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A review of botany, phytochemistry, and pharmacology of the forest Natal mahogany (*Trichilia dregeana* Sond.)

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ABSTRACT

Trichilia dregeana is an underutilized plant species native to tropical Africa and known for its nutritional and medicinal properties. The present review compiles existing information on botany, traditional uses, and chemical and pharmacological properties of *T. dregeana*. Multiple searches on existing literature on the traditional, medicinal, phytochemistry, and pharmacological properties of *T. dregeana* were conducted in online databases such as Scopus®, Google Scholar, SpringerLink®, SciELO, ScienceDirect®, PubMed® and Web of Science, as well as using pre-electronic literature sources obtained from the university library. *Trichilia dregeana* is used as a medicinal plant against human and animal diseases in seven countries, that is, 33.3% of the countries where the species is indigenous. The phytochemical evaluation of the plant revealed that it contains alcohols, alkanes, amides, esters, lignan, limonoids, sesquiterpenes, steroids, and triterpenoids. The pharmacological assessments showed that the crude extracts and phytochemical compounds isolated from the species demonstrated antibacterial, antifungal, antimycobacterial, antiviral, acetylcholinesterase, anti-inflammatory, antioxidant, insecticidal, prostaglandin-synthesis inhibitory, nitric oxide production inhibitory, wound healing, mutagenicity, and toxicity activities. Detailed studies focusing on toxicity and safety, mechanisms of action *in vivo*, and clinical research aimed at corroborating the traditional medical applications of T. dregeana are recommended.

INTRODUCTION

Trichilia dregeana Sond. (Fig. 1) is an underutilized plant species native to tropical Africa and known for its nutritional and medicinal properties. *Trichilia dregeana*, commonly known as the forest Natal mahogany belongs to the Meliaceae or the mahogany family. The seeds of *T. dregeana* have been valued and used in eastern, central, and southern Africa since immemorial times [1]. Once the seed coat has been removed, the seeds are edible and the seed arils are cooked as a condiment or vegetable, and also crushed to yield a milky juice which is taken as a drink [2,3]. The seed oil of *T. dregeana* is used in various ways. The seed oil is edible and used for cooking, and also used medicinally, as a cosmetic, and for making soap [4,5]. The seed oil has preservative qualities, as the seed oil is boiled with the fruit pulp of *Strychnos innocua* Delile and stored as reserve food that lasts for at least 2 years [6]. The seed residue that remains after oil extraction is used as animal feed or as fertilizer [1,7]. Research by Van Wyk [8] showed that the seed aril of *T. dregeana* has potential as a vegetable in South Africa while the seed oil has the potential for producing skin care products as well as pharmaceutical products for rheumatism and other related ailments [9].

Trichilia dregeana is a successful ornamental, shade or street tree in many countries throughout the world, with the tree shape, size, and non-aggressive root system making the species ideal for the garden, parking areas, or habitats near water or watering points in camps [7]. *Trichilia dregeana* is useful as general-purpose timber, used for carving various wooden items, musical instruments, wooden drums, construction, furniture, household utensils, firewood, and charcoal. The tree

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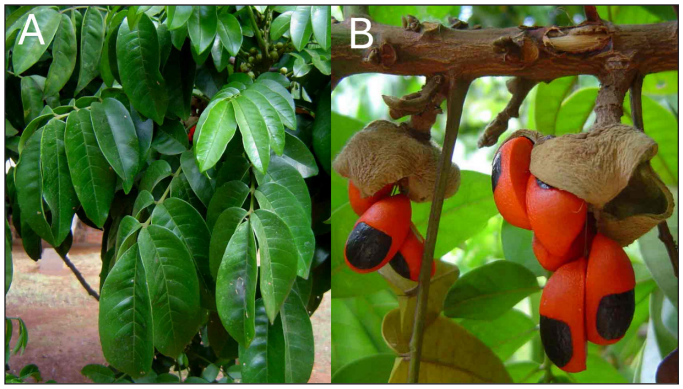

Figure 1. *Trichilia dregeana* A: branch showing leaves and B: branch showing fruits (photos: BT Wursten).

is important to a variety of animals for shade, shelter, and above all, for food. The seeds are eaten by many birds [10], and the leaves are browsed by stock and wildlife [1].

Trichilia dregeana is a multipurpose species with its different parts used as sources of ecosystem services and goods that are important for human well-being and survival. It is an important source of vegetable oils in tropical Africa [11], characterized by both food values and non-food applications. Seed oil extracted from *T. dregeana* is of local or regional importance with seeds being sold for soap making in Tanzania while oil from the seeds is used commercially to produce cosmetics, candles, and soap [12]. Since seed oil extracted from *T. dregeana* is characterized by water-insoluble triacylglycerols and trace amounts of organic compounds such as sterols and antioxidants [11], the species, therefore, is in the same category as castor (*Ricinus communis* L.), coconut (*Cocos nucifera* L.), groundnuts (*Arachis hypogaea* L.), linseed (*Linum usitatissimum* L.), mustard (*Brassica juncea* (L.) Czern., rapeseed (*Brassica napus* L.), sesame (*Sesamum indicum* L.), soybean (*Glycine max* (L.), Merr. and sunflower (*Helianthus annuus* L.) which are the principal sources of vegetable oils in the world [11,13,14]. Recent research shows that vegetable oils are important sources of nutraceuticals such as carotenoids, fatty acids, lignans, phenolics, phytosterols, tocopherols, and tocotrienols [14]. There is also growing demand for edible vegetable oils, with some of them being developed into functional foods, medicinal foods, nutraceuticals, and therapeutic foods aimed at improving human health [15,16]. *Trichilia dregeana* is a well-known medicinal plant throughout its distributional range, and in the Eastern Cape, Gauteng, and KwaZulu-Natal provinces in South Africa, the bark of the species is sold in informal herbal medicine markets as sources of traditional medicines [17–20]. It is, therefore, within this context that the current study was undertaken aimed at compiling the medicinal, chemical, and pharmacological properties of *T. dregeana*.

