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Stangeria eriopus (Stangeriaceae): medicinal uses, phytochemistry and biological activities

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Abstract

Stangeria eriopus is a perennial and evergreen cycad widely used as herbal medicine in South Africa. This study reviewed medicinal uses, phytochemistry and pharmacological properties of *S. eriopus*. Relevant information on the uses, phytochemistry and pharmacological properties of *S. eriopus* 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 *S. eriopus* is used as a protective charm against enemies, evil spirits, lightning, and bring good fortune or luck. The caudices, leaves, roots, seeds, stems and tubers of *S. eriopus* are used as emetics and purgatives, and as herbal medicine for body pains, congestion, headaches, high blood pressure and ethnoveterinary medicine. Phytochemical compounds identified from the species include alkaloids, amino acids, biflavones, fatty acids, glycosides, polyphenols, saponins and tannins. Pharmacological studies revealed that *S. eriopus* extracts have anti-hypertensive, anti-inflammatory and β-glycosidase activities. *Stangeria eriopus* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological properties.

Keywords: Ethnopharmacology, South Africa, *Stangeria eriopus*, Stangeriaceae, traditional knowledge

INTRODUCTION

Use of gymnosperms for medicinal purposes is entrenched in cultural practices throughout the African continent. Species of Gymnosperm families such as Cupressaceae, Ephedraceae, Pinaceae and Taxaceae are widely used as sources of traditional medicines in Pakistan.[1] Similarly, Gymnosperm species are used as aphrodisiac and diuretics, and as herbal medicines against asthma, cough, sore throat, diarrhoea, hypertension, rheumatism, fever, ulcer, diabetes, kidney stone problems and bronchitis in the Indian traditional systems of medicine.[2-5] In Turkey, about 20 Gymnosperm taxa are used as herbal remedies in treating and managing vulnerary, asthma, bronchitis, ulcer, antiseptic, stomach ache, tuberculosis, gastrointestinal disorders, skin disorders, stomachic, abscess, antirheumatic, cough and diabetes and as ethnoveterinary medicines.[6] Crude extracts and compounds isolated from Gymnosperm species are characterized by anti-inflammatory, antimalarial, antimelanogenic, antifungal, antibacterial, antioxidant, anticancer, apoptotic, anti-aging, antiparasitic, antirheumatic, antibronchitis, antiasthemic, antiviral, cytotoxicity, diuretic and hypotensive activities.[7-16]

In South Africa, a Gymonosperm species, *Stangeria eriopus* (Kunze) Baill. (Stangeriaceae family) is widely used as herbal medicine in the country. *Stangeria eriopus* is categorized as Vulnerable under the IUCN Red List Categories and Criteria[17-19] as the species is threatened by habitat loss and increased harvesting for the traditional medicine trade in South Africa.[18-35] The species is popular in the medicinal plant trade in South Africa and collection of both mature and immature individuals from the wild by ornamental plant collectors. *Stangeria eriopus* is sold as herbal medicine in informal herbal medicine markets in the Eastern Cape and KwaZulu Natal provinces.[21,22,30,36-44] *Stangeria eriopus* is popular as herbal medicine in South Africa and the species is traded outside its natural range like Gauteng, Mpumalanga and the Western Cape provinces of South Africa.[25,31,34,35,42,45-48] *Stangeria eriopus* has potential to be commercially produced as herbal medicine and ornamental plant.[49] Micropropagation protocols for *S. eriopus* were developed through vegetative propagation by means of leaf cuttings.[29,32,50,51] In an endeavour to save *S. eriopus* from extinction in the wild in South Africa, the *Stangeria eriopus* Conservation Project was launched at the Durban Botanic Gardens in 2000[29,30,32] aimed at propagating the species. Therefore, *S. eriopus* is regarded as a priority species for propagation and conservation considering its importance as both source of traditional medicines and as an ornamental plant species. It is within this context that this review was undertaken aimed at reviewing the medicinal uses, phytochemistry and biological activities of *S. eriopus* so as to provide baseline data required in evaluating the therapeutic potential of the species.

