

SCABIOSA COLUMBARIA: A REVIEW OF ITS MEDICINAL USES, PHYTOCHEMISTRY, AND BIOLOGICAL ACTIVITIES

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ABSTRACT

Scabiosa columbaria is a perennial herb widely used as herbal medicine throughout its distributional range in tropical Africa, Asia, and Europe. This study is aimed at providing a critical review of the biological activities, phytochemistry, and medicinal uses of *S. columbaria*. Documented information on biological activities, medicinal uses, and phytochemistry of *S. columbaria* was collected from several online sources which included BMC, Scopus, SciFinder, Google Scholar, ScienceDirect, Elsevier, PubMed, and Web of Science. Additional information on the biological activities, phytochemistry, and medicinal uses of *S. columbaria* was gathered from pre-electronic sources such as book chapters, books, journal articles, theses, and scientific publications sourced from the university library. This study showed that the aerial parts, leaves, roots, stems, and the whole plant parts of *S. columbaria* are used as colic, love charm and for magical purposes, and as herbal medicine for eye problems, heartburn, respiratory problems, wounds, female infertility, venereal diseases, skin infections, and menstrual problems. Phytochemical compounds identified from the aerial parts and roots of *S. columbaria* are glycoside scabiosin, loganin, sweroside, palmitic acid, phthalic acid, diisooctyl phthalate, bis-(ethylhexyl) phthalate, and dibutyl phthalate. Pharmacological research revealed that *S. columbaria* extracts and compounds have antibacterial, antifungal, and antiprotozoan activities. Future research should focus on evaluating the phytochemical, pharmacological, and toxicological properties of *S. columbaria* crude extracts as well as compounds isolated from the species.

Keywords: *Caprifoliaceae*, *Dipsacaceae*, Ethnopharmacology, Herbal medicine, Indigenous pharmacopeia, *Scabiosa columbaria*.

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INTRODUCTION

Scabiosa columbaria L. is a member of the *Dipsacaceae* or teasel family. Although the species is often included in the family *Caprifoliaceae* in some classification systems [1-3], the phylogenetic analyses of both the chloroplast and nuclear genomes as well as their combination show that *Dipsacaceae* is a monophyletic group [4-11]. The *Dipsacaceae* family contains about 300 species of annual and perennial herbs or shrubs that have been recorded mainly in the Mediterranean Basin, with about 20% distributed in Asia, Eastern and Southern Africa [7,11,12]. The genus *Scabiosa* L. has been recorded in Europe, primarily in the Mediterranean Basin (five species and two species complexes that include about 14 taxa), Asia (12 species), and Eastern and Southern Africa (eight species) [13]. The species of *Scabiosa* are mainly annuals; others are perennials, with some of the species characterized by woody rootstocks [14]. Several species of the genus *Scabiosa* are widely used in the food, cosmetic, and pharmaceutical industries [15]. The biological activities of *Scabiosa* species include antibacterial, analgesic, antidiabetic, hepatoprotective, anti-inflammatory, antifungal, antioxidant, antiviral, and anti-parasitic and these pharmacological activities are closely related to its high content of phenolic compounds, and these activities corroborate the beneficial properties of these medicinal plants [16].

Research by Van Wyk [17] showed that the leaves and roots of *S. columbaria* L. have commercial potential as colic and herbal medicine for heartburn in South Africa. Moreover, the roots and whole plants of *S. columbaria* are sold as herbal medicines in informal herbal medicine markets in 66.7% of the provinces in South Africa, that is, in the Eastern Cape [18], Gauteng [19-22], KwaZulu-Natal [23], Limpopo [24], Mpumalanga [22], and Northern Cape [25] Provinces. Williams [19] categorized *S. columbaria* as a fast-selling and popular herbal medicine, with its roots purchased at least once a day in the Witwatersrand herbal medicine informal market in the Gauteng Province in South

Africa. Research by Williams *et al.* [26] showed that 58% of informal herbal medicine shops in the Gauteng Province were selling the whole plants of *S. columbaria* in 1995 at prices ranging from R77.3 to R98.6/kg (US\$21.3–US\$27.2). *S. columbaria* has been incorporated into the traditional material medica in South Africa and is included in the book “medicinal plants of South Africa,” a photographic guide to the most commonly used plant medicines in the country, with a potential contribution to primary health care of local communities in South Africa. Therefore, this is the rationale behind the current study, aimed at providing a critical review of the ethnomedicinal uses, phytochemistry, and biological activities of *S. columbaria* as well as exploring the potential of the species as herbal medicine.