MATERIALS AND METHODS

The literature search on the botany, phytochemistry, and pharmacology of the forest Natal mahogany (*Trichilia dregeana* Sond.) was conducted from September 2023 to March 2024. This information on these aspects was obtained using online databases such as Scopus® (http://www.scopus.com/), Google Scholar (https://scholar.google.com/), SpringerLink® (https://link.springer.com/), SciELO (https://search.scielo.org/), ScienceDirect® (https://www.sciencedirect.com/search), PubMed® (https://pubmed.ncbi.nlm.nih.gov/), and Web of Science (https://www.webofknowledge.com). Additional information on the botany, phytochemistry, and pharmacology of the forest Natal mahogany (*Trichilia dregeana* Sond.) was also obtained by a systematic search of various resources that are not covered by electronic databases, and these included journal papers, books, dissertations, book chapters, theses and other scientific articles obtained from the University library. The keywords used in the search included "*T. dregeana,*" the synonyms of the species "*Trichilia dregeana* Sond.,*"* English common names "cape mahogany," "Christmas bells," "forest mahogany," "forest Natal mahogany," "red ash," "thunder tree," and "white mahogany." An additional search was also conducted using the keywords *"*biological activities of *T. dregeana,*" "pharmacological properties of *T. dregeana,*" "ethnobotany of *T. dregeana,"* "medicinal uses of *T. dregeana,*" "phytochemistry of *T. dregeana,*" and "traditional uses of *T. dregeana."*

RESULTS AND DISCUSSION

Morphological description and taxonomy of the species

Trichilia P.Browne is a genus of about 85 cosmopolitan shrub and tree species in the tropics and subtropics, concentrated in America, with 15 species recorded in Africa, and only two in Asia [21]. The two species recorded in southern Africa are *T. emetica* Vahl and *T. dregeana* Sond. [22], which are morphologically similar, closely related, and often confused in the field. However, the two species grow under different conditions, fruit and leaf characters are often used to distinguish the two species. *Trichilia dregeana* grows in high rainfall, evergreen forests, characterized by pointed leaflets that are almost hairless with a smooth lower surface, and fruits with very short and sturdy stalks [10,23,24]. On the other hand, *T. emetica* often grows in lower rainfall areas in bushland, woodlands, and along river sides. The leaflets of *T. emetica* are usually rounded while lower surfaces are usually densely hairy and the fruit has a long stalk [10,23,24].

The genus name *Trichilia* is based on the Greek word "*tricho*" which means "in three parts" in reference to "3-locular" or "3-celled fruits" [10]. The species name "*dregeana"* is in honour of a German plant collector, horticulturalist, and botanical explorer, Johann Fran(t)z Drège often referred to as Jean François Drège (March 25, 1794 to February 3, 1881), who visited South Africa between 1826 and 1834, and collected the species in Natal [10]. The synonyms associated with *T. dregeana* include *Trichilia chirindensis* Swynnerton and Bak.f., *T. dregeana* Sond. var. *oblonga* (Sond.) C.DC., *T. dregeana* Sond. var. *oblonga* Sond., *T. dregei* E.Mey. ex C.DC., *T. dregei* E.Mey. var. *oblonga* C.DC., *T. grandiflora* Oliv., *T. ledermannii* Harms, *T. rekdacta* Bullock ex Burtt Davy, *T. schliebenii* Harms, *T. splendida* A.Chev., *T. strigulosa* Welw. ex C.DC., *T. stuhlmannii* Harms, *T. tomentosa* A.Chev., *T. umbrosa* Vermoesen and *T. vestita* C.DC. and *T. vestita* C.DC [22–25].

Trichilia dregeana is known by several English common names which include "cape mahogany," "Christmas bells," "forest mahogany," "forest Natal mahogany," "red ash," "thunder tree," and "white mahogany" [10].

Trichilia dregeana is a medium to large dioecious and evergreen tree with a dense and spreading crown growing up to 40 m in height [22]. The tree trunk is tall, straight, and sometimes lightly buttressed and up to 2 m in diameter [10,26]. The main stem has smooth and black bark on young trees and dark grey to brown bark on older stems and branches. The leaves of *T. dregeana* are opposite or alternate with imparipinnate pairs of leaflets. The leaflets are oblanceolate to obovate in shape, dark glossy green above and paler below with tips more or less sharply pointed. The leaflet has entire margins, hairless below, and leathery with sunken midrib. The flowers are unisexual, similar in appearance, creamy white in color, and pleasantly scented, occurring in terminal and axillary flower heads. The fruit is round in shape, pale green in color, a woody dehiscent capsule, splitting open to reveal `black seeds that are completely enveloped by a bright red aril [3]. *Trichilia dregeana* has been recorded in Eswatini, Angola, Guinea, Cameroon, Rwanda, Central African Republic, South Sudan, Congo, the Democratic Republic of Congo, Ethiopia, Ivory Coast, Kenya, Zambia, Liberia, Malawi, Uganda, Mozambique, Sudan, Zimbabwe, Tanzania, and South Africa (Fig. 2). *Trichilia dregeana* has been recorded in montane and riverine forest, transition zone between savanna and forest at an altitude ranging from 15 to 2,000 m above sea level [22–25,27].

