Evaluation Of Medicinal Uses, Phytochemistry And Pharmacological Properties Of Dioscorea Sylvatica (Dioscoreaceae)

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Abstract: Dioscorea sylvatica Eckl. is a twining herb widely used as traditional medicine in southern Africa. The current study critically reviewed the medicinal uses, phytochemistry and pharmacological properties of D. sylvatica. A systematic review of the literature studies was carried out to document the medicinal uses, phytochemistry and pharmacological properties of D. sylvatica. The results of the current study are based on literature survey conducted using various search engines such as Web of Science, Elsevier, Pubmed, Google scholar, Springer, Science Direct, Scopus, Taylor and Francis, and pre-electronic sources such as books, book chapters, scientific journals and other grey literature obtained from the University library. This study revealed that D. sylvatica is used mainly as blood purifier, charm, rituals and ethnoveterinary medicine, traditional medicine for gastro-intestinal problems, gonorrhoea, respiratory infections, rheumatism, skin infections, sores, wounds and cuts. Pharmacological research identified 2-carboxyarabinitol, alkaloids, anthocyanins, bibenzyl, calcium oxalate crystals, diarylnonanoids, flavonoids, pyrogallol, sapogenin, saponins, shikimic acid, tannins and terpenoids. The crude extracts of D. sylvatica and phytochemical compounds isolated from the species exhibited antibacterial, antimycobacterial, antifungal, anti-inflammatory, antioxidant and antibiotic-potentiating activities. Dioscorea sylvatica should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological activities.

Keywords: Dioscorea sylvatica, Dioscoreaceae, ethnopharmacology, herbal medicine, indigenous knowledge, southern Africa

1 INTRODUCTION

Dioscorea sylvatica Eckl. (Fig. 1) is a twining herb belonging to the Dioscoreaceae family. The genus Dioscorea Plum ex L. is a genus of over 600 tuberous herbaceous climbing species which naturally occurs throughout the tropical and warm temperate regions of the world [1,2]. The genus name Dioscorea is in honour of Pedanius Dioscorides (40 – 90 AD), a Greek author, botanist, pharmacologist and physician [3]. The species name sylvatica means “growing in woods” or “forest-loving” [4]. The synonyms associated with the name D. sylvatica include D. brevipes Burtt Davy, D. hederifolia Griseb., D. marlothii R. Knuth, D. montana (Burch.) Spreng var. glauca R. Knuth, D. montana (Burch.) Spreng var. lobata Weim., D. montana (Burch.) Spreng var. sagittata Suess., D. rehmannii Baker, D. sylvatica ssp. lydenbergensis Blunden, Hardman & F.J. Hind, D. sylvatica (Kunth) Eckl. var. brevipes (Burtt Davy) Burkill, D. sylvatica (Kunth) Eckl. var. sylvatica, Testudinaria glaucescens Hügel, T. multiflora Marloth, T. paniculata Dummer, T. rehmannii (Baker) G.D. Rowley, T. sylvatica Kunth, T. sylvatica var. brevipes (Burtt Davy) G.D. Rowley, T. sylvatica var. lydenbergensis (Blunden, Hardman & F.J. Hind) G.D. Rowley, T. sylvatica var. multiflora (Marloth) G.D. Rowley, T. sylvatica var. paniculata (Dummer) G.D. Rowley and T. sylvatica var. rehmannii (Baker) G.D. Rowley [5,6]. Dioscorea sylvatica is closely related to D. elephantipes (L'Hér.) Engl. as the two species are characterised by abundance of phytochemical compounds shikimic acid and pyrogallol [7]. Dioscorea sylvatica has alternate, heart-shaped and often tapering to a long point at the apex [8] (Figure 1). The underground tubers of D. sylvatica are characteristically dark brown, corky and flattened, with reticulate markings [9]. Dioscorea sylvatica has been recorded in Eswatini, Mozambique, South Africa, Zambia and Zimbabwe in bushland, rocky outcrops, dunes, woodland, coastal regions and forest margins at an altitude ranging from 125 m to 1650 m above sea level [6,10,11].

