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A review of ethnobotanical, therapeutic value, phytochemistry and pharmacology of *Gasteria bicolor*

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Abstract

Gasteria bicolor is a valuable succulent herb widely used as herbal medicine in South Africa. This study reviewed ethnobotanical uses, phytochemical and pharmacological properties of *G. bicolor*. Relevant information on the uses, phytochemistry and pharmacological properties of *G. bicolor* was collected from electronic scientific databases such as ScienceDirect, SciFinder, PubMed, Google Scholar, Medline, and SCOPUS. Pre-electronic literature search of conference papers, scientific articles, books, book chapters, dissertations and theses was carried out at the University library. Literature search revealed that *G. bicolor* is used as a protective charm against evil spirits or lightning, bring good fortune or luck and dispel nightmares. The leaves of *G. bicolor* are used as herbal medicines for skin diseases such as eczema, scabies and skin irritation, prophylactic purposes, dermatophytoses, stomach problems and as ethnoveterinary medicine. Phytochemical compounds identified from the species include alkaloids, flavonoids, phenolics, proanthocyanidin, saponins and dihydroanthracenones. Pharmacological studies revealed that *G. bicolor* extracts have antifungal, antioxidant and cytotoxicity activities. *Gasteria bicolor* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological activities.

Keywords: Asphodelaceae, *Gasteria bicolor*, South Africa, traditional knowledge

INTRODUCTION

Gasteria bicolor Haw. is a succulent herbaceous perennial belonging to the Asphodelaceae or *Aloe* family. Members of the Asphodelaceae family are known to be used medicinally as a purgative (laxatives), as herbal medicines for arthritis, eczema, skin irritations, burns, hypertension and stress.[1] Aloe L. species for example are used as purgatives, herbal medicines for arthritis, sinusitis, conjunctivitis, opthalmia and eye ailments, wounds, sores, burns, venereal ulcers, herpes, shingles, blood purification, emetics or gargled for sore throat, hypertension and stress, infertility in women and impotence in men, parasitic and skin infections and as ethnoveterinary medicine for redwater and various other ailments in cattle and sheep.[2-5] Species of the Asphodelaceae family are also widely used as traditional medicines in Algeria, Cyprus, Egypt, India, Libya, Pakistan, Palestine, Spain and Turkey for burns, wounds, colds, earache, eczema, microbial infections, inflammatory disorders, haemorrhoids, jaundice, nephritis, parasitic infections, peptic ulcers, rheumatism and skin diseases.[6-27] Research carried out by Malmir et al.[27] revealed that crude extracts and compounds isolated from species of the Asphodelaceae family are characterized by anti-inflammatory, antimalarial, antimelanogenic, antimicrobial, antioxidant, apoptotic, antiparasitic, antiviral, cytotoxicity, diuretic and hypotensive activities.

Gasteria bicolor var. *bicolor* is not only cultivated for its aesthetic value as an ornamental plant but the species is highly valued by local communities in South Africa for its medicinal and magical applications.[28-32] Van Jaarsveld[30] argued that *G. bicolor* var. *bicolor* and *G. bicolor* var. *liliputana* (Poelln.) Van Jaarsv. can be used as succulent indoor or outdoor plants. Van Jaarsveld[30] also argued that *G. bicolor* var. *liliputana* can be used as a pot plant on window sills, verandas, in a miniature succulent garden or in outdoor rockeries. *Gasteria bicolor* var. *liliputana* is threatened with extinction and is categorized as Near Threatened (NT) by Victor and Dold[33] and as naturally rare in South Africa[34-36]. Research by Hilton-Taylor,[34] Raimondo et al.[35] and Williams et al.[36] revealed that the habitat of *G. bicolor* var. *liliputana* is not suitable for agricultural activities and other land use practices but the species is restricted in its distribution with extent of occurrence (EOO) not exceeding 500 km^2. Victor and Keith[37] and Von Staden et al.[38] argued that plant species characterized by stable populations and categorized as Least Concern (LC) under the IUCN Red List Categories and Criteria version 3.1 can additionally be flagged as of conservation concern either as rare, critically rare or declining, and this is exemplified by *G. bicolor* var. *liliputana*. While *G. bicolor* var. *liliputana* is facing a much lower risk of extinction, it needs conservation action if viable populations are to be maintained. Research by Dold and Cocks[39] and Dold and Cocks[40] showed that *Gasteria bicolor* var. *bicolor* is unsustainably harvested from the wild and heavily traded in the Eastern Cape province with a trader selling about 112.0 kg of the species per annum at an average price of R52.00 (US$5.00) per kg. Therefore, *G. bicolor* var. *bicolor* is among the top ten most traded or used medicinal plants in the Eastern Cape and Western Cape provinces in South Africa.[39-48] Research by Wiersum et al.[49] revealed that *G. bicolor* var. *bicolor* is managed and cultivated in home gardens of the Eastern Cape province where the species is required for sustained utilization as herbal medicine but also as a tool for combined biodiversity conservation and poverty alleviation through income generated through its marketing in informal herbal medicine markets. *Gasteria bicolor* var. *bicolor* has been introduced in the home gardens of the North West province in South Africa where the species is not indigenous, but cultivated as an ornamental plant and also as a source of herbal medicines.[50] It is within this context that this review was undertaken aimed at reviewing the ethnobotanical,

medicinal uses, phytochemistry and biological activities of *G. bicolor* so as to provide baseline data required in evaluating the therapeutic potential of the species.