Ethnomedicinal significance

Trichilia dregeana is used as a source of traditional medicines in Tanzania, Cameroon, Ethiopia, Mozambique, Zimbabwe, South Africa, and Uganda, that is, 33.3% of the countries where the species is indigenous (Table 2). The traditional medicines prepared from the bark, fruits, leaves, roots, seeds, seed oil, and stem bark of *T. dregeana* are used to treat and manage 27 human and livestock diseases and ailments in tropical Africa. The main ailments and diseases treated by *T. dregeana* crude extracts include its use as traditional medicine against intestinal worms, respiratory infections, sores, and wounds which have been recorded in two countries and supported by two literature sources, followed by fever (two country and four literature records), fish poison, lumbago and rheumatism (two country and five literature records), skin problems, laxative and purgative (two country and six literature records), kidney and liver problems (two country and seven literature records), sexually transmitted infections (two country and eight literature records), and gastro-intestinal problems (4 country and 11 literature records) (Fig. 3). Other medicinal applications of *T. dregeana* supported by at least two literature sources include the use of the bark, fruits, leaves, roots, seeds, seed oil and stem bark as abortifacient, blood purifier, emetic, and tonic, and also as tonic for human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) symptoms and traditional medicine for fractures, pain and sleeplessness (Table 1). In South Africa, the leaves of *T. dregeana* are mixed with those of *Albizia adianthifolia* (Schumach.) W.Wight as traditional medicine for sexually transmitted infections (gonorrhea and syphilis) [28,29].

Figure 2. Distribution of *T. dregeana* in tropical Africa (map drawn using mapchart.net).

Nutritional composition

The seed oil extracted from *T. dregeana* is nutritious by virtue of having amino acids, fats, fatty acids, and proteins (Table 2), which are comparable to a commercial vegetable oil crop, *G. max* [57]. In terms of mineral content, seed oil extracted from *T. dregeana*, species appears to be a good source of essential minerals such as phosphorus, calcium, magnesium, iron, potassium, copper, and sodium [57]. Several fatty acids and amino acids (Table 2) have been identified from the seed oil of *T. dregeana* [1,57,58]. Compared to conventional vegetable oil crops such as *G. max, T. dregeana* is a good source of both macro- and micronutrients (Table 2).

Phytochemistry and pharmacological properties of *T. dregeana*

Several phytochemical compounds such as alcohols, alkanes, amides, esters, lignan, limonoids, sesquiterpenes, steroids, and triterpenoids (Table 3) have been isolated from the leaves, seeds, seed oil, and stems of *T. dregeana.* Some of the phytochemical compounds isolated from *T. dregeana* exhibited antibacterial, antifungal, anti-inflammatory, antioxidant, and nitric oxide (NO) production inhibitory activities (Table 4).

Antibacterial and antifungal activities

The medicinal value of *T. dregeana* against diarrhea, dysentery, scabies, sexually transmitted infections, sores, stomach ache, tinea capitis, toothache, tuberculosis, and wounds could be ascribed to antibacterial properties of phytochemical compounds (3*β*,23*E*)-9,19-cyclolanosta-23,25-

Table 1. Traditional and ethnomedicinal uses of *T. dregeana*.

