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REVIEW ARTICLE

# *Pseudodictamnus africanus* (L.) Salmaki & Siadati (Lamiaceae): Ethnomedicinal uses, phytochemistry and pharmacological properties

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## Abstract

*Pseudodictamnus africanus* (L.) Salmaki & Siadati is a perennial herb which naturally occurs in Namibia and South Africa. Southern Africa is characterized by several indigenous medicinal plants and natural products that are widely used in traditional *materia medica*. However, there is dearth of information on botanical description, medicinal uses, plant parts used, preparation and dosage, active ingredients and pharmacological effects of medicinal plants like *P. africanus* in the public domain. Therefore, this study reviewed the medicinal uses, active bioactives and biological activities of *P. africanus*. A systematic review of electronic databases and pre-electronic sources with information on the botany, medicinal uses, herbal preparations, active bioactives and pharmacological effects of *P. africanus* was conducted. No time limit was set for the research and all literature sources aligned with the scope of the research were included. This study showed that *P. africanus* is used as traditional medicine for liver problems, sores, wounds, heart problems, hysteria, skin ailments, headache, insomnia, fever, typhoid fever and respiratory problems. Pharmacological research identified hispanolone, dehydrohispanolone, saponins, tannins, phenolics, flavonoids, reducing sugars, resveratrol, triterpene steroids and essential oils. The crude extracts of *P. africanus* and essential oils isolated from the species exhibited antibacterial, antifungal, anti-inflammatory, anti-nociceptive, immunological and sedative-hypnotic activities. More research is needed to assert the medicinal and ethnopharmacological properties of the crude extracts of *P. africanus* and phytochemical compounds isolated from the species, and also determine the toxicological effects of the species and its phytochemical compounds.

## Keywords

*Ballota africana*, active bioactives, medicinal uses, Labiatae, Lamiaceae, pharmacological effects, *Pseudodictamnus africanus*

## Introduction

*Pseudodictamnus africanus* (L.) Salmaki & Siadati is an aromatic shrublet belonging to the Lamiaceae or Labiatae or sage or deadnettle or mint family. The majority of species belonging to the Lamiaceae family are aromatic and include widely used culinary and medicinal herbs. Such species include *Ballota nigra* L. indigenous to Europe and Asia, and naturalized in North America is reputed to treat stomach spasms, nausea, as a calming herb, sedative, persistent cough and nervous system disorders, especially minor sleeplessness in both children and adults (1). *Pseudodictamnus africanus*

was originally treated as *Ballota africana* (L.) Benth. (2) but Siadati *et al.* (3, 4) described genus *Ballota* L. as consisting of three herbaceous species confined to Europe, western Asia and the Mediterranean. Species classified under *Pseudodictamnus* Fabr. are herbaceous plants which naturally occur in the African and Mediterranean regions (3, 4). The synonyms of *P. africanus* include *Ballota africana, Beringeria africana* (L.) Neck., *Beringeria crispa* (L.) G. Don, *Marrubium africanum* L., *Marrubium crispum* L., *Marrubium laurifolium* Steud., *Marrubium thouinii* Schult. ex Weinm., *Pseudodictamnus emarginatus* (L.) Moench and *Stachys africana* (L.) Kuntze (2, 3). The English common names of *P. africanus* are African horehound, Cape horehound, English cat herb and horehound. *Pseudodictamnus africanus* is an evergreen, perennial, aromatic, soft, greyish shrublet growing up to 1.2 m in height (5, 6). Leaves are opposite, softly hairy, heart-shaped with toothed margins. Flowers are pale pink, purple, mauve or greyish white in colour, occur in spikes, arranged in dense whorls around the stem and alternating with each pair of leaves (7). *Pseudodictamnus africanus* has been recorded in rocky or disturbed places in southern Namibia, through the Eastern Cape, Free State and the Western Cape provinces in South Africa (Fig. 1) at an altitude from 0 to 1525 m above the sea level (8).

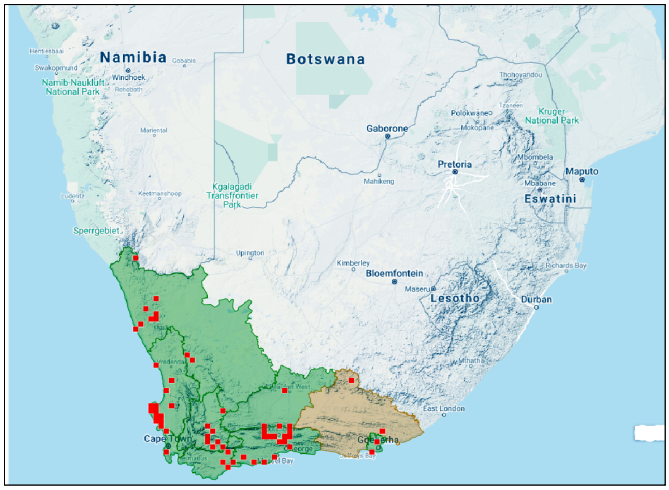


**Fig. 1.** Distribution of *Pseudodictamnus africanus* in southern Africa (https://www.inaturalist.org/taxa/524606-Ballota-africana).