Botanical profile of *Stangeria eriopus*

The genus name *Stangeria* T. Moore is in honour of a British physician and naturalist William Stanger (1811-1854) who worked in South Africa as a Surveyor General of Natal and geologist.[52,53] The specific epithet comes from the Greek prefix "*erio*" meaning "wolly" and suffix "*pus*" meaning "footed" in reference to the wolly petiole bases. Synonyms associated with *S. eriopus* include *Lomaria coriacea* Kuntze, *L. eriopus* Kunze, *S. katzeri* Regel, *S. paradoxa* T. Moore, *S. paradoxa* T. Moore forma *schizodon*, *S. paradoxa* T. Moore var. *katzeri* (Regel) Marloth, *S. paradoxa* T. Moore var. *schizodon* (Bull.) Marloth, *S. sanderiana* J. Schust., *S. schizodon* W. Bull. and *S. zeyheri* Stoneman.[54-57] The English common names of *S. eriopus* include Natal grass cycad, stangeria and Stanger's cycad. *Stangeria eriopus* is a long-lived perennial and evergreen cycad with large fern-like leaves of up to two metres in height.[54,56,58-60] *Stangeria eriopus*

does not have a visible stem, but rather a swollen subterranean lignotuber. The young leaves of the species are dotted with short, gray hairs which usually fall off and stick to the petiole. Male and female cones are borne on separate plants. The male cone is slender, cylindrical and tapers at the apex with numerous spirally arranged and overlapping scales. The female cone is broader, egg-shaped with a rounded tip with stalked scales bearing large red and fleshy seeds. *Stangeria eriopus* is native to the coastal areas of the Eastern Cape and KwaZulu Natal provinces in South Africa and southern Mozambique.[56,61] Palgrave[55] and Hyde et al.[57] argue that *S. eriopus* is probably endemic to South Africa as there appear to be no definite records of the species in southern Mozambique. The species has been recorded in the grassland, closed forest, forest margins, meadows near the coastal dunes in heavy black clay, sandy, granite and stony acidic soils at an altitude ranging from 15 m to 1300 m above sea level.[56]

Medicinal uses of *Stangeria eriopus*

The caudices, leaves, roots, seeds, stems and tubers of *S. eriopus* are used as emetics, purgatives and protective charm and herbal medicine for body pains, congestion, headaches, high blood pressure and ethnoveterinary medicine (Table 1, Figure 1). The caudices of *S. eriopus* are mixed with roots of *Haworthiopsis limifolia* (Marloth) G.D. Rowley, *Gasteria croucheri* Bak., *Albuca fastigiata* Dryand and *Clivia miniata* (Lindl.) Bosse as a protective charm to ward off evil spirits.[22]

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Table 1: Medicinal uses of *Stangeria eriopus*