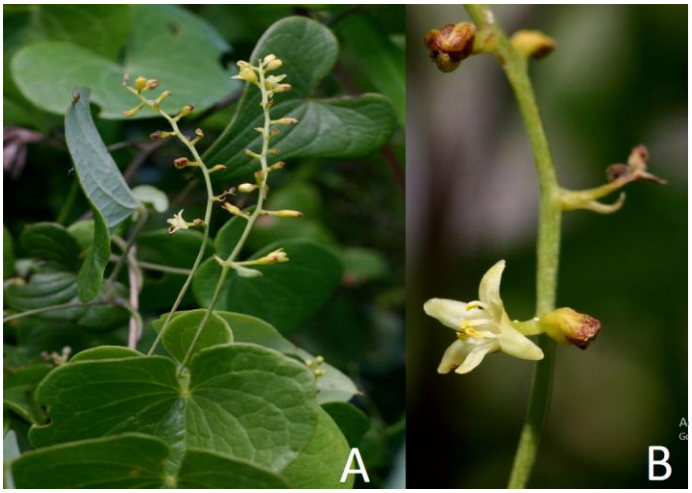

***Fig. 1**: Dioscorea sylvatica: A: branch showing leaves and flowers and B: flowers (photos: BT Wursten)*

Dioscorea sylvatica is a valuable medicinal plant in southern Africa and an overview of its botanical description, active ingredients, pharmacological effects and distribution are outlined in the monograph “medicinal plants of South Africa” [12]. Dioscorea sylvatica is cultivated in home gardens as a source of traditional medicines in the Limpopo province, South Africa [13,14]. Several Dioscorea species contain a spirostane steroidal sapogenin known as diosgenin, used to manufacture cortisone and other steroid hormones [15] with D. zingiberensis C.H. Wright (Chinese yam) being the commercial source of the phytochemical compound [16]. Moreover, a patent highlighting the production of a phytochemical compound shikimic acid from aerial parts of D. sylvatica as well as other Dioscorea species such as D. elephantipes, D. sylvatica, D. villosa L., D. communis (L.) Caddick & Wilkin, D. caucasia Lipsky, D. nipponica Makino, D. deltoidea Wall. Ex Griseb., D. tokoro Makino ex Miyabe, D. preussi Pax, D. alata L., D. altissima L., D. sansibarensis Pax,

D. bulbifera L., D. antaly Jum. & H. Perrier, D. praehensilis Benth. and D. minutiflora Mart. ex Griseb. [17]. A tremendous population decline of D. sylvatica was recorded in South Africa from 1955-1960 due to indiscriminate commercial harvesting for diosgenin [18-23]. Research by Raimondo et al. [22] showed that D. sylvatica is categorized as Vulnerable A2cd under the IUCN Red List Categories and Criteria version 3.1 (http://www.iucnredlist.org). Dioscorea sylvatica is sold in informal herbal medicine markets in Eswatini and South Africa [24-38]. Wiersum et al. [39] recommended D. sylvatica for cultivation in home gardens to serve as a tool for combined biodiversity conservation and poverty alleviation in South Africa. It is therefore, within this context that this study was undertaken aimed at reviewing the medicinal uses, phytochemistry and pharmacological properties of D. sylvatica.

2. MATERIALS AND METHODS

Several electronic databases were searched which included Web of Science, Elsevier, Pubmed, Google scholar, Springer, Science Direct, Scopus, Taylor and Francis. Additional information was obtained from pre-electronic sources such as books, book chapters, scientific journals and other grey literature obtained from the University library. The relevant terms Dioscorea sylvatica was paired with keywords such as “medicinal uses of Dioscorea sylvatica”, “phytochemicals of Dioscorea sylvatica”, “biological activities of Dioscorea sylvatica”, “pharmacological properties of Dioscorea sylvatica”, “ethnobotany of Dioscorea sylvatica”, and various other synonyms and common names of the plant species. The ultimate goal of this search was to explore articles that investigated the medicinal uses, phytochemical and pharmacological properties of D. sylvatica. A total of 40 articles published between 1954 and 2021 matched the inclusion criteria and were included in this review (Fig. 2).