Traditional or medicinal uses	Parts used	Country	Reference
Abortifacient	Bark decoction	Zimbabwe	[7,30,31]
Blood purifier	Bark decoction	South Africa	[31–33]
Cosmetic (body ointment and hair)	Seeds used	South Africa	[34]
Earache	Fruit decoction applied topically	South Africa	[35]
Emetic	Bark and fruit decoction taken orally	South Africa	[7,10,36,37]
Fever	Bark, leaf and root decoction taken orally	South Africa and Tanzania	[6,7,12,38]
Fish poison	Stem bark decoction	South Africa and Zimbabwe	[7,30,31,39,40]
Fractures	Seed oil used as massage	South Africa	[7,36]
Gastro-intestinal problems (diarrhoea, dysentery, indigestion, and stomach problems)	Bark, leaf, root and stem bark decoction, infusion or maceration	Mozambique, South Africa, Tanzania and Zimbabwe	[7,12,30,31,33,38,41–45]
Impotence	Bark decoction taken orally	South Africa	[46]
Induce labour	Root decoction taken orally	Tanzania	[12]
Infertility	Root decoction taken orally	Tanzania	[12]
Inflammation	Bark decoction applied topically	South Africa	[42]
Intestinal worms	Root decoction taken orally decoction taken orally	South Africa and Tanzania	[12,38]
Kidney and liver problems	Bark and leaf decoction taken orally	Cameroon and South Africa	[7,32,33,41,42,46,47]
Laxative and purgative	Bark, fruit and root decoction taken orally	South Africa and Zimbabwe	[7,10,30,31,35,38]
Lumbago and rheumatism	Bark, leaves, roots, seeds and seed oil used as massage	South Africa and Tanzania	[7,10,12,36,38]
Pain (abdominal, back ache and general body pains)	Bark and stem bark decoction and/or infusion	South Africa	[7,30,31,33,44,48,49]
Protection against bad spirits	Whole plant	South Africa	[46]
Respiratory infections (colds and tuberculosis)	Root and stem bark decoction taken orally	Tanzania and Uganda	[12,50]
Sexually transmitted infections (gonorrhoea and syphilis)	Leaves mixed with those of *Albizia adianthifolia* (Schumach.) W.Wight	Ethiopia and South Africa	[28,31–33,41,46,51,52]
Skin problems (bruises, eczema, leprosy, scabies and tinea capitis)	Bark, fruit, leaf, roots and seed oil used as massage or poultices or as a compress	Ethiopia and South Africa	[7,10,33,36,38,53]
Sleeplessness	Bark, leaves, roots, seed oil and seeds	South Africa	[7,10,36]
Sores and wounds	Bark and leaf decoction or infusion applied topically	Ethiopia and South Africa	[54,55]
Sunken fontalle	Bark decoction applied topically	South Africa	[49]
Tonic and tonic for HIV/AIDS symptoms	Bark and root decoction taken orally	South Africa	[7,37,49]
Toothache	Bark decoction used as mouthwash	South Africa	[49]
Ethnoveterinary medicine (trypanosomosis)	Bark decoction administered orally	Ethiopia	[56]

dien-3-ol and maslinic acid which exhibited activities against *Escherichia coli* and *Salmonella enteritidis* with minimum inhibitory concentration (MIC) value of 31.25 µg/ml [61]. The compounds also demonstrated moderate antifungal activities against *Candida albicans* with a MIC value of 62.5 µg/ml [61]. In addition to these pharmacological effects, ethanol extract of *T. dregeana* bark and leaves exhibited activities against *Staphylococcus aureus* with a MIC value of 1.2 mg/ml [65]. Similarly, aqueous and organic extract of *T. dregeana* leaves exhibited activities against *Ureaplasma urealyticum* clinical strain with a MIC value of 0.25 mg/ml [66]. Dichloromethane and methanol extracts of *T. dregeana* bark and leaf exhibited activities against *Bacillus cereus, Moraxella catarrhalis, Streptococcus mutans,* and *Fusobacterium nucleatum* subsp. *nucleatum* with MIC values ranging from 0.25 to 0.50 mg/ml [67].

Antimycobacterial activities

Ethanol extract of *T. dregeana* bark exhibited activities against *Mycobacterium aurum* A+ with a MIC value of 0.78 mg/ml [68] but more ethnopharmacological studies are required as stem bark of the species are used traditionally to treat tuberculosis in Uganda [50].

Table 2. Nutritional composition of *T. dregeana* and soybean (*Glycine max* (L.) Merr.

Nutritional component	Plant part	*Trichilia dregeana*	*Glycine max*	Reference
Ash (%)	Seeds	3.4	3.8	[57]
Boron (mg/kg)	Seeds	2.0	2.8	[57]
Calcium (mg/kg)	Seeds	300.0	245.0	[57]
Copper (mg/kg)	Seeds	1.1	1.1	[57]
Fat (%)	Seeds	51.5	20.2	[57]
Iron (mg/kg)	Seeds	6.3	10.0	[57]
Magnesium (mg/kg)	Seeds	142.0	233.0	[57]
Manganese (mg/kg)	Seeds	1.8	3.83	[57]
Moisture (%)	Seeds	4.9	9.1	[57]
Phosphorus (mg/kg)	Seeds	272.0	463.0	[57]
Potassium (mg/kg)	Seeds	1,350.0	1,695.0	[57]
Protein (%)	Seeds	17.3	45.4	[57]
Sulphur (mg/kg)	Seeds	142.0	367.0	[57]
Zinc (mg/kg)	Seeds	2.3	3.5	[57]
Amino acids				
Alanine (g/100 g)	Seeds	5.3	6.2	[57]
Arginine (g/100 g)	Seeds	9.5	9.2	[57]
Aspartic acid (g/100 g)	Seeds	15.2	14.0	[57]
Cysteine (g/100 g)	Seeds	0.7	0.7	[57]
Glutamic acid (g/100 g)	Seeds	17.1	18.9	[57]
Glycine (g/100 g)	Seeds	6.0	6.2	[57]
Histidine (g/100 g)	Seeds	3.6	4.4	[57]
Isoleucine (g/100 g)	Seeds	9.2	7.2	[57]
Leucine (g/100 g)	Seeds	13.3	13.9	[57]
Lysine (g/100 g)	Seeds	15.7	16.0	[57]
Methionine (g/100 g)	Seeds	3.1	4.8	[57]
Phenyalanine (g/100 g)	Seeds	11.7	15.8	[57]
Proline (g/100 g)	Seeds	5.9	6.3	[57]
Serine (g/100 g)	Seeds	5.5	6.0	[57]
Threonine (g/100 g)	Seeds	2.9	3.9	[57]
Tryptophan (g/100 g)	Seeds	1.8	2.1	[57]
Tyrosine (g/100 g)	Seeds	3.2	3.6	[57]
Valine (g/100 g)	Seeds	9.9	8.2	[57]
Fatty acids				
Elaidic acid (%)	Seed oil	49.0		[58]
Linoleic acid (%)	Seed oil	11.0–32.2	56.8–57.9	[1,58,59]
Linolenic acid (%)	Seed oil	1.0	9.8–11.2	[1,59]
Oleic acid (%)	Seed oil	31.0–51.0	20.1–20.9	[1,58,59]
Palmitic acid (%)	Seed oil	15.3–69.0	0.2–9.8	[1,58,59]
Stearic acid (%)	Seed oil	3.0	1.2–2.0	[1,59]