Medicinal use	Parts used	References
Body pains	Stems	Van Wyk et al.[60]; Pujol[62]; Long[63]; Amusan et al.[64]; Mhlongo and Van Wyk[65]
Cleansing the body	Stems	Osborne et al.[22]; Douwes and Dalzell[39]; Osborne and Grove[66]; Hutchings et al.[67]
Congestion	Stems	Osborne et al.[22]; Douwes[30]; Van Wyk et al.[60]; Osborne and Grove[66]; Hutchings et al.[67]; Van Wyk and Gericke[68]
Emetic	Roots and stems	Douwes[30]; Douwes and Dalzell[39]; Cousins and Witkowski[44]; Osborne and Grove[66]; Hutchings et al.[67]; Van Wyk and Gericke[68]; Watt and Breyer-Brandwijk[69]; McGaw et al.[70]
Fits	Stems	Mhlongo and Van Wyk[65]
Headaches	Leaves, roots and tubers	Douwes[30]; Ndawonde et al.[40]; Van Wyk et al.[60]; Hutchings et al.[67]; Van Wyk and Gericke[68]; Watt and Breyer-Brandwijk[69]; Broster and Bourn[71]; Coopoosamy and Naidoo[72]; Balogun and Ashafa[73]
High blood pressure	Roots and stems	Douwes[30]; Osborne et al.[22]; Douwes and Dalzell[39]; Van Ndawonde et al.[40]; Cousins and Witkowski[44]; Wyk et al.[60]; Long[63]; Osborne and Grove[66]; Hutchings et al.[67]; Van Wyk and Gericke[68]; Balogun and Ashafa[73]; Duncan et al.[74]
Protective charm (evil spirits, lightning and good luck)	Roots and stems	Osborne et al.[22]; Douwes and Dalzell[39]; Ndawonde et al.[40]; Van Wyk et al.[60]; Long[63]; Osborne and Grove[66]; Hutchings et al.[67]; Gerstner[75]; Batten and Bokelmann[76]
Protective charm (ward off evil spirits)	Caudices mixed with roots of *Haworthiopsis limifolia* (Marloth) G.D. Rowley, *Gasteria croucheri* Bak., *Albuca fastigiata* Dryand and *Clivia miniata* (Lindl.) Bosse	Osborne et al.[22]
Purgative	Roots and seeds	Osborne et al.[22]; Van Wyk et al.[60]; Pujol[62]; Osborne and Grove[66]; Watt and Breyer-Brandwijk[69]; McGaw et al.[70]; Coopoosamy and Naidoo[72]; Batten and Bokelmann[76]
Tonic	Stems	Mhlongo and Van Wyk[65]
Ethnoveterinary medicine (heartwater and internal parasites in cattle)	Leaves and roots	Balogun and Ashafa[73]; Dold and Cocks[77]; McGaw and Eloff[78]; Zukulu et al.[79]; Kambizi[80]

Table 2: Phytochemical composition of *Stangeria eriopus*

Phytochemical composition	Value	Plant part	Reference
β-alanine	-	Caudices	Osborne et al.[22]
p-coumaric	-	Leaves	Wallace[87]
p-hydroxy-benzoic	-	Leaves	Wallace[87]
γ-aminobutyric acid	-	Caudices	Osborne et al.[22]
