolo Ndiege PS, Omolo N, Sunnerhagen P. Cytotoxic and antioxidant Flemingins G-P from the leaves of Flemingia grahamiana. J Nat Prod. 2014. https://doi.org/10.1021/np500418n.
25. Abdulqawi LN, Quadri A, Islam S, Santra MK, Farooqui M. Chemical compositions and anticancer activity of Yemeni plant Flemingia grahamiana Wight Arn. and *Myrtus communis* L. Trop J Nat Prod Res. 2021;5(5):877–82. https://doi.org/10.26538/tjnpr/v5i5.14.
26. Al-Asbahi NH, Alasbahi RH. The in vitro antibacterial activity of a multiherbal combination used traditionally in Aden for topical treatment of Furuncles. Univ Aden J Nat Appl Sci. 2016;20(2):305–11. https://doi.org/10.47372/uajnas.2016.n2.a06.
27. Alasbahi RH, Safiyeva S, Craker LE. Antimicrobial activity of some Yemeni medicinal plants. J Herbs Spices Med Plants. 1999;6(3):75–83. https://doi.org/10.1300/J044v06n03_07.
28. Kisan GS, Van der Maesen LJG, Madhwanand LM. Taxonomic Revision of the Genus *Flemingia* (Leguminosae: Papilionoideae) in India. Webbia. 2020;75(2):141–218. https://doi.org/10.36253/jopt-8767.

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