Antiviral activities

The methanol extract of *T. dregeana* roots exhibited activities against hepatitis C virus (HCV) infection with a half maximal inhibitory concentration (IC_{50}) value of 16.2 µg/ml [47]. The use of *T. dregeana* in treating and managing viral infections is yet to be extensively evaluated scientifically. Possible identification and isolation of active ingredients with antiviral properties is important.

Acetylcholinesterase (AChE) activities

The leaf and twig extracts of *T. dregeana* exhibited AChE inhibition of 81.1%–94.8% [69] and the ethyl acetate

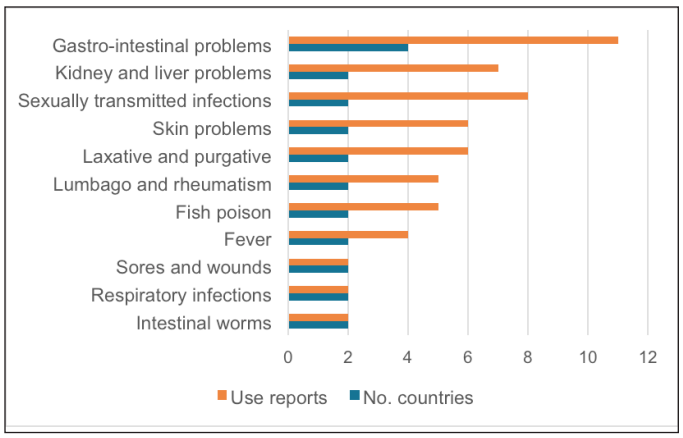

Figure 3. Main ethnomedicinal applications of *T. dregeana* in tropical Africa.

extract of the bark demonstrated moderate activities with IC_{50} value of 0.8 mg/ml [65]. However, these AChE inhibitory activities are probably due to the phytochemical compound cycloart-23-ene-3,25-diol which exhibited weak activities of 53.0% at a concentration of 0.4 mM [63]. Therefore, future research should focus on searching for AChE inhibitory compounds that characterize *T. dregeana* as a medicinal plant.

Anti-inflammatory activities

The ethyl acetate extract of *T. dregeana* bark and leaves inhibited cyclooxygenase (COX-1) and COX-2) at 78.0% and 81.0%, respectively [65]. Similarly, the phytochemical compound cycloart-23-ene-3,25-diol isolated from the leaves of *T. dregeana* exhibited activities against COX-1 (56.0%) and COX-2 (80.0%) and IC50 = 97.0 and 40.0 µM, respectively [63]. In *in vivo* studies, the crude leaf extract also showed anti-inflammatory activities at 100.0, 200.0, and 400.0 mg/kg by inhibiting ear edema, exudate, and granuloma formation [55]. These exhibited anti-inflammatory activities appear to corroborate the ethnomedicinal applications of the bark extracts of the species against inflammation in South Africa [42].

Antioxidant activities

The leaf and twig extracts of *T. dregeana* showed antioxidant activities against 2,2-diphenyl-1-picrylhydrazyl (DPPH) free scavenging assay exhibiting half maximal effective concentration (EC50) values of 1.3–14.6 µg/ml [69]. Similarly, leaf extract exhibited activities with IC_{50} values ranging from 11.5 to 27.5 µg/ml using DPPH, 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid (ABTS), and ferric reducing antioxidant potential (FRAP) assays [61]. The compound 9,19-cyclolanost-24-en-23-one isolated from the leaves of *T. dregeana* exhibited activities with IC_{50} values ranging from 11.9 to 21.3 µg/ml against ABTS, DPPH, and FRAP assays [61]. Therefore, the documented in vitro antioxidant activities exhibited by the extracts and phytochemical compounds isolated from *T. dregeana* could imply that the species has the capacity to protect animal body cells from harmful damage caused by free radicals.

NO production inhibitory activities

The ethyl acetate extract of *T. dregeana* leaves inhibited NO production in lipopolysaccharide (LPS)-stimulated RAW264.7 macrophage cells with the IC_{50} value of 83.5 µg/ml and also the compounds *24ξ-hydroxy-24ξ-methyl-3β,10β-epoxy-19(10→9)abeo-euphan-25-ene* and lupenone isolated from the species inhibited NO production in LPS-stimulated RAW264.7 macrophage cells with IC_{50} values of 81.3 and 85.7 µM, respectively [62]. Demonstration of NO production inhibitory activities by *T. dregeana* extracts and phytochemical compounds isolated from the species suggest that the species may provide important leads for cancer chemopreventive and anti-inflammatory agents [70].