Alinine	-	Caudices	Osborne et al.[22]
Amentoflavone	-	Leaves	Meurer-Grimes and Stevenson[81]; Meurer-Grimes and Stevenson[82]
Arachidic (%)	20.0	Caudices	Osborne et al.[22]
Arachidic acid (%)	1.2 – 1.8	Leaves	Mongrand et al.[88]
Arachidonic acid (%)	1.0 – 1.9	Leaves	Mongrand et al.[88]
Ash (%)	1.3 – 2.4	Caudices	Osborne et al.[22]
Asparagine	-	Caudices	Osborne et al.[22]
Aspartic acid	-	Caudices	Osborne et al.[22]
Behenic acid (%)	1.1 – 2.2	Leaves	Mongrand et al.[88]
Bilobetin	-	Leaves	Meurer-Grimes and Stevenson[81]; Meurer-Grimes and Stevenson[82]
Caffeic	-	Leaves	Wallace[87]
Carbohydrates (%)	41.5 – 85.1	Caudices	Osborne et al.[22]
Cycasin (%)	0.2 – 0.4	Caudices and leaves	Osborne et al.[22]; Yagi[85]
Dihomo-*γ*-linolenic acid (%)	2.3 – 4.4	Leaves	Mongrand et al.[88]
Eicosadienoic acid (%)	1.3 – 1.8	Leaves	Mongrand et al.[88]
Fat (%)	0.1 – 0.3	Caudices	Osborne et al.[22]
Ferulic	-	Leaves	Wallace[87]
Fibre (%)	2.2 – 6.1	Caudices	Osborne et al.[22]
Glutamine	-	Caudices	Osborne et al.[22]
Glutamic acid	-	Caudices	Osborne et al.[22]
Glycine	-	Caudices	Osborne et al.[22]
Hexadecadienoic acid (%)	0.4 – 0.7	Leaves	Mongrand et al.[88]
Lauric acid (%)	0.5 – 1.9	Leaves	Mongrand et al.[88]
Linolelaidic acid (%)	7.5 – 10.5	Leaves	Mongrand et al.[88]
Linolenic acid (%)	22.6 – 32.4	Leaves	Mongrand et al.[88]
Macrozamin (%)	0.05 – 0.2	Caudices, leaves and seed kernels	Osborne et al.[22]; Yagi[85]; Nair and Van Staden[86]
Moisture (%)	53.3	Caudices	Osborne et al.[22]
Myristic acid (%)	0.8 – 2.2	Leaves	Mongrand et al.[88]
Oleic acid (%)	3.8 – 42.0	Caudices and leaves	Osborne et al.[22]; Mongrand et al.[88]
Palmitic acid (%)	18.0 – 23.4	Caudices and leaves	Osborne et al.[22]; Mongrand et al.[88]
Palmitoleic acid (%)	2.3 – 13.7	Leaves	Mongrand et al.[88]
Palmitolinolenic acid (%)	0.8 – 1.9	Leaves	Mongrand et al.[88]
Proline	-	Caudices	Osborne et al.[22]
Protein (%)	1.6 – 6.1	Caudices	Osborne et al.[22]
Protocatechin	-	Leaves	Wallace[87]
Pyroglutamic acid	-	Caudices	Osborne et al.[22]
Serine	-	Caudices	Osborne et al.[22]
Sitosterol	-	Caudices	Osborne et al.[22]
Sodium sulphate (%)	12.0	Caudices	Osborne et al.[22]
Stearic acid (%)	1.2 – 13.0	Caudices and leaves	Osborne et al.[22]; Mongrand et al.[88]
Stigmasterol	-	Caudices	Osborne et al.[22]
Threonine	-	Caudices	Osborne et al.[22]
Vanillic	-	Leaves	Wallace[87]