BOTANICAL DESCRIPTION OF *S. COLUMBARIA*

S. columbaria is native to Southern, East and North Africa, temperate Asia and Europe [27-46]. In Europe, *S. columbaria* has been recorded exclusively in semi-dry or dry grasslands, a vegetation type which has been drastically reduced in the Swiss lowlands, and to a lesser extent in the Pre-alps and the Swiss Jura mountains, due to land-use changes and transformation processes in the last decades [47]. In Italy, *S. columbaria* has been recorded in grasslands, arid pastures, nutrient poor habitats, grazed, and mown calcareous grasslands [48]. *S. columbaria* is considered endangered in the Netherlands [49,50], the Pre-alps and the Swiss Jura mountains in Northern Switzerland [51]. In Africa, *S. columbaria* has been recorded in open woodland, grassland, Bushveld, sandy flats, rocky slopes, mountain slopes, and valleys at an altitude ranging from 5 m to 3475 m above sea level [28,33,34]. The genus name “*Scabiosa*” is derived from the word scabies meaning “to scratch” because, in medieval times, the species was used as an herbal medicine for scabies, skin sores, and other skin infections [52]. The specific epithet, “*columbaria*” is a Latinized word meaning “dove-like or dove-colored” in reference to some flower forms of the species [46,52]. Two infra species of *S. columbaria* are recognized,

namely *S. columbaria* subsp. *banatica* (Waldst. and Kit.) Diklic, and *S. columbaria* subsp. *Caespitosa* Jamzad. The common English names of *S. columbaria* include butterfly blue and wild scabious [53].

S. columbaria is a perennial evergreen herb up to 1 m in height with annual branches developing from persistent fleshy roots [52,53]. The leaves are oblanceolate in shape, thin-textured, slightly hairy, and variable in shape with characteristically lobed margins forming a rosette on the ground. The basal leaves have serrated margins, while those higher on the stems have deeply lobed margins. The long, slender, erect, and seldom branched stems have a terminal head of small flowers which are surrounded by bristly bracts. The flowers are compact, pink, and sometimes white or lilac in color [52].

MEDICINAL USES OF *S. COLUMBARIA*

The aerial parts, leaves, roots, stems, and the whole plant parts of *S. columbaria* are used as herbal medicines against 20 human diseases in Southern Africa and Europe (Table 1). *S. columbaria* is mainly used as colic, love charm, and for magical purposes, and as an herbal medicine for eye problems, heartburn, respiratory problems, wounds, female infertility, venereal diseases, skin infections, and menstrual problems (Fig. 1). In Lesotho, the roots of *S. columbaria* are mixed with those of

Dicoma anomala Sond. or leaves of *Asclepias humilis* (E. Mey.) Schltr. and rhizome of *Gunnera perpensa* L. or those of *Searsia divaricata* (Eckl. & Zeyh.) Moffett and *Cussonia paniculata* Thunb. as herbal medicine for menstrual problems [54-59]. The roots of *S. columbaria* are mixed with those of *S. divaricata* and *C. paniculata* and used as colic [54]. The roots of *S. columbaria* are mixed with those of *Aster bakerianus* Burttt Davy ex C.A.Sm. as herbal medicine for skin rash [60,61] and roots of *S. columbaria* are mixed with those of *D. anomala*, *Helichrysum caespitium* (DC.) Sond. ex Harv. and *Zantedeschia albomaculata* (Hook.) Baill. as herbal medicine for venereal diseases [59,62,63]. Apart from its usage as herbal medicine, *S. columbaria* is also used as a leafy vegetable in Italy [64].