Botanical profile of *Gasteria bicolor*

The generic name *Gasteria* Duval is derived from the Greek word "gaster" which means "belly" in reference to the inflated lower perianth tube[51,52] and the species epithet "*bicolor*" means "two-coloured". *Gasteria bicolor* is a variable species characterized by multiple proliferous stems covered by masses of shiny, mottled, colourful and succulent leaves. The flowers are tubular, bell-shaped and pink to orange in colour. Two varieties of *G. bicolor* are recognized distinguished on the basis of geographical distribution and morphological characteristics. *Gasteria bicolor* var. *bicolor* is taller and more widespread, recorded at an altitude ranging from 18 m to 610 m above sea level while var. *liliputana* is rare, short and recorded at an altitude up to 1000 m.[53,54] Synonyms associated with *G. bicolor* include *Aloe bicolor* (Haw.) Schult. & Schult.f., *A. boureana* Schult. & Schult.f., *A. bowieana* Salm-Dyck, *A. dictyodes* Schult. & Schult.f., *A. formosa* (Haw.) Schult. & Schult.f., *A. guttata* Salm-Dyck, *A. lingua* Ker Gawl., *A. maculata* Thunb., *A. maculata* Thunb. var. *obliqua* Aiton, *A. marmorata* Steud., *A. obliqua* (Aiton) Haw., *A. obliqua* Haw. var. *fallax* (Haw.) Schult. & Schult.f., *A. planifolia* Baker, *A. vittata* Schult. & Schult.f., *A. zeyheri* Salm-Dyck, *G. biformis* Poelln., *G. caespitosa* Poelln., *G. chamaegigas* Poelln., *G. colubrina* N.E.Br., *G. fasciata* (Salm-Dyck) Haw., *G. formosa* Haw., *G. herreana* Poelln., *G. kirsteana* Poelln., *G. liliputana* Poelln., *G. lingua* (Ker Gawl.) A.Berger, *G. loeriensis* Poelln., *G. longiana* Poelln., *G. longibracteata* Poelln., *G. maculata* (Thunb.) Haw., *G. maculata* (Thunb.) Haw. var. *dreagana* A.Berger, *G. maculata* (Thunb.) Haw. var. *fallax* Haw., *G. marmorata* Baker, *G. multiplex* Poelln., *G. obliqua* (Haw.) Duval, *G. picta* Haw., *G. planifolia* (Baker) Baker, *G. retata* Haw., *G. salmdyckiana* Poelln., *G. spiralis* Baker, *G. variolosa* Baker and *G. zeyheri* (Salm-Dyck) Baker.[51,53,54] *Gasteria bicolor* has been recorded in shallow soil on rocky slopes and outcrops in the thicket biome with annual rainfall ranging from 500 mm to 600 mm.[53]

Medicinal uses of *Gasteria bicolor*

The leaves or entire herbaceous *G. bicolor* are used mainly for magical uses, see Table 1. *Gasteria bicolor* is used as a protective charm against evil spirits or lightning, bring good fortune or luck and dispel nightmares.[41-44,55-59] Research by Afolayan et al.[60] showed that the leaves of *G. bicolor* are used as herbal medicines for skin diseases such as eczema, scabies and skin irritation. The leaves of *G. bicolor* are also used for prophylactic purposes,[57] herbal medicines for dermatophytoses,[61,62] stomach problems[56] and as ethnoveterinary medicine, mainly as anthelmintics in goats.[63]

Table 1: Medicinal uses of *Gasteria bicolor*

Medicinal use	Parts used	References
Dermatophytoses	Leaves	Otang et al.[61]; Otang[62]
Prophylactic purposes	Leaves	Dold and Cocks[57]
Magical purposes (dispel nightmares, good fortune, protection against evil spirits and lightning)	Leaves and whole plants	Cocks[41]; Cocks and Dold[42]; Dold and Cocks[43]; Cocks and Møller[44]; Crouch et al.[56]; Dold and Cocks[57]; Cocks and Dold[58]; Koopman[59]
Skin diseases (eczema, scabies and skin irritation)	Leaves	Afolayan et al.[60]
Stomach problems	Leaves	Crouch et al.[56]
Ethnoveterinary medicine (anthelmintics in goats)	Leaves	Maphosa and Masika[63]