*Pseudodictamnus africanus* is an important source of traditional medicines in the Eastern Cape, Free State and the Western Cape provinces in South Africa, and the species is listed in three monographs, "medicinal and magical plants of southern Africa: An annotated checklist" (9), "medicinal plants of the world" (1) and "medicinal plants of South Africa" (10). Similarly, arguments are on the leaf infusions or tinctures of *P. africanus* have potential in the development of new medicinal products as they are widely used for various medicinal applications (11). It was showed that in the Eastern Cape, Free State and the Western Cape provinces in South Africa, the leaves of *P. africanus* are often mixed with those of *Stachys thunbergii* Benth. (family Lamiaceae) and *Valeriana capensis* Thunb. (family Caprifoliaceae) as traditional medicines for asthma, bronchitis, hysteria and insomnia (12, 13). *Pseudodictamnus africanus* is mainly collected from the wild but also available in informal herbal medicine markets and sold as bunches of dried and/or fresh material consisting of stems, leaves and sometimes mixed with flowers, fruits and roots. The leaves of *P. africanus* are also used as snack, vegetable, herbal tea and flavourant in South Africa (14, 15). In South Africa, the conservation status of *P. africanus* is categorized as Least Concern based on the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria version 3.1, indicating that the species is generally widespread and occurring in abundance with a low risk of extinction (16). However, the popularity of *P. africanus* as medicinal plant species requires the need for a holistic conservation approach in its use and future management of the species in southern Africa. Given this background, the current investigation was conducted aimed at documenting the medicinal uses, active bioactives and biological activities of *P. africanus*.

The use of medicinal plants such as *P. africanus* in the management of diverse ailments is entrenched in the culture of indigenous people in southern Africa. From time immemorial, local communities have relied on medicinal plants to treat and manage diseases and ailments, and these plants also provide several health or pharmaceutical products. Some communities rely exclusively on medicinal plants as sources of medicines because they are the most affordable and easily accessible source of treatment in the primary healthcare system of the resource poor communities and those people occupying marginal areas (17-19). It was argued that medicinal plants are an important aspect of the daily lives of many people and an important part of the African cultural heritage (10). Similarly, research revealed that there is an increase in the popularity of natural remedies and botanicals in modern world as is seen in the rapid growth of over-the-counter medicines, dietary supplements and functional foods (20). Therefore, there is need to fully explore the ethnopharmacological properties of plant species widely used as traditional medicines, focusing on their therapeutic potential, phytochemical properties, empirical evidence of their efficacies based on *in vitro, in vivo* and appropriate clinical tests and models.

## Materials and Methods

A systematic review of electronic databases such as Taylor and Francis, Science Direct, Google Scholar, Scopus, Web of Science, SpringerLink, SciELO, Pubmed and Elsevier. Pre-electronic sources such as national, international journal and other scientific publications, dissertations, theses, books and grey literature with information on the botany, medicinal uses, herbal medicine preparations, active bioactives and pharmacological effects of *Pseudodictamnus africanus* were used. No time limit was set for the research and all literature sources aligned with the scope of the research were included. The key words *Pseudodictamnus africanus* and commonly used synonym *Ballota africana* were used in combination with other key words such as "active bioactives of *Pseudodictamnus africanus* or *Ballota africana*", "ethnobotany of *Pseudodictamnus africanus* or *Ballota africana*", "medicinal uses of *Pseudodictamnus africanus* or *Ballota africana*", "phytochemicals of *Pseudo-*

*dictamnus africanus* or *Ballota africana"*, "biological activities of *Pseudodictamnus africanus* or *Ballota africana"*, "pharmacological properties of *Pseudodictamnus africanus* or *Ballota africana"* and "traditional uses of *Pseudodictamnus africanus* or *Ballota africana"*.

## Results and Discussion

### *Traditional medicinal uses of Pseudodictamnus africanus*

The fresh or dried leaves, stems and aerial parts of *P. africanus* are mainly used as traditional medicine for liver problems, sores, wounds, heart problems, hysteria, skin ailments, headache, insomnia, fever, typhoid fever and respiratory infections (Table 1, Fig. 2). Research showed that in South Africa *P. africanus* is often mixed with *Valeriana capensis* as traditional medicine for asthma, bronchitis, heart trouble, hysteria and insomnia (12, 21). Research showed that in South Africa, the leaves of *P. africanus* are often mixed with those of various *Salvia* species (family Lamiaceae) to treat and manage fevers and measles (10, 12). Similarly, research showed that in South Africa the leaves, roots and stems of *P. africanus* are often mixed with those of *Lasiosiphon deserticola* (Gilg) C.H. Wright (family Thymelaeaceae) and *Lessertia frutescens* (L.) Goldblatt & J.C. Manning (family Fabaceae) as remedy for diabetes and pain (21, 22). Other traditional medicinal uses of the fresh or dried leaves, stems and aerial parts of *P. africanus* supported by at least 5 literature records include colic and traditional medicine for arthritis, gastro-intestinal problems, haemorrhoids, high and low blood pressure, mouth infections and thrush, painful feet and legs, rheumatism, snake bite, stress and urinary problems (Table 1).