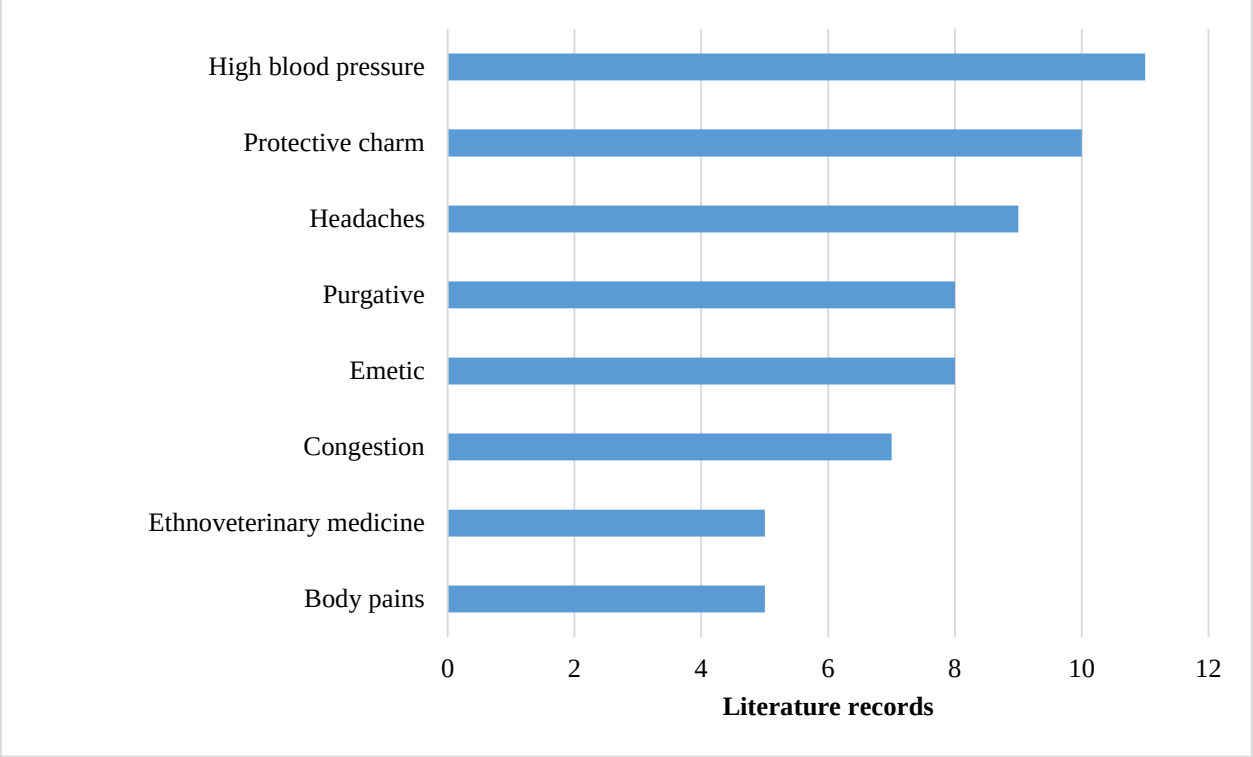

Figure 1. Medicinal applications of *Stangeria eriopus* derived from literature records

Phytochemistry of *Stangeria eriopus*

Meurer-Grimes and Stevenson[81] and Meurer-Grimes and Stevenson[82] identified biflavones amentoflavone and bilobetin from the leaves of *S. eriopus* (Table 2). Amusan et al.[64] identified alkaloids, polyphenols, saponins and tannins from the leaves of *S. eriopus*. Van Wyk et al.[83] argued that utilization of leaves, roots, seeds, stems and tubers of *S. eriopus* as traditional medicine is associated with the risk of acute or chronic poisoning. The possible toxicity of *S. eriopus* is associated with the presence of cycasin and macrozamin, the two glycosides of methylazoxymethanol.[83-86] Osborne et al.[22] and Van Wyk et al.[83] argued that the emetic use of *S. eriopus* is ascribed to the presence of high concentrations of sodium sulphate (Table 2).

Biological activities of *Stangeria eriopus*

The following biological activities have been reported from the aerial parts and leaf extracts of *S. eriopus*: anti-hypertensive,[74] anti-inflammatory[89] and β-glycosidase[85] activities.

Anti-hypertensive activities

Duncan et al.[74] evaluated the anti-hypertensive activities of aqueous and ethanolic leaf extracts of *S. eriopus* by using the angiotensin-converting enzyme (ACE) assay. The aqueous extract exhibited 55.0% ACE inhibitory activities.[74]

Anti-inflammatory activities

Jäger et al.[89] evaluated anti-inflammatory activities of aqueous and ethanolic extracts of aerial parts of *S. eriopus* in an *in vitro* assay for cyclooxygenase (COX) inhibitors with indomethacin (0.5 µg) as the control. Both the aqueous and ethanolic extracts showed inhibition of 56.0% and 75.0%, respectively which were comparable to 66.5% inhibition exhibited by the indomethacin control.[89]

***β*-glycosidase activities**

Yagi[85] evaluated the *β*-glycosidase activities in mature leaves of *S. eriopus by assessing t*he ratios of *β*-glycosidase activities towards cycasin and macrozamin in extracts from the leaves of the species. The hydrolysis of cycasin and macrozamin was high the extracts.[85]

CONCLUSION

The present review summarizes the ethnomedicinal uses and recent findings on phytochemistry and pharmacological properties of *S. eriopus*. Alkaloids, amino acids, biflavones, fatty acids, glycosides, polyphenols, saponins and tannins have been demonstrated to be the main active ingredients of *S. eriopus*. A few ethnopharmacological studies have focused on evaluating anti-hypertensive, anti-inflammatory and *β*-glycosidase activities of the different extracts of the species. But there is not yet enough data on ethnopharmacological evaluation and clinical research on the species and no evaluations of target-organ toxicity have been documented. Since *S. eriopus* contain potentially toxic compounds, future studies should include the identification of toxic compounds, possible side effects caused by taking *S. eriopus* as herbal medicine, and mechanisms of how potential toxic components of the species can be managed.

Conflict of interest

The author declares that he has no conflict of interest.

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