Prostaglandin-synthesis inhibitory activities

The ethanol extract of *T. dregeana* bark exhibited 100% prostaglandin-synthesis inhibitory activities [71]. Medicinal plants exhibiting prostaglandin-synthesis inhibitory activities play an important role in treating and managing inflammation and pain-related diseases.

Wound healing activities

In *in vivo* studies, the crude leaf extract of *T. dregeana* showed wound healing activities causing wound contraction, decreasing period of epithelialization, and increased tensile strength [55]. Therefore, an increase in wound contraction, reduction in the period of epithelialization, and increase in tensile strength exhibited by *T. dregeana* extracts corroborate the ethnomedicinal applications of the species as traditional medicine against sores and wounds [54,55].

Insecticidal activities

The acetone extract of *T. dregeana* leaves showed insecticidal activities exhibiting 71.0% and 65.0% repellence against *Spodoptera frugiperda* and *Plutella xylostella*, respectively, with antifeeding deterrent coefficients of 62.0 and 112.3 against the two species [60]. Therefore, this species has the potential to be used as a biocontrol agent against insect pests.

Mutagenicity and toxicity activities

The dichloromethane: methanol (1:1) extracts of *T. dregeana* bark, leaf, and root exhibited mutagenic activities against *Salmonella typhimurium* TA100 strain [72]. The aqueous and organic extracts of *T. dregeana* bark and roots exhibited toxicity activities causing mortality of brine shrimp larvae varying from 75% to 100% after 24 hours [72] and 75% to 95% [73]. The toxic effects of *T. dregeana* is well-known and the species is categorized as having both poisonous and medicinal properties in the monograph "Medicinal and magical plants of southern Africa: an annotated checklist" [74]. Literature studies revealed that the seedcoat of *T. dregeana* is poisonous and widely used as fish poison in eastern and southern Africa [7,30,31,39,40], and only well-prepared seed oil is considered as safe for consumption [7]. Similarly, research by Kunene *et al.* [75] showed that the leaves of *T. dregeana* are consumed by cattle, goats, and sheep, but the species is known to cause diarrhea and even death of these animals after consuming the leaves [75].

Table 3. Phytochemical composition of *T. dregeana*.

Chemical composition	Formula	Plant part	Reference
1H-Naphtho[2,1-b]pyran,3-ethenyldodecahydro-3,4a,7,7,10apentamethyl-,[3R-(3α,4aβ,6aα,10aβ,10bα)]-	$C_{20}H_{34}O$	Leaves	[60]
1-Naphthalenemethanol, 1,4,4a,5,6,7,8,8aoctahydro-2,5,5,8a-tetramethyl-	$C_{15}H_{26}O$	Leaves	[60]
(1R,3E,7E,11R)-1,5,5,8-Tetramethyl-12-oxabicyclo[9.1.0]dodeca-3,7-diene	$C_{15}H_{24}O$	Leaves	[60]
1,2-Benzenediol,o-dichloroacetyl-o'-cyclopropanecarbonyl-	$C_{12}H_{10}C_{l2}O_4$	Leaves	[60]
1,2-Benzisothiazol-3-amine	$C_{13}H_{20}N_2SSi$	Leaves	[60]
1,6,10,14-Hexadecatetraen-3-ol,3,7,11,15-tetramethyl-, (E,E)-	$C_{20}H_{34}O$	Leaves	[60]
1,6-Heptadiene, 2-methyl-	C_8H_{14}	Leaves	[60]
2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-	$C_{15}H_{26}O$	Leaves	[60]
2,6,10-Dodecatrienal, 3,7,11-trimethyl-,(E,E)-	$C_{15}H_{24}O$	Leaves	[60]
2-Hydroxy-4-methoxy-7-methyl-7,8,9,10,11,12,13,14-octahydro-6-oxabenzocyclododecen-5-one	$C_{17}H_{24}O_4$	Leaves	[60]
2-Undecanone, 6,10-dimethyl-	$C_{13}H_{26}O$	Leaves	[60]
(3β,23E)-9,19-cyclolanosta-23,25-dien-3-ol	$C_{30}H_{48}O_4$	Leaves	[61]
(3β,5α,8α,9β,10β,13α,14β,17β,20β,24αβ)-24-methyl-3,10-epoxy-19(10→9)abeo-euphan-25-ene	$C_{31}H_{52}0$	Leaves	[62]
(3S,5S,8R,9R,10R,13S,14R,17S,20S)-24,24-Dimethyl-3β,10β-epoxy-19(10→9)abeo-euphan-25-ene	$C_{32}H_{54}0$	Leaves	[62]
3-Hydroxymyristic acid	$C_{14}H_{28}O_3$	Leaves	[60]
4,14-Dimethyl-11-isopropyltricyclo[10,14)]tetradec-4-en-8-one	$C_{19}H_{30}O$	Leaves	[60]
4,8,12,16-Tetramethylheptadecan-4-olide	$C_{21}H_{40}O_2$	Leaves	[60]
4-Hepten-2-one,(E)-	$C_7H_{12}O$	Leaves	[60]
4-tert-Octylphenol	$C_{17}H_{30}OSi$	Leaves	[60]
9-Octadecenamide, (Z)-	$C_{18}H_{35}NO$	Leaves	[60]
24ξ-Hydroxy-24ξ-methyl-3β,10β-epoxy-19(10→9)abeo-euphan-25-ene	$C_{31}H_{52}O_2$	Leaves	[62]
Bicyclo[3.1.1]hept-2-ene,2,20-(1,2-ethanediyl)bis[6,6-dimethyl-	$C_{20}H_{30}$	Leaves	[60]
Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	Leaves	[60]
Butyl 4,7,10,13,16,19-docosahexaenoate	$C_{26}H_{40}O_2$	Leaves	[60]
Butylated Hydroxytoluene	$C_{15}H_{24}O$	Leaves	[60]
Butyric acid	$C_{20}H_{40}O_2$	Leaves	[60]
Carbohydrazide	CH_6N_4O	Leaves	[60]
Cycloartene-23-ene-3,25-diol	$C_{30}H_{50}O_2$	Leaves	[63]
Cyclotrisiloxane	$C_6H_{18}O_3Si_3$	Leaves	[60]
n-Decanoic acid	$C_{10}H_{20}O_2$	Leaves	[60]
Dibutyl phthalate	$C_{16}H_{22}O_4$	Leaves	[60]
Dodecanamide	$C_{12}H_{25}NO$	Leaves	[60]
Dodecanoic acid	$C_{13}H_{26}O_2$	Leaves	[60]
Dodecanoic acid, 2-methyl-	$C_{13}H_{26}O_2$	Leaves	[60]
Dregeanol (1)	$C_{30}H_{50}O_3$	Leaves	[61]
(E)-3-Methyl-5-((1R,4aR,8aR)-5,5,8a-trimethyl-2-methylenedecahydronaphthalen-1-yl)pent-2-en-1-ol	$C_{20}H_{34}O$	Leaves	[60]
Eicosane	$C_{20}H_{42}$	Leaves	[60]
Ergost-5-en-3-ol, acetate, (3β,24R)-	$C_{30}H_{50}O_2$	Leaves	[60]
Ethanol, 2,2-dichloro-	$C_2H_4Cl_2O$	Leaves	[60]
Heptacosane	$C_{27}H_{56}$	Leaves	[60]
Hexadecane	$C_{16}H_{34}$	Leaves	[60]
n-Hexadecanoic acid	$C_{16}H_{32}O_2$	Leaves	[60]
Hexadecyl pentyl ether	$C_{21}H_{44}O$	Leaves	[60]
Humulane-1,6-dien-3-ol	$C_{15}H_{26}O$	Leaves	[60]
Humulene	$C_{15}H_{24}$	Leaves	[60]
Hydrazine	H_4N_2	Leaves	[60]
Hispidin C	$C_{13}H_{10}O_5$	Seeds	[64]