### *Phytochemistry of Pseudodictamnus africanus*

**Table 1.** Medicinal uses of fresh or dried leaves, stems and aerial parts of *Pseudodictamnus africanus*

| Medicinal uses | Plant parts used and administration | References |
|---|---|---|
| Arthritis | Leaf infusions or brandy tinctures used as a foot bath | (10, 23-28) |
| Backache | Leaf infusion taken orally | (29-32) |
| Blood circulation | Foliage infusion taken orally | (25, 33) |
| Cancer | Leaf infusion taken orally | (32) |
| Colic | Leaf infusion taken orally | (12, 22, 23, 27, 34, 35) |
| Convulsions | Leaf infusion taken orally | (29, 30, 32) |
| Diabetes mellitus | Leaf infusion taken orally | (31, 36) |
| Earache | Leaf infusion applied topically | (29) |
| Fever and typhoid fever | Leaf infusions or brandy tinctures are taken orally | (1, 5, 10, 13, 14, 22-29, 31-33, 35-45 |
| Galactagogue | Leaf infusion taken orally | (29, 39) |
| Gastro-intestinal problems (diarrhoea and stomachache) | Leaf infusion taken orally | (24, 25, 29-33, 46) |
| Gout | Leaf infusion taken orally | (31) |
| Haemorrhoids | Leaf infusions or brandy tinctures are taken orally | (10, 13, 23, 26, 27, 35, 41) |
| Headache | Leaf infusions or brandy tinctures are taken orally | (5, 10, 13, 23-33, 35, 39-41, 45, 46) |
| Heart problems | Leaf infusions or brandy tinctures are taken orally | (10, 23-28, 31, 33, 35, 39-48) |
| High and low blood pressure | Leaf infusion taken orally | (12, 22, 27, 29, 31, 49-51) |
| Hysteria | Leaf infusions or brandy tinctures are taken orally | (1, 10, 12, 13, 21, 23-27, 33, 35, 39-41, 48, 52-54) |
| Inflammation | Leaf infusion applied topically | (31, 55) |
| Insect repellent | Foliage used as insect repellent | (25) |
| Insomnia | Leaf infusions or brandy tinctures are taken orally | (10, 12, 13, 21, 23-27, 31, 34, 35, 38, 40-43, 45, 47, 48, 52, 54) |
| Liver problems | Leaf infusions or brandy tinctures are taken orally | (10, 23-28, 39-41) |
| Mastitis | Leaf infusion taken orally | (29, 30, 32) |
| Mouth infections and thrush | Leaf infusion applied topically | (12, 13, 27, 35, 56) |
| Over-excitement | Leaf infusion taken orally | (23, 35) |
| Pain | Leaf infusion taken orally | (1, 29, 31, 55, 57) |
| Painful feet and legs | Leaf infusion applied topically | (29-32, 39) |
| Postpartum | Leaf infusion taken orally | (31, 39) |
| Respiratory problems (asthma, bronchitis, chest pains, cough, hoarseness, influenza, lung infections, pneumonia, sore throat and tuberculosis) | Leaf infusions or brandy tinctures are taken orally | (1, 5, 10, 12-14, 23-35, 37-46, 58-61) |
| Rheumatism (inflamed joints and joint pain) | Leaf infusion applied topically | (13, 29-32) |
| Skin ailments (boils and measles) | Leaf infusion applied topically | (10, 13, 14, 23-32, 35, 39, 44, 45) |
| Snake bite | Leaf infusion applied topically | (12, 23, 24, 27, 34, 35) |
| Sores and wounds | Leaf infusion applied topically | (12, 27, 29-32, 38, 42, 56, 57) |

| | | |
|---|---|---|
| Stress | Leaf infusion taken orally | (13, 27, 38, 42, 45) |
| Stroke | Leaf infusion taken orally | (31) |
| Toothache | Leaf infusion applied topically | (29, 30, 32) |
| Urinary problems (bladder and kidneys) | Leaf infusion taken orally | (13, 27, 31, 32, 35) |

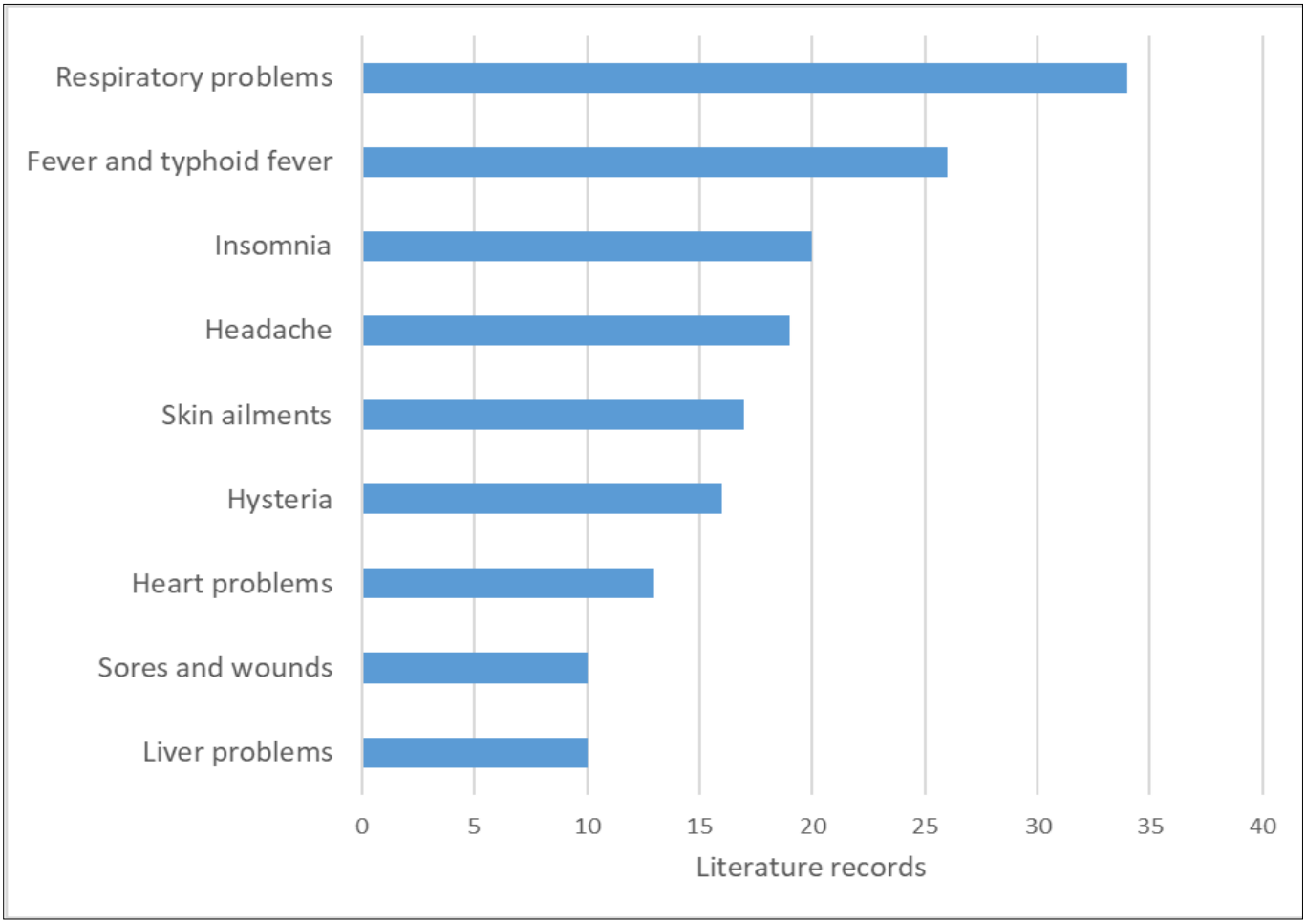


**Fig. 2.** Medicinal uses of *Pseudodictamnus africanus* based on literature records.

It was identified hispanolone and dehydrohispanolone (Fig. 3) from the aerial parts of *P. africanus* (34) while documentation and isolation of tannins and saponins isolated