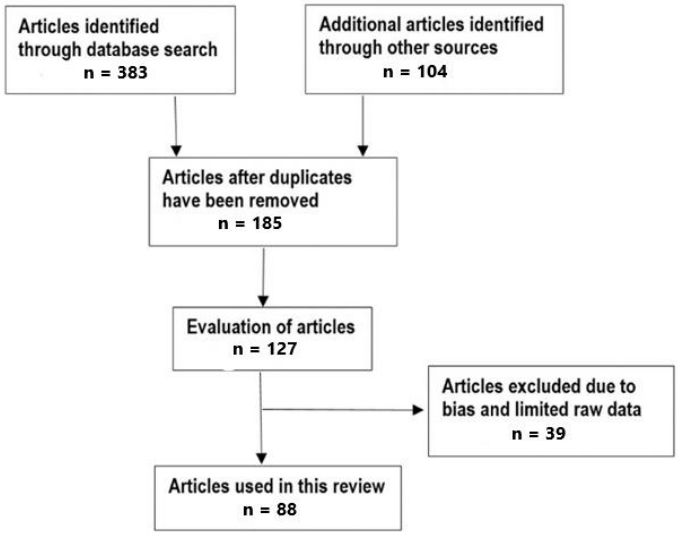

***Fig. 2**. Flow chart showing the number of research publications used in this study*

3. RESULTS AND DISCUSSION

3.1 Medicinal uses of Dioscorea sylvatica

The roots and tubers of D. sylvatica are mainly used as blood purifier, charm, rituals and ethnoveterinary medicine, traditional medicine for gastro-intestinal problems, gonorrhoea, respiratory infections, rheumatism, skin infections, sores, wounds and cuts (Table 1; Fig. 3). Other medicinal applications of the roots and tubers of D. sylvatica supported by at least two literature records epilepsy [40,41], facilitation of labour [41,42], parasite repellent [43,44] and swellings [43,44].

TABLE 1
MEDICINAL USES OF DIOSCOREA SYLVATICA

Medicinal uses	Plant part	Country	References
Blood pressure	Tuber	South Africa	45
Blood purifier	Roots and tubers	Eswatini and South Africa	36,41,43,44, 46-49
Body pains	Tuber	South Africa	38
Charm and ritual (good luck, protective and ritual emetics)	Roots	South Africa	30,36,40,47, 48,50,51
Contraceptive	Tubers	South Africa	42
Epilepsy	Roots and tubers	South Africa	40,41
Facilitate labour	Tubers	South Africa	41,42
Fibroids	Tuber	South Africa	52
Foot disorder	Tubers	South Africa	38
Gastro-intestinal problems (abdominal cramps and stomach ache)	Tuber	South Africa and Zimbabwe	41,53
Gonorrhoea	Roots and tuber	South Africa	13,14,54
Gonorrhoea	Tuber mixed with roots of Aloe marlothii A. Berger	South Africa	55,56
Heart problems	Tuber	South Africa	30
Hysteria	Tuber	South Africa	41
Infertility	Tuber	South Africa	41
Inflammation	Roots and tuber	South Africa	57
Leg pains	Tuber	South Africa	36
Nervous spasms	Tuber	South Africa	42
Parasite repellent	Roots	South Africa	43,44
Respiratory infections (aphonia, asthma, bronchiectasis, chest complaints and tuberculosis)	Roots and tubers	Eswatini and South Africa	11,36,41,43, 46-49,58-67
Rheumatism	Tuber	South Africa and Zimbabwe	52,53,58,68-70
Skin infections (abscess, pimples, rashes and skin complexion)	Tubers and whole plant	Eswatini, South Africa and Zimbabwe	42,47,48,53, 58,69-74
Sores, wounds and cuts	Leaves and tubers	South Africa	8,29,31,40-42,52,75-78
Strengthen muscles	Tuber	South Africa	30
Stroke	Tuber	South Africa	30
Swellings	Tubers	South Africa	45,47,48
Vomiting	Roots	South Africa	40
Ethnoveterinary medicine (sores and wounds, udder mastitis in cows and uterine problems in cows)	Tuber	South Africa	31,36,42,43, 49,58,77,79-82