PHYTOCHEMISTRY OF *S. COLUMBARIA*

The compound glycoside scabiosin has been isolated from the roots of *S. columbaria* [66] while Horn *et al.* [73] identified two iridoid glycosides, namely, loganin and sweroside from the roots of *S. columbaria*. Vinnitska [93] isolated palmitic acid, phthalic acid, diisooctyl phthalate, bis-(ethylhexyl) phthalate, and dibutyl phthalate from the aerial parts of *S. columbaria*. Horn *et al.* [73] evaluated the antibacterial activities of the compounds loganin and sweroside isolated from the roots of *S. columbaria* against *Bacillus cereus*, *Bacillus pumilus*, *Bacillus subtilis*,

Table 1: Medicinal uses of *Scabiosa columbaria*

Medicinal use	Parts of the plant used	Country	References
Abdominal pains	Roots and stems	Lesotho	[65]
Augmentation of labor	Roots	Lesotho	[54,60]
Broncho-sedative, fluidizing, purifying, and sialagogue	Roots	Italy	[48]
Chilblains	Roots	Italy	[48]
Colic	Leaves and roots	South Africa and Swaziland	[52,53,66-69]
Colic	Roots mixed with <i>Searsia divaricata</i> (Eckl. and Zeyh.) Moffett and <i>Cussonia paniculata</i> Thunb	Lesotho	[54]
Constipation	Whole plant	Turkey	[70]
Diuretic	Whole plant	Turkey	[70]
Eye problems	Leaves and roots	South Africa and Swaziland	[67,67,71]
Female infertility	Roots	Lesotho and South Africa	[52,57,60,66,67,72-75]
Heartburn	Leaves and roots	South Africa and Swaziland	[52,53,68,69]
High blood pressure	Leaves and roots	Lesotho	[76,77]
Love charm and magical purposes	Roots	South Africa and Swaziland	[68,71,78,79]
Menstrual problems	Leaves, roots, and stems	Lesotho, South Africa, and Swaziland	[52,65,67,68,72,74,76,77,80]
Menstrual problems	Roots mixed with <i>Dicoma anomala</i> Sond.	Lesotho	[54,55,59]
Menstrual problems	Roots mixed with leaves of <i>Asclepias humilis</i> (E. Mey.) Schltr. and rhizome of <i>Gunnera perpensa</i> L.	Lesotho	[56-58]
Menstrual problems	Roots mixed with <i>S. divaricata</i> and <i>C. paniculata</i>	Lesotho	[54]
Pregnancy complications and cleanses womb	Leaves and roots	Lesotho	[57,60,76,77]
Reduces mother-child HIV transmission	Leaves and roots	Lesotho	[76,77,81]
Respiratory problems, diphtheria, and flu	Aerial parts, leaves, and roots	Iberian Peninsula and Lesotho	[76,77,82-84]
Skin infections (acariasis, dermatitis, eczema, follicular acne, fungus-borne skin disease, measles, and rash)	Leaves, roots, and stems	Iberian Peninsula, Italy and South Africa	[48,79,85]
Skin rash	Roots mixed with <i>Aster bakerianus</i> Burttt Davy ex C.A.Sm.	Lesotho	[60,61]
Uterine disorders	Leaves and roots	Lesotho	[76,86]
Venereal diseases	Roots mixed <i>D. anomala</i> , <i>Helichrysum caespitium</i> (DC.) Sond. ex Harv. and <i>Zantedeschia albomaculata</i> (Hook.) Baill.	Lesotho	[59,62,63]
Venereal sores	Roots	Lesotho and South Africa	[53,54,60,66,67,72,77,81,87,88]
Wounds	Leaves, roots, and whole plant	South Africa and Turkey	[53,70,89-92]

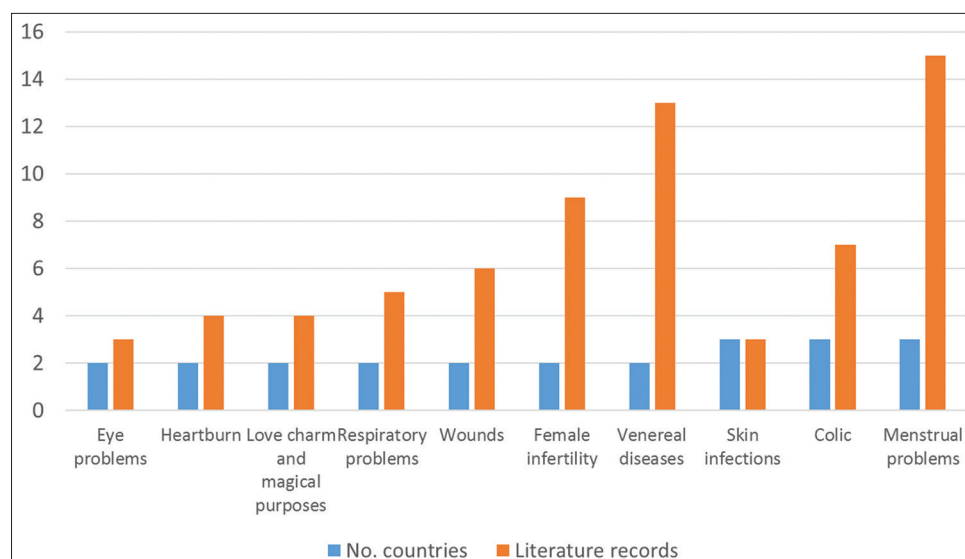


Fig. 1: Medicinal applications of *Scabiosa columbaria* derived from literature records