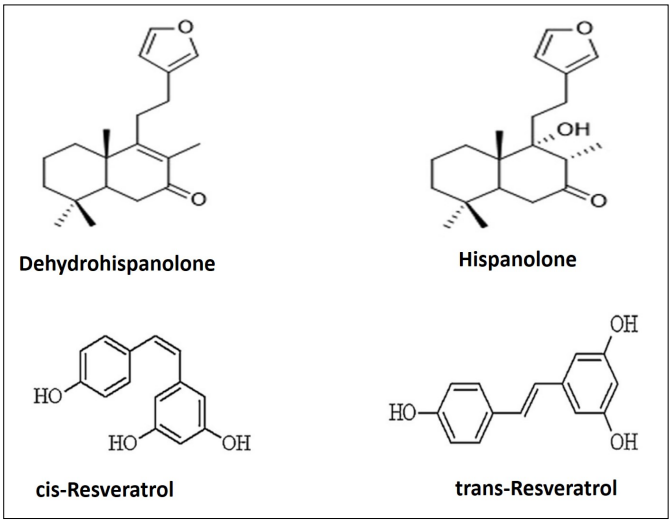


**Fig. 3.** Chemical structures of phytochemical compounds isolated from the aerial parts and leaves of *Pseudodictamnus africanus.*

from the leaves (38). Similarly, reports are on a phenolic compound resveratrol from the leaves of *P. africanus* (62) while reports are on flavonoids, reducing sugars, saponins, tannins and triterpene steroids from the leaves (47). Other research carried out showed that *P. africanus* is a source of essential oils and diterpenoids (43). Similar compounds have also been identified from a closely related species, *Ballota nigra* and these phytochemical compounds include diterpenoid lactones of the labdane type such as ballotenol, ballotinone, 7α-acetoxymarrubiin and preleosibirin, flavonoid glycosides, phenylpropanoids and traces of volatile oil (1). The phytochemical compounds identified from different aerial parts and leaves of *P. africanus* are important and these findings could be used to explain the health benefits of the species (Table 1). The identified compounds isolated from the aerial parts and leaves of *P. africanus* clearly highlight the importance of detailed and further investigations on active bioactives of the species in the aerial parts, leaves and stems as these organs remain the most widely utilised plant parts as traditional medicine.

## *Pharmacological properties of Pseudodictamnus africanus*

The pharmacological effects (Table 2) of the essential oils isolated from *P. africanus*, stem and leaf extracts of the

**Table 2.** Summary of pharmacological activities of the extracts and compounds isolated from different parts of *Pseudodictamnus africanus*