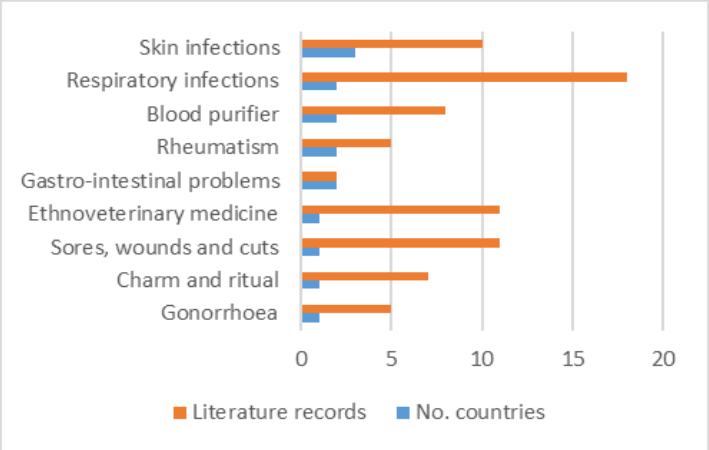

***Fig. 3**: Medicinal uses of Dioscorea sylvatica in southern Africa*

3.2 Phytochemistry of Dioscorea sylvatica

A variety of chemical compounds have been isolated and identified from D. sylvatica (Table 2). These phytochemical compounds identified from the aerial parts, tubers and whole plant parts of D. sylvatica include 2-carboxyarabinitol, alkaloids, anthocyanins, bibenzyl, calcium oxalate crystals, diarylnonanoids, flavonoids, pyrogallol, sapogenin, saponins, shikimic acid, tannins and terpenoids (Table 2).

TABLE 2
PHYTOCHEMICAL COMPOUNDS ISOLATED FROM DIOSCOREA SYLVATICA

Phytochemical compound	Value	Plant part	Reference
2-carboxyarabinitol (nmol/g)	99.0	Leaves	83
5-(2-hydroxyphenethyl)-2,3-dimethoxyphenol)	-	Tubers	84,85
Alkaloids (%)	9.9	Whole plant	42
Anthroquinones	-	Whole plant	42
Bibenzyl	-	Tubers	85
Calcium oxalate crystals	-	Tubers	69
(E)-32-((3-(3-hydroxy-4-methoxyphenyl)isoferuloyl)oxy)dotriacontanoic acid	-	Tubers	84,85
Flavonoids	-	Whole plant	42,73
Pyrogallol	-	Aerial parts	7
Sapogenin	-	Tubers	86,87
Saponins (%)	9.0	Whole plant	42,73
Shikimic acid	-	Aerial parts	7
Steroids	-	Whole plant	42
Tannins	-	Whole plant	42,73
Terpenoids	-	Whole plant	42,73

3.3 Pharmacological properties of Dioscorea sylvatica

The following biological activities have been reported from the roots, tubers, tuber bark and whole plant parts of D. sylvatica and phytochemical compounds isolated from the species: anti-acetylcholinesterase [70], antibacterial [42,58,70,73,77], antimycobacterial [58,88], antifungal [42,58,70,73,88], anti-inflammatory [42], antioxidant [42,70] and antibiotic-potentiating [84,85] activities.

3.3.1 Anti-acetylcholinesterase activities

Cogne [70] evaluated the anti-acetylcholinesterase activities of petrol ether, water, methanol, dichloromethane, ethyl acetate and butanol extracts of D. sylvatica tuber using a rapid TLC bioautographic method for the detection of acetylcholinesterase. The petrol ether, dichloromethane and ethyl acetate extracts exhibited moderate activities [70].