(Continued)

Chemical composition	Formula	Plant part	Reference
Kaur-15-ene	$C_{20}H_{32}$	Leaves	[60]
Lupenone	$C_{30}H_{48}O$	Leaves	[62]
Lupeol	$C_{30}H_{50}O$	Leaves	[62]
Maslinic acid	$C_{30}H_{48}O_4$	Leaves	[61]
Methyl alcohol	CH_4O	Leaves	[60]
Neophytadiene	$C_{20}H_{38}$	Leaves	[60]
Nonanamide	$C_9H_{19}NO$	Leaves	[60]
Phenanthrene,7-ethenyl-1,2,3,4,4a,4b,5,6,7,9,10,10adodecahydro-1,1,4a,7-tetramethyl-,[4aS-(4aα,4bβ,7β,10aβ)]-	$C_{20}H_{32}$	Leaves	[60]
Phenol, 2,2′-methylenebis[6-(1,1-dimethylethyl)-4-methyl-	$C_{23}H_{32}O_2$	Leaves	[60]
Phenol, 2,5-bis(1,1-dimethylethyl)-	$C_{14}H_{22}O$	Leaves	[60]
Phosphine, tris(trifluoromethyl)-	C_3F_9P	Leaves	[60]
Phthalic acid, 4-cyanophenyl heptyl ester	$C_{22}H_{23}NO_4$	Leaves	[60]
Phthalic acid, heptyl pentyl ester	$C_{20}H_{30}O_4$	Leaves	[60]
Phthalic acid, monoamide,N-ethyl-N-(3-methylphenyl)-, isobutyl ester	$C_{21}H_{25}NO_3$	Leaves	[60]
Phytol	$C_{20}H_{40}O$	Leaves	[60]
(R,1E,5E,9E)-1,5,9-Trimethyl-12-(prop-1-en-2-yl)cyclotetradeca-1,5,9-triene	$C_{20}H_{32}$	Leaves	[60]
α-Santalol	$C_{15}H_{24}O$	Leaves	[60]
β-sitosterol	$C_{29}H_{50}O$	Leaves	[60–62]
ϒ-Sitostenone	$C_{29}H_{48}O$	Leaves	[60]
Stigmasta-5,24(28)-dien-3-ol, (3β,24Z)-	$C_{29}H_{48}O$	Leaves	[60]
Stigmasterol	$C_{29}H_{48}O$	Leaves	[60,61]
Supraene	$C_{30}H_{50}$	Leaves	[60]
Thioacetic acid	C_2H_4OS	Leaves	[60]
α-Tocopheryl acetate	$C_{31}H_{52}O_3$	Leaves	[60]
Tridecanoic acid	$C_{14}H_{28}O_2$	Leaves	[60]
Tris(trifluoromethyl) bromomethane	C_4BrF_9	Leaves	[60]

Table 4. Biological activities of *T. dregeana*.