| Activity tested | Extract/ compound | Plant part | Model | Effect | Reference |
|---|---|---|---|---|---|
| Antibacterial | Methanol | Leaves | Modified disc diffusion | Showed weak activities against *Proteus mirabilis* with the inhibition zone of 7.0 mm | 28 |
| | | | Disc diffusion | Showed weak activities against *Proteus mirabilis* with the minimum inhibitory concentration (MIC) values of 4278.0 µg/ml | 28 |
| | Aqueous | Leaves | Microdilution | Showed activities against *Staphylococcus aureus* with MIC value of 3.1 mg/ml, *Klebsiella pneumoniae* and *Streptococcus pyogenes* with MIC value of >12.5 mg/ml | 41 |
| | | Stems | Microdilution | Showed weak activities against *Klebsiella pneumoniae, Staphylococcus aureus* and *Streptococcus pyogenes* with MIC value of >12.5 mg/ml | 41 |
| | Dichloro-methanea | Leaves | Microdilution | Showed activities against *Staphylococcus aureus* with MIC value of 0.4 mg/ml, *Klebsiella pneumoniae* (1.6 mg/ml) and *Streptococcus pyogenes* (6.3 mg/ml) | 41 |
| | | Stems | Microdilution | Showed activities against *Streptococcus pyogenes* with MIC value of 0.4 mg/ml, *Klebsiella pneumoniae* (1.6 mg/ml) and *Staphylococcus aureus* (3.1 mg/ml) | 41 |
| | 80% ethanol | Leaves | Microdilution | Showed activities against *Streptococcus pyogenes* with MIC value of 0.4 mg/ml, *Klebsiella pneumoniae* (3.1 mg/ml) and *Staphylococcus aureus* (6.3 mg/ml) | 41 |
| | | Stems | Microdilution | Showed activities against *Streptococcus pyogenes* with MIC value of 1.6 mg/ml, *Klebsiella pneumoniae* and *Staphylococcus aureus* with MIC value of 3.1 mg/ml | 41 |
| | Petroleum ether | Leaves | Microdilution | Showed activities against *Klebsiella pneumoniae* and *Staphylococcus aureus* with MIC value of 3.1 mg/ml each, and *Streptococcus pyogenes* with MIC value of 12.5 mg/ml | 41 |
| | | Stems | Microdilution | Showed activities against *Staphylococcus aureus* and *Streptococcus pyogenes* with MIC value of 1.6 mg/ml each, and *Klebsiella pneumoniae* with MIC value of 3.1 mg/ml | 41 |
| | Aqueous | Leaves | Disc diffusion | Showed activities against *Klebsiella pneumoniae* with inhibition zone of 7.0 mm | 62 |
| | Methanol | Leaves | Disc diffusion | Showed activities against *Klebsiella pneumoniae* with inhibition zone of 8.0 mm | 62 |
| | Aqueous | Leaves | Microdilution | Showed activities against *Klebsiella pneumoniae* with MIC value of 379.0 µg/ml | 62 |
| | Methanol | Leaves | Microdilution | Showed activities against *Klebsiella pneumoniae* with MIC value of 438.0 µg/ml | 62 |
| Antifungal | Aqueous | Leaves | Microdilution | Showed activities against *Candida albicans* with MIC value of 3.1 mg/ml and minimum fungicidal concentrations (MFC) value of >12.5 mg/ml | 41 |
| | | Stems | Microdilution | Showed activities against *Candida albicans* with MIC value of 6.3 mg/ml and MFC value of >12.5 mg/ml | 41 |
| | Dichloro-methane | Leaves | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 1.6 mg/ml and 3.1 mg/ml, respectively | 41 |
| | | Stems | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 3.1 mg/ml | 41 |
| | 80% ethanol | Leaves | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 3.1 mg/ml | 41 |
| | | Stems | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 3.1 mg/ml and 6.3 mg/ml, respectively | 41 |
| | Petroleum ether | Leaves | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 3.1 mg/ml and 6.3 mg/ml, respectively | 41 |
| | Petroleum ether | Stems | Microdilution | Showed activities against *Candida albicans* with MIC and MFC value of 3.1 mg/ml and 6.3 mg/ml, respectively | 41 |
| Anti-inflammatory | Aqueous | Essential oils | 5-lipoxygenase inhibitory | Essential oils exhibited activities with half maximal inhibitory concentration ($IC_{50}$) value of 30.0 ppm | 56,63 |
| Antinociceptive | Methanol | Leaves | Hot plate test | Exhibited dose-dependent activities | 47 |
| | | | Acetic acid writhing test | Exhibited dose-dependent activities | 47 |
| Immunological | Ethanol | Leaves | Anti-histamine assay | Exhibited affinity with histamine receptor binding of 90.0% | 41 |
| | | Stems | Anti-histamine assay | Exhibited affinity with histamine receptor binding of 95.0% | 41 |
| Sedative-hypnotic | Methanol | Leaves | Pentobarbitone induced sleep test | Exhibited dose-dependent activities | 47 |
| | | | Locomotor activity test | Exhibited dose-dependent activities | 47 |

species included the following: antibacterial (28, 41, 62), antifungal (41), anti-inflammatory (56, 63), antinociceptive (47), immunological (41) and sedative-hypnotic (47) activities.

### Antibacterial activities

Reports are on the assessment of the antibacterial effects of aqueous and methanol extracts of *P. africanus* leaves were tested using *Proteus vulgaris* (ATCC 33420) and *Proteus mirabilis* (ATCC 43071) against the disc diffusion approach with chloramphenicol (10.0 µg) and ampicillin (2.0 µg) as positive controls (28). The methanolic extract exhibited weak activities against *Proteus mirabilis* (ATCC 43071) with the inhibition zone of 7.0 mm and minimum inhibitory concentration (MIC) values of 4278.0 µg/ml (28). The antibacterial effects of aqueous, petroleum ether, dichloromethane and 80% ethanol extracts of *P. africanus* stems and leaves against *Haemophilus parainfluenzae* (ATCC 7901), *Streptococcus pyogenes* (ATCC 12344), *Staphylococcus aureus* (ATCC 12600) and *Klebsiella pneumoniae* (ATCC 13883) were tested against the disc diffusion and microdilution methods using neomycin (50.0 µg/ml), ampicillin (50.0 µg/ml) and penicillin (50.0 µg/ml) as the positive controls in the investigation (41). The extracts of the species showed activities against *Streptococcus pyogenes* (ATCC 12344), *Staphylococcus aureus* (ATCC 12600) and *Klebsiella pneumoniae* (ATCC 13883) with MIC values within the range of 0.4 mg/ml to >12.5 mg/ml (41). Reports are on the assessment of the antibacterial effects of methanol and water extracts of *P. africanus* leaves tested against *Klebsiella pneumoniae* (ATCC 13883) using the disc diffusion method with ampicillin (2.0 µgg) and chloramphenicol (10.0 µgg) used as the positive controls (62). The water and methanolic extracts demonstrated the antibacterial effects againnst *Klebsiella pneumoniae* (ATCC 13883) with inhibition zone of 7.0 mm and 8.0 mm and MIC values of 379.0 µg/ml and 438.0 µg/ml respectively (62).

### Antifungal activities

The antifungal effects of aqueous, 80% ethanol, petrolleum ethers and dichloromethane extracts of *P. africanus* leaves and stems using *Candida albicans* (ATCC 10231) against the microdilution method using the amphotericin B (50.0 µg/ml) as the positive control were assessed (41). The extracts of the species demonstrated activities against the experimental pathogens with the MIC and minimum fungicidal concentrations (MFC) values within the of 1.6 mg/ml and >12.5 mg/ml (41). The preliminary antibacterial and antifungal activities exhibited by *P. africanus* extracts are strongly linked to several physiological processes and activities which act against microbial growth and multiplication, hence the species is popular as traditional medicine against gastro-intestinal problems, mouth infections and thrush, skin infections, respiratory infections, sores, wounds and toothache. Although the research aimed at establishing the antibacterial and antifungal activities of *P. africanus* is noteworthy, the screened panel of bacterial and fungal microorganisms are inadequate in comparison to the documented microbial-related human and animal health conditions in southern Africa. There is need to evaluate antibacterial and antifungal activities of *P. africanus* against bacterial and fungal microorganisms that are of relevance to dermatological problems and respiratory infections. There is obviously need to conduct *in vivo* and clinical tests as there are several limitations associated with the *in vitro* models (64).