3.3.2 Antibacterial activities

Kelmanson et al. [77] evaluated the antibacterial activities of methanol, ethyl acetate and water extracts of D. sylvatica roots, tubers and tuber bark against Bacillus subtilis, Escherichia coli, Kleibsiella pneumoniae, Micrococcus luteus, Pseudomonas aeruginosa, Staphylococcus aureus and Staphylococcus epidermidis using the disc diffusion assay and twofold serial dilution with neomycin (2.0 µg) as a positive control. The ethyl acetate and methanol extracts exhibited activities against Bacillus subtilis, Escherichia coli, Micrococcus luteus, Staphylococcus aureus and Staphylococcus epidermidis with minimal inhibitory concentration (MIC) values ranging from 2.0 mg/ml to 4.0 mg/ml [77]. Cogne [70] evaluated the antibacterial activities of petrol ether, water, methanol, dichloromethane, ethyl acetate and butanol extracts of D. sylvatica tuber against Bacillus subtilis using a rapid TLC bioautographic method. The petrol ether, dichloromethane and ethyl acetate extracts exhibited moderate activities [70]. Seaman [58] evaluated the antibacterial activities of acetone and methanol extracts of D. sylvatica tubers against Staphylococcus aureus, Enterococcus faecalis, Bacilus cereus, Pseudomonas aeruginosa, Klebsiella pneumoniae, Serratia odorifera and Moraxella catarrhalis using broth microdilution method with neomycin and ciprofloxacin as positive controls. The extracts showed activities against the tested pathogens with MIC values ranging from 0.5 mg/ml to 8.0 mg/ml [58]. Xaba [42] and Xaba and Buwa [73] evaluated the antibacterial activities of methanol, ethanol, acetone and aqueous extracts of D. sylvatica whole plant against Pseudomonas aeruginosa, Bacillus pumilus, Staphylococcus aureus, Escherichia coli, and Kliebsella pneumoniae using microplate dilution assay. The extracts exhibited activities against tested pathogens with MIC values ranging between 3.2 mg/ml and 12.5 mg/ml [42,73].

3.3.3 Antimycobacterial activities

Seaman [58] evaluated the antimycobacterial activities of acetone and aqueous leaf extracts of N. ivifolia against Mycobacterium smegmatis and Mycobacterium aurum using broth microdilution technique and Mycobacterium tuberculosis using BACTEC susceptibility testing with rifampicin and ciprofloxacin as positive controls. The extracts exhibited activities with MIC values ranging from 0.3 mg/ml to 8.0 mg/ml [58]. Lehasa et al. [88] evaluated the antimycobacterial activities of aqueous and ethanol extracts of D. sylvatica tubers against Mycobacterium tuberculosis. The extract exhibited activities against tested pathogen with MIC values ranging between 0.2 mg/ml and 0.8 mg/ml [88].

3.3.4 Antifungal activities

Cogne [70] evaluated the antifungal activities of petrol ether, water, methanol, dichloromethane, ethyl acetate and butanol extracts of D. sylvatica tuber against Cladosporium cucumerinum and Candida albicans using a rapid TLC bioautographic method. The petrol ether and dichloromethane extracts exhibited weak activities against Cladosporium cucumerinum [70]. Seaman [58] evaluated the antifungal activities of methanol and acetone extracts of D. sylvatica tubers against Candida albicans using the broth microdilution

method with nystatin as a positive control. The methanol and acetone extracts exhibited activities with MIC value of 4.0 mg/ml [58]. Xaba [42] and Xaba and Buwa [73] evaluated the antifungal activities of methanol, ethanol, acetone, and aqueous extracts of D. sylvatica whole plant against Candida albicans and Trichophyton mucoides using microplate dilution assay. The extracts exhibited activities against tested pathogens with an MIC values ranging from 0.4 mg/ml to 3.1 mg/ml [42,73]. Lehasa et al. [88] evaluated the antifungal activities of aqueous and ethanol extracts of D. sylvatica tubers against against Candida albicans and Trichophyton mucoides using microplate dilution assay. The extract exhibited activities against tested pathogen with MIC values ranging between 0.05 mg/ml and 0.7 mg/ml [88].

3.3.5 Anti-inflammatory activities

Xaba [42] evaluated the anti-inflammatory activities of aqueous, acetone, ethanol and methanol extracts of D. sylvatica whole plant using the 5-lipoxygenase enzyme (Cayman) assay with nordihydroguaiaretic acid as a positive control. The extracts exhibited activities with percentage inhibition of enzyme of >85.0% and half maximal inhibitory concentration (IC50) values ranging from 0.2 µg/ml and 0.7 µg/ml, which was comparable to IC50 value of 0.6 µg/ ml exhibited by the positive control [42].