Micrococcus kristinae, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterobacter cloacae*, and *Serratia marcescens* at concentrations of 0.001 mg/ml–1.0 mg/ml. The compound sweroside showed moderate activities at a concentration of 1.0 mg/ml against all tested pathogens with the exception of *S. marcescens* [73].

BIOLOGICAL ACTIVITIES OF *S. COLUMBARIA* EXTRACTS

From literature, only antibacterial [77,88], antifungal [88], and antiprotozoan [88] activities were identified.

Antibacterial activities

Van Vuuren and Naidoo [88] evaluated antibacterial activities of aqueous and a mixture of methanol and dichloromethane (1:1) leaf and root extracts of *S. columbaria* against bacterial pathogens associated with urogenital or sexually transmitted infections which included *Gardnerella vaginalis*, *Neisseria gonorrhoeae*, *Oligella ureolytica*, and *Ureaplasma urealyticum* using the microdilution technique with ciprofloxacin (0.01 mg/ml) as a positive control. The extracts exhibited activities with minimal inhibitory concentration (MIC) values ranging from 2.0 mg/ml to >16.0 mg/ml which were higher than 0.1 mg/ml exhibited by the control [88]. Seleteng-Kose [77] evaluated the antibacterial activities of aqueous and organic root extracts of *S. columbaria* against *Citrobacter freundii*, *Enterobacter homaensis*, *K. pneumoniae*, *Moraxella catarrhalis*, *Mycobacterium fortuitum*, *Mycobacterium smegmatis*, and *S. aureus* using microdilution technique using ciprofloxacin (0.01 mg/ml) as a positive control. The extracts showed activities against all tested microorganisms with the exception of *Mycobacterium fortuitum* and *Mycobacterium smegmatis*, exhibiting MIC values ranging from 1.3 mg/ml to >8.0 mg/ml [77].

Antifungal activities

Van Vuuren and Naidoo [88] evaluated antifungal activities of aqueous and a mixture of methanol and dichloromethane (1:1) leaf and root extracts of *S. columbaria* against fungal pathogen associated with urogenital or sexually transmitted infections, *Candida albicans* using the microdilution technique with amphotericin B (0.1 mg/ml) as a positive control. The extracts exhibited activities with MIC values ranging from 2.0 mg/ml to 8.0 mg/ml, which were comparable to MIC value of 2.5 mg/ml exhibited by the control [88].

Antiprotozoan activities

Van Vuuren and Naidoo [88] evaluated antiprotozoan activities of aqueous and a mixture of methanol and dichloromethane (1:1) leaf and root extracts of *S. columbaria* against protozoan pathogen associated

with urogenital or sexually transmitted infections, *Trichomonas vaginalis* using the microdilution technique with ciprofloxacin (0.01 mg/ml) as a positive control. The extracts exhibited activities with MIC values ranging from 3.0 mg/ml to >16.0 mg/ml which were higher than 0.1 mg/ml exhibited by the control [88].

CONCLUSION

The diverse medicinal uses of *S. columbaria* documented throughout the distributional range of the species and the scientific evidence of its phytochemistry and biological activities indicates its potential as herbal medicine. The preliminary pharmacological activities carried out so far are directly or indirectly involved in the protection against the growth of undesirable microbes. There is a need for further research on the phytochemistry, pharmacological, and toxicological activities of the crude extracts and compounds isolated from the species. Future research should also focus on the clinical significance of the pharmacological properties, cytotoxicity, and toxicity using *in vivo* models. The biological potency of such phytochemicals and crude extracts need to be evaluated aimed at exploring the potential of the species as herbal medicine.

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AUTHORS' CONTRIBUTIONS

The author declares that this work was done by the author named in this article.

CONFLICTS OF INTEREST

The author declares that they have no conflicts of interest.

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