### Anti-inflammatory effects

Reports are on the assessment of the anti-inflammatory effects of methanol and water extracts of *P. africanus* leaves and essential oils isolated from the species by evaluating the 5-lipoxygenase inhibitory effects which were tested using a threefold stepwise dilution approach using Tween®20 and dimethyl sulfoxide (DMSO) as negative controls and nordihydroguaiaretic acid was used as the positive control (56, 63). The essential oils exhibited 5-lipoxygenase inhibitory effects which were supported by half maximal inhibitory concentration ($IC_{50}$) value of 30.0 ppm (56, 63). These results support the traditional use of the species in various inflammatory ailments and diseases ranging from microbial infection to injury that result in cell injury and death.

### Antinociceptive effects

Reports are on the assessment of the antinociceptive effects of methanol extracts of *P. africanus* leaves against the hot plate and the acetic acid writhing tests in mice (47). The extract of the species demonstrated the dose-dependent effects which were similar to the dose-dependent effects demonstrated by a positive control (47). These findings could be used to corroborate traditional uses of *P. africanus* extracts as traditional medicines for mechanical injury and sensory nervous system such as fever, inflammation, rheumatism, toothache, sores and wounds.

### Immunological activities

The immunological effects of the ethanolic crudes extracts of *P. africanus* leaves and stems were tested against the anti-histamine assay (41). The *P. africanus* leaves and stems extracts exhibited excellent affinity with histamine receptor binding of 90.0% to 95.0% respectively (41). More research is needed to correlate the traditional use of the species in various inflammatory ailments and diseases with the biological activities of crude extracts or compounds isolated from the species.

### Sedative-hypnotic effects

The sedative-hypnotic effects of methanol extract of *P. africanus* leaves were tested against the pentobarbitone induced sleep and locomotor activity tests in mice (47). The extract of the species demonstrated the dose-dependent effects which were similar to the dose-dependent effects demonstrated by a positive control (47).

### Toxicity

The oral preparation and administration procedure involving the methanol extracts of *P. africanus* aerial parts demonstrated the median lethal dose ($LD_{50}$) of the species is probably over 4000.0 mg/kg in mice (47). Therefore, detailed studies focusing on evaluating the toxicological effects, particularly the long-term acute and chronic toxici-

ty effects *in vivo* and animal models are recommended.

## Conclusion

This study provided a summary of information on the medicinal uses, active bioactives and the pharmacological effects of *P. africanus*. Considering the high number of studies reporting on ethnomedicinal uses of *P. africanus,* there are still further avenues and opportunities to unravel the phytoconstituents and the biological activities of this species. Such advanced ethnopharmacological research on *P. africanus* will enable local communities in southern Africa to continuously utilize the species for human diseases and ailments.

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## Compliance with ethical standards