Phytochemistry of *Gasteria bicolor*

Dagne et al.[64] identified dihydroanthracenones namely 3,4-dihydro-2,6,9-trihydroxy-8-methyl-1(2H)-anthracenone (gasteriacenone A), 3,4-dihydro-2,4,9-trihydroxy-6-methoxy-8-methyl-1(2H)-anthracenone (gasteriacenone B) and 3,4-dihydro-4,6,9-trihydroxy-7-carbomethoxy-8-methyl-1(2H)-anthracenone (gasteriacenone C) from the stems and leaves of *G. bicolor*. Otang[62] and Otang et al.[65] and identified alkaloids, flavonoids, phenolics, proanthocyanidin and saponins from the leaf extracts of *G. bicolor*.

Antifungal activities

Otang,[62] Otang et al.[66] and Otang et al.[67] evaluated antifungal activities of acetone, aqueous and hexane leaf extracts *G. bicolor* against *Candida albicans*, *Candida krusei*, *Candida glabrata*, *Candida neoformans*, *Aspergillus fumigatus*, *Aspergillus niger*, *Trichophyton tonsurans*, *Trichophyton mucoides*, *Microsporum gypseum* and *Microsporum canis* using agar diffusion and micro-dilution methods with amphotericin B, nystatin and grieseofulvin as positive controls. Acetone extracts exhibited activities against *Candida albicans* and *Candida krusei* with zone of inhibition ranging from 10 mm to 15 mm. The hexane extracts exhibited activities against all fungal species with the exception of *Candida neoformans*, *Trichophyton tonsurans*, Trichophyton mucoides and *Microsporum gypseum* exhibiting zone of inhibition ranging from 8 mm to 16 mm. The minimum inhibitory concentrations (MIC) and minimum fungicidal

concentration (MFC) values ranged from 0.04 mg/ml to 5.0 mg/ml.[62,66,67] David et al.[68] evaluated antifungal activities of acetone and methanol leaf extracts of *G. bicolor* against *Absidia corymbifera, Aspergillus flavus, Aspergillus fumigatus, Aspergillus niger, Penicillium chalybeum* and *Penicillium expansum* using the poisoned food technique with amphotericin B as a positive control. The extracts exhibited activities with half maximal inhibitory concentration (IC_{50}) values ranging from 0.2 mg/ml to >10.00 mg/ml. The MIC and MFC values ranged from 0.8 mg/ml to 12.5 mg/ml.[68]

Antioxidant activities

Otang[62] and Otang et al.[65] evaluated the *in vitro* antioxidant activities of acetone leaf extracts of *G. bicolor* using DPPH (1,1-diphenyl-2-picrylhydrazyl), NO (nitric oxide), H_2O_2 (hydrogen peroxide) radical scavenging assays and reducing power assay with gallic acid, rutin, vitamin C and butylatedhydroxytoluene (BHT) as positive controls. The extracts exhibited activities with IC_{50} values of 0.3 µg/ml in DPPH and reducing power assays and 0.2 µg/ml in NO and H_2O_2 assays.[62,65]

Cytotoxicity activities

Otang[62] and Otang et al.[69] evaluated cytotoxicity activities of acetone and hexane leaf extracts of *G. bicolor* using the *Artemia salina* Leach (brine shrimp) hatching and lethality assays with amphotericin B as a positive control. The hatching success of brine shrimps in the extracts was not significantly different from that of the positive control. The extracts exhibited MIC values of >2.0 mg/ml and median lethal concentration (LC_{50}) values ranging from 0.8 mg/ml to 1.1 mg/ml which was comparable to MIC value of >2.0 mg/ml and LC_{50} value of 1.1 mg/ml exhibited by the positive control.[62,69] Otang[62] and Otang et al.[70] evaluated cytotoxicity activities of acetone and hexane leaf extracts of *G. bicolor* against the Chang Liver cell line using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay with griseofulvin as a positive control. The extracts induced cell cytotoxicity in a concentration-dependent manner with acetone and hexane extracts exhibiting IC_{50} values of 156.0 µg/ml and 278.8 µg/ml, respectively which were much higher than 9.0 µg/ml exhibited by the positive control.[62,70]

CONCLUSION

The present review summarizes the medicinal uses, phytochemistry and biological activities of *G. bicolor*. From a chemical, pharmacological and toxicological point of view, G. bicolor has not received any major emphasis. Currently, there is not yet enough data on ethnopharmacological evaluations on the species that can be correlated with its medicinal applications. Therefore, detailed phytochemical, pharmacological and toxicological studies of *G. bicolor* are recommended.

Conflict of interest

The author declares that he has no conflict of interest.

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