Activity	Assay	Results	Reference
Antibacterial	Microdilution	Ethanol bark and leaf extracts exhibited activities with MIC value of 1.2 mg/ml against *Staphylococcus aureus*	[65]
		Aqueous and organic leaf extracts exhibited activities against *Ureaplasma urealyticum* clinical strain with MIC value of 0.25 mg/ml	[66]
		Dichloromethane and methanol bark and leaf extracts exhibited activities against *Bacillus cereus, Moraxella catarrhalis, Streptococcus mutans* and *Fusobacterium nucleatum* subsp. *nucleatum* with MIC values ranging from 0.25 to 0.50 mg/ml	[67]
		Compounds (3*β*,23*E*)-9,19-cyclolanosta-23,25-dien-3-ol and maslinic acid exhibited activities against *Escherichia coli* and *Salmonella enteritidis* with MIC value of 31.25 µg/ml	[61]
Antimycobacterial	Microdilution	Ethanol extracts of the bark exhibited activities against *Mycobacterium aurum* A+ with MIC value of 0.78 mg/ml	[68]
Antifungal	Microdilution	Compounds (3*β*,23*E*)-9,19-cyclolanosta-23,25-dien-3-ol and maslinic acid exhibited weak activities against *Candida albicans* with MIC value of 62.5 µg/ml	[61]
Antiviral	HCV cell culture inhibition assay	Methanol root extract exhibited activities with IC_{50} value of 16.2 µg/ml	[47]
AChE	Anti-cholinesterase	Compound cycloart-23-ene-3,25-diol exhibited weak activities (53.0%) at a concentration of 0.4 mM	[63]
	Ellman's method	Ethyl acetate bark extract exhibited moderate activities with IC_{50} value of 0.8 mg/ml	[65]
	Colorimetric method	Leaf and twig extracts exhibited AChE inhibition of 81.1%–94.8%	[69]

Activity	Assay	Results	Reference
Anti-inflammatory	Cyclooxygenase assays (COX-1 and COX-2)	Ethyl acetate bark and leaf extracts inhibited COX-1 (78.0%) and COX-2 (81.0%)	[65]
		Compound cycloart-23-ene-3,25-diol exhibited activities against COX-1 (56.0%) and COX-2 (80.0%) and IC_{50} = 97.0 µM and 40.0 µM, respectively	[63]
	Xylene-induced ear edema and cotton pellet granuloma	Extracts inhibited ear edema, exudate and granuloma formation	[55]
Antioxidant	DPPH	Leaf and twig extracts exhibited activities with EC_{50} values of 1.3–14.6 µg/ml	[69]
	ABTS, DPPH and FRAP	Leaf extract exhibited activities with IC_{50} values ranging from 11.5 to 27.5 µg/ml against ABTS, DPPH and FRAP	[61]
		Compound 9,19-cyclolanost-24-en-23-one exhibited activities with IC_{50} values ranging from 11.9 to 21.3 µg/ml against ABTS, DPPH and FRAP	[61]
NO production inhibitory	Griess	Ethyl acetate extract inhibited NO production in LPS-stimulated RAW264.7 macrophage cells with the IC_{50} values of 83.5 µg/ml	[62]
		Compounds *24ξ-hydroxy-24ξ-methyl-3β,10β-epoxy-19(10→9)abeo-euphan-25-ene* and lupenone inhibited NO production in LPS-stimulated RAW264.7 macrophage cells with the IC_{50} values of 81.3 and 85.7 µM, respectively	[62]
Prostaglandin-synthesis inhibitory	Cyclooxygenase	Ethanol extract of the bark exhibited 100% inhibitory activities	[71]
Wound healing	Excision, incision and burn wound models	Extracts caused wound contraction, decreasing period of epithelialization and increased tensile strength	[55]
Insecticidal	Repellence and feeding deterrence	Extracts caused repellence percentage of 71.0% against *Spodoptera frugiperda* and *Plutella xylostella* (65.0%), antifeeding deterrent coefficient of 62.0 and 112.3, respectively	[60]
Mutagenicity	Ames test	Dichloromethane : methanol (1:1) bark, leaf and root extracts were mutagenic to *Salmonella typhimurium* TA100 strain	[72]
Toxicity	Brine shrimp lethality	Aqueous and organic bark and roots exhibited toxicity varying from 75% to 100% after 24 hours	[72]
		Highly toxic causing 75%–95% mortality	[73]

CONCLUSION

The present review provides a summary of the botany, traditional uses, medicinal applications, and chemical and pharmacological properties of *T. dregeana*. Such ethnopharmacological studies are important for plant species widely used as sources of traditional medicines as assessing their phytochemistry, pharmacological properties, and toxicological evaluations is important. However, detailed studies focusing on toxicity and safety, mechanisms of action *in vivo,* and clinical research aimed at corroborating the traditional medical applications of *T. dregeana* are recommended.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the international committee of medical journal editors (ICMJE) requirements/guidelines.

CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest associated with this research work.

ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

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