**Conflict of interest**: The author declares that there is no conflict of interest associated with this research.

**Ethical issues**: None.

## References

1. Van Wyk B-E, Wink M. Medicinal Plants of the World: An Illustrated Scientific Guide to Important Medicinal Plants and Their Use. Briza Publications, Pretoria. 2017. https://doi.org/10.1079/9781786393258.0000
2. Codd LE. The genus Ballota. Flora of S. Afr. 1985;28:48-50. https://doi.org/10.17764/jiet.1.28.2.g5367h1124v87467
3. Siadati S, Salmaki Y, Mehrvarz SS, Heubl G, Weigned M. Untangling the generic boundaries in tribe Marrubieae (Lamiaceae: Lamioideae) using nuclear and plastid DNA sequences. Taxon. 2018;67:770-83. https://doi.org/10.12705/674.6.
4. Siadati S, Salmaki Y, Brauchler C. Trichome morphology provides phylogenetically informative signal for generic delimitation in tribe Marrubieae (Lamiaceae). Flora. 2020;273:151720. https://doi.org/10.1016/j.flora.2020.151720
5. Manning J. Photo guide to the wildflowers of South Africa. Briza Publications, Pretoria. 2012.
6. Manning JC, Goldblatt P. Plants of the Greater Cape Floristic region 1: The Core Cape Flora. South African National Biodiversity Institute, Pretoria. 2012.
7. Snijman D. 2013. Plants of the Greater Cape Floristic region 2: The extra Cape Flora. South African National Biodiversity Institute, Pretoria. 2013.
8. Germishuizen G, Meyer NL. Plants of Southern Africa: An annotated checklist. Strelitzia 14, National Botanical Institute, Pretoria. 2003.
9. Arnold TH, Prentice CA, Hawker LC, Snyman EE, Tomalin M,Crouch NR, Pottas-Bircher C. Medicinal and magical plants of southern Africa: An annotated checklist Strelitzia 13, National Botanical Institute, Pretoria. 2002.
10. Van Wyk B-E, Van Oudtshoorn B, Gericke N. Medicinal Plants of South Africa. Briza Publications, Pretoria. 2013.
11. Van Wyk B-E. 2011. The potential of South African plants in the development of new medicinal products. S Afr J Bot. 2011;77:812-29. https://doi.org/10.1016/j.sajb.2011.08.011
12. Watt JM, Breyer-Brandwijk MG. The Medicinal and Poisonous Plants of Southern and Eastern Africa. Livingstone, London. 1962.
13. Van Wyk B-E, Gericke N. People's plants: A Guide to Useful Plants of Southern Africa. Briza Publications, Pretoria. 2018.
14. Van Wyk B-E. A review of Khoisan and Cape Dutch medical ethnobotany. J Ethnopharmacol. 2008;119:331-41. https://doi.org/10.1016/j.jep.2008.07.021.
15. Welcome AK, Van Wyk B-E. An inventory and analysis of the food plants of southern Africa. S Afr J Bot. 2019;122:136-79. https://doi.org/10.1016/j.sajb.2018.11.003
16. Raimondo D, von Staden L, Foden W, Victor JE, Helme NA, Turner RC, Kamundi DA, Manyama PA. Red List of South African plants. Strelitzia, 25. South African National Biodiversity Institute, Pretoria. 2009.
17. Maroyi A. Ethnobotanical study of medicinal plants used by people in Nhema communal area, Zimbabwe. J Ethnopharmacol. 2011;136:347-54. https://doi.org/10.1016/j.jep.2011.05.003.
18. Maroyi A. Traditional use of medicinal plants in south-central Zimbabwe: Review and perspectives. J Ethnobiol Ethnomed. 2013;9:31. https://doi.org/10.1186/1746-4269-9-31.
19. Maroyi A. Use of ethnomedicinal herbs to treat and manage schistosomiasis in Zimbabwe: Past trends and future directions. In: JL Martinez, Munoz-Acevedo A, Rai M, editors., Ethnobotany: Application of Medicinal Plants, CPC Press, London. 2019, pp. 36-47.
20. Van Wyk B-E, Wink M. Phytomedicines, herbal drugs and plant poisons. Briza Publications, Pretoria. 2015. https://doi.org/10.7208/chicago/9780226205076.001.0001
21. Van Vuuren SF, Motlhatlego KE, Netshia V. Traditionally used polyherbals in a southern African therapeutic context. J Ethnopharmacol. 2022;288:114977. https://doi.org/10.1016/j.jep.2022.114977.
22. Davids D, Gibson D, Johnson Q. Ethnobotanical survey of medicinal plants used to manage high blood pressure and type 2 diabetes mellitus in Bitterfontein, Western Cape Province, South Africa. J Ethnopharmacol. 2016;194:755-66. https://doi.org/10.1016/j.jep.2016.10.063
23. Van der Walt L. *Ballota africana* (L.) Benth., 2004. Available from: http://pza.sanbi.org/ballota-africana, accessed on 17 November 2021.
24. Thring TSA, Weitz FM. Medicinal plant use in the Bredasdorp/Elim region of the Southern Overberg in the Western Cape Province of South Africa. J Ethnopharmacol. 2006;103:261-75. https://doi.org/10.1016/j.jep.2005.08.013
25. Philander LA. An ethnobotany of Western Cape Rasta bush medicine. J Ethnopharmacol. 2011;138:578-94. https://doi.org/10.1016/j.jep.2011.10.004
26. Philander LEA, Makunga NP, Platten SJ. Local medicinal plant knowledge in South Africa preserved by apartheid. Hum Ecol. 2011;39:203-16. https://doi.org/10.1007/s10745-011-9387-x
27. Arendse ML. Medicinal plant use in the Dwarsrivier Valley, Stellenbosch. MSc Dissertation. University of the Western Cape, Cape Town. 2013.
28. Cock IE, van Vuuren SF. Anti-proteus activity of some South African medicinal plants: their potential for the prevention of rheumatoid arthritis. Inflammopharmacol. 2014;22:23-36. https://doi.org/10.1007/s10787-013-0179-3
29. Nortje JM. Medicinal ethnobotany of the Kamiesberg, Namaqualand, Northern Cape province, South Africa. MSc Dissertation, University of Johannesburg, Johannesburg. 2011
30. Nortje JM, Van Wyk B-E. Medicinal plants of the Kamiesberg, Namaqualand, South Africa. J Ethnopharmacol. 2015;171:205-22. https://doi.org/10.1016/j.jep.2015.04.049
31. Hulley IM, Van Wyk B-E. Quantitative medicinal ethnobotany of

Kannaland (western Little Karoo, South Africa): Non-homogeneity amongst villages. S Afr J Bot. 2019;122:225-65. https://doi.org/10.1016/j.sajb.2018.03.014