3.3.6 Antioxidant activities

Cogne [70] evaluated the antioxidant activities of petrol ether, water, methanol, dichloromethane, ethyl acetate and butanol extracts of D. sylvatica tuber using 1,1-diphenyl-2-picryl hydrazyl (DPPH) free radical scavenging assay. The ethyl acetate extract exhibited moderate activities [70]. Xaba [42] evaluated the antioxidant activities of acetone, aqueous, ethanol, and methanol extracts of D. sylvatica whole plant using DPPH free radical scavenging and the phosphomolybdate assays with ascorbic acid and gallic acid as positive controls. The extracts exhibited activities with IC50 values ranging from 0.1 µg/ml to 0.4 µg/ml against DPPH and IC50 values of 0.04 µg/ml to 0.8 µg/ml against phosphomolybdate assay [42].

3.3.7 Antibiotic-potentiating activities

Sibandze et al. [84] and Sibandze et al. [85] evaluated the antibiotic-potentiating activities of the compounds (E)-32-((3-(3-hydroxy-4-methoxyphenyl)isoferuloyl)oxy)dotriacontanoic acid and 5-(2-hydroxyphenethyl)-2,3-dimethoxyphenol) isolated from D. sylvatica tubers using two multi-drug resistant Staphylococcus aureus strains SA-1199B and XU212 with reserpine as positive control. The compounds exhibited potent antibiotic-potentiating activities [84,85].

4. Conclusion

The present review summarizes the ethnomedicinal uses, phytochemistry and pharmacological properties of D. sylvatica. The historical traditional usage of D. sylvatica as herbal medicine in southern Africa calls for detailed phytochemical and pharmacological studies aimed at correlating its documented ethnomedicinal uses with the phytochemical and pharmacological properties of the species. There is need for clinical and toxicological evaluations of both crude extracts and phytochemical compounds associated with D. sylvatica.

Dioscorea sylvatica has been traditionally used as herbal medicine throughout its distributional range in sub-Saharan Africa, used as blood purifier, charm, rituals and ethnoveterinary medicine, traditional medicine for gastro-intestinal problems, gonorrhoea, respiratory infections, rheumatism, skin infections, sores, wounds and cuts. Recent research on D. sylvatica focused primarily on evaluating the anti-acetylcholinesterase, antibacterial, antimycobacterial, antifungal, anti-inflammatory, antioxidant and antibiotic-potentiating activities. The 2-carboxyarabinitol, alkaloids, anthocyanins, bibenzyl, calcium oxalate crystals, diarylnonanoids, flavonoids, pyrogallol, sapogenin, saponins, shikimic acid, tannins and terpenoids appear to be the major plant derivatives and have been demonstrated to be the main active ingredients in aerial parts, tubers and whole plant parts of D. sylvatica. Although contemporary research involving D. sylvatica is promising, it is too preliminary and sometimes too general to be used to explain and support some of the ethnomedicinal uses. In addition to this, some of the pharmacological activities assessed so far, were routine screenings using standard procedures lacking molecular mechanisms of the pharmacological effects of D. sylvatica. There is not yet enough systematic data regarding the pharmacokinetics and clinical research of D. sylvatica products and compounds. There are also very few to nil experimental animal studies, randomized clinical trials and target-organ toxicity studies involving D. sylvatica and its derivatives that have been carried out so far. Therefore, there is not sufficient evidence to interpret the documented ethnomedicinal uses linking them to specific chemical mechanisms associated with some of the documented biological activities of the species. Therefore, future studies should identify the bioactive components, details of the molecular modes or mechanisms of action, pharmacokinetics and physiological pathways for specific bioactives of D. sylvatica. Further research should comprise of the models which would more precisely refer to the current knowledge about pathophysiology, extensive phytochemical, pharmacological, preclinical and clinical research on well documented and established ethnomedicinal uses of the species. This future research should also include the identification of any side effects and/or toxicity, aspects of quality control to ensure safety, quality and efficacy of the D. sylvatica products.

CONFLICTS OF INTEREST

No conflict of interrest is associatted with this worrk.

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