32. Rosselli S, Fontana G, Bruno M. A review of the phytochemistry, traditional uses, and biological activities of the genus Ballota and Otostegia. Planta Med. 2019;85:869-910. https://doi.org/10.1055/a-0953-6165
33. Rattray RD, Van Wyk B-E. The botanical, chemical and ethnobotanical diversity of southern African Lamiaceae. Molecules. 2021;26:3712. https://doi.org/10.3390/molecules26123712
34. Davies-Coleman MT, Rivett DEA. Transformation of hispanolone from *Ballota africana* into 15,16-epoxy-9-hydroxylabda-13(16),14-diene. S Afr J Chem. 1990;43:117-19.
35. Roberts M, Roberts S. Indigenous Healing Plants. Briza Publications, Pretoria. 2017.
36. Cock IE, Ndlovu N, Van Vuuren SF. The use of South African botanical species for the control of blood sugar. J Ethnopharmacol. 2021;264:113234. https://doi.org/10.1016/j.jep.2020.113234
37. Cocks ML, Wiersum KF. The significance of plant diversity to rural households in Eastern Cape province of South Africa. For Trees Livelih. 2003;13:39-58. https://doi.org/10.1080/14728028.2003.9752443
38. Scott GA, Springfield EP, Coldrey N. A pharmacognostical study of 26 South African plant species used as traditional medicines. Pharm Biol. 2004;42:186-13. https://doi.org/10.1080/13880200490514032
39. De Beer JJJ, Van Wyk B-E. An ethnobotanical survey of the Agter–Hantam, Northern Cape province, South Africa. S Afr J Bot. 2011;77:741-54. https://doi.org/10.1016/j.sajb.2011.03.013
40. Lall N, Kishore N. Are plants used for skin care in South Africa fully explored? J Ethnopharmacol. 2014;153:61-84. https://doi.org/10.1016/j.jep.2014.02.021
41. Motlhatlego KE. Evaluation of plants used in African traditional medicine for asthma and related conditions. MSc Dissertation. University of KwaZulu-Natal, Pietermaritzburg. 2014.
42. Etsassala NGER. Detection of selective tyrosinase inhibitors from some South African plant extracts of Lamiaceae family. MSc Dissertation. University of the Western Cape, Cape Town. 2016.
43. Van Wyk B-E. A review of African medicinal and aromatic plants. In: Neffati M, Najjaa H, Mathé A, editors., Medicinal and aromatic plants of the world: Africa volume 3. Springer, Leiden. 2017; pp. 19-60. https://doi.org/10.1007/978-94-024-1120-1_2
44. Van Wyk B-E, Gorelik B. The history and ethnobotany of Cape herbal teas. S Afr J Bot. 2017;110:18-38. https://doi.org/10.1016/j.sajb.2016.11.011
45. Morteza-Semnani K, Ghanbarimasir Z. A review on traditional uses, phytochemistry and pharmacological activities of the genus *Ballota*. J Ethnopharmacol. 2019;233:197-217. https://doi.org/10.1016/j.jep.2018.12.001.
46. Van Wyk B-E, De Wet H, Van Heerden FR. An ethnobotanical survey of medicinal plants in the southeastern Karoo, South Africa. S Afr J Bot. 2008;74:696-704. https://doi.org/10.1016/j.sajb.2008.05.001
47. Amabeoku GJ, Mbamalu ON, Amardien L, Mbiyi MF, Mohamed M, Motala IM, Toffar WN. Investigation of the anti-nociceptive and sedative hypnotic effects of leaf methanol extract of *Ballota africana* (L.) Benth. (Lamiaceae) in mice. Clin Exp Pharmacol. 2016;6:4. http://dx.doi.org/10.4172/2161-1459.C1.014
48. Sobiecki JF. A preliminary inventory of plants used for psychoactive purposes in southern African healing traditions. Transact Royal Soc S Afr. 2002;57:1-24. https://doi.org/10.1080/00359190209520523
49. Nzue, APMM. Use and conservation status of medicinal plants in the Cape Peninsula, Western Cape province of South Africa. Unpublished MSc thesis. University of Stellenbosch, Stellenbosch. 2009.
50. Balogun FO, Ashafa AOT. Review of plants used in South African traditional medicine for the management and treatment of hypertension. Planta Med. 2019;85:312-34. https://doi.org/10.1055/a-0801-8771
51. Niazi M, Yari F, Shakarami A. A review of medicinal herbs in the Lamiaceae family used to treat arterial hypertension. Entomol Appl Sci Lett. 2019;6:22-27.
52. Stafford GI, Pedersen ME, Van Staden J, Jäger AK. Review on plants with CNS-effects used in traditional South African medicine against mental diseases. J Ethnopharmacol. 2008;119:513-37. https://doi.org/10.1016/j.jep.2008.08.010
53. Masondo NA, Stafford GI, Aremu AO, Makunga NP. Acetylcholinesterase inhibitors from southern African plants: An overview of ethnobotanical, pharmacological potential and phytochemical research including and beyond Alzheimer's disease treatment. S Afr J Bot. 2019;120:39-64. https://doi.org/10.1016/j.sajb.2018.09.011
54. Stafford GI, Pedersen ME, Van Staden J, Jäger AK. Review on plants with CNS-effects used in traditional South African medicine against mental diseases. J Ethnopharmacol. 2008;119:513-37. https://doi.org/10.1016/j.jep.2008.08.010
55. Khumalo GP, Van Wyk B-E, Feng Y, Cock IE. A review of the traditional use of southern African medicinal plants for the treatment of inflammation and inflammatory pain. J Ethnopharmacol. 2022;283:114436. https://doi.org/10.1016/j.jep.2021.114436
56. Frum Y. *In vitro* 5-Lipoxygenase and anti-oxidant activities of South African medicinal plants commonly used topically for skin diseases. MSc Dissertation. University of the Witwatersrand, Johannesburg. 2006. https://doi.org/10.1159/000095253
57. Wheat NM. An ethnobotanical, phytochemical and metabolomics investigation of plants from the Paulshoek communal area, Namaqualand. PhD Thesis. University of Cape Town, Cape Town. 2013.
58. McGaw LJ, Lall N, Meyer JJM, Eloff JN. The potential of South African plants against *Mycobacterium* infections. J Ethnopharmacol. 2008;119:482-500. https://doi.org/10.1016/j.jep.2008.08.022.
59. Hutchings A, Scott AH, Lewis G, Cunningham AB. Zulu medicinal plants: An inventory. University of Natal Press, Pietermaritzburg. 1996.
60. Cock IE, Van Vuuren SF. The traditional use of southern African medicinal plants in the treatment of viral respiratory diseases: A review of the ethnobotany and scientific evaluations. J Ethnopharmacol. 2020;262:113194. https://doi.org/10.1016/j.jep.2020.113194.
61. Ndhlovu PT, Omotayo AO, Otang-Mbeng W, Aremu AO. Ethnobotanical review of plants used for the management and treatment of childhood diseases and well-being in South Africa. S Afr J Bot. 2021;137:197-215. https://doi.org/10.1016/j.sajb.2020.10.012
62. Cock IE, Van Vuuren SF. The potential of selected South African plants with anti-Klebsiella activity for the treatment and prevention of Ankylosing spondylitis. Inflammopharmacol. 2015;23:21-35. https://doi.org/10.1007/s10787-014-0222-z.
63. Frum Y, Viljoen AM. *In vitro* 5-lipoxygenase and antioxidant activities of South African medicinal plants commonly used topically for skin diseases. Skin Pharmacol Physiol. 2006;19:329-35. https://doi.org/10.1159/000095253
64. Heinrich M, Appendino G, Efferth T, Fürst R, Izzo AA, Kayser O, Pezzuto JM, Viljoen A. Best practice in research: Overcoming common challenges in phytopharmacological research. J Ethnopharmacol. 2020;246:112230. https://doi.org/10.1016/j.jep.2019.112230

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