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Review Article
Combretum erythrophyllum (Burch.) Sond. (Combretaceae): Medicinal Uses, Phytochemistry and Pharmacological Properties

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Abstract

Combretum erythrophyllum (Burch.) Sond. is a tree species widely used in traditional medicine in Southern Africa. The current study documented existing information on the medicinal uses, phytochemicals and pharmacological properties of *C. erythrophyllum.* A search for available information on the medicinal uses, phytochemical and pharmacological properties of *C. erythrophyllum* was conducted by systematically searching the scientific databases such as PubMed®, ScienceDirect®, Web of Science, Google Scholar, SpringerLink®, SciELO and Scopus®, as well as pre-electronic literature sources such as book chapters, books and other scientific publications obtained from the university library. This study showed that the bark, gum powder, leaf, root and stem decoction or infusion of *C. erythrophyllum* are used as aphrodisiac, purgative and ethnoveterinary medicine and traditional medicine against pregnancy-related problems, gastro-intestinal problems, infertility in women, respiratory infections, sexually transmitted infections, sores and wounds. The ethnopharmacological assessment of the species showed that it contains flavonoids, fatty acids, alkaloids, sterols, tannins, phenols, stilbenoids, lactones and triterpenoids. Pharmacological assessments revealed that antibacterial, anti-inflammatory, antifungal, antioxidant and cytotoxicity activities characterize the phytochemical compounds isolated from the species and its crude extracts. To realize the full potential of *C. erythrophyllum* as a medicinal plant species, future research should focus on conducting detailed phytochemical, pharmacological and toxicological evaluations of the species, *in vivo* and clinical research.

Key words: Bush willow, combretaceae, combretum erythrophyllum, Southern Africa, traditional medicine

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Combretum erythrophyllum (Burch.) Sond. (Fig. 1a-c) is a member of the Combretaceae family, commonly known as the white mangrove, Indian almond, or bush willow family. *Combretum erythrophyllum* is a multipurpose species and these taxa are often associated with use categories such as food, medicines, fuel, timber, ornamental, recreational and symbolic applications[1-6]. *Combretum erythrophyllum* is widely used in traditional medicine throughout its distributional range in Southern Africa[7]. The roots and seeds of *C. erythrophyllum* are also reputed to be poisonous[8] but widely used in Southern Africa to purge dogs of intestinal worms[7]. *Combretum erythrophyllum* is an important fodder species with its leaves, flowers, fruits, shoots and young twigs being palatable and browsed by livestock and game, particularly during the dry periods[9-12]. *Combretum erythrophyllum* is an attractive tree which is popular as an ornamental and/or shade plant in larger private gardens and also used as a street tree in Southern Africa, tolerating frost and moderate drought[10]. The gum that exudes from damaged branches and stems of *C. erythrophyllum* is used as a wood varnish and for tanning leather[11,12]. Similarly, a dark, rich brown dye is extracted from the roots of *C. erythrophyllum* and used for tanning animal hides[13]. *Combretum erythrophyllum* wood is yellow in colour, hard, heavy, strong, compact, easily worked and makes a useful general-purpose timber as construction material for houses, livestock enclosures, fencing posts, handles of agricultural implements, furniture and ornaments[10]. The wood of the species is also considered to be one of the most important and best quality firewoods as it burns slowly with intense heat, little smoke and makes good charcoal[9,10]. Therefore, this article reviews the importance of *C. erythrophyllum* in traditional medicine with a holistic approach that includes its botany, phytochemistry and pharmacological properties.

MATERIALS AND METHODS

A search for available information on medicinal uses, phytochemical and pharmacological properties of *Combretum erythrophyllum* was conducted by systematically searching the scientific databases such as ScienceDirect®, PubMed®, Web of Science, SpringerLink®, Google Scholar, Scopus® and SciELO and as well as pre-electronic literature sources such as book chapters, books and other scientific publications obtained from the university library. The search was conducted from June, 2024 to February, 2025 using the following keywords: "*Combretum erythrophyllum*", "Biological activities of *Combretum erythrophyllum*", "Pharmacological properties of *Combretum erythrophyllum*", "Ethnobotany of *Combretum erythrophyllum*", "Medicinal uses of *Combretum erythrophyllum*", "Phytochemistry of *Combretum erythrophyllum*" and "Traditional uses of *Combretum erythrophyllum*". The search covered publications from 1962 to 2024, a long period to capture literature on the medicinal, phytochemical and pharmacological properties of *C. erythrophyllum*.

RESULTS AND DISCUSSION

Botanical description of *Combretum erythrophyllum*: The genus name "*Combretum*" is of classical origin, as the name was first used by the Roman naturalist, natural philosopher, naval and army commander Gaius Plinius Secundus, known in English as Pliny (23-79 AD), used in reference for an unknown plant[9,10]. The name was also re-used by the Swedish botanist Pehr Löfling (31 January 1729-22 February 1756) for the *Combretum* genus[9,10]. The species name "*erythrophyllum*" is based on Greek words meaning "red leaf"[9] as the species is characterized by the beautiful crimson colour of the leaves in autumn. The common name 'bush willow' indicates a superficial resemblance of the species to willows, that is, species belonging to the genus *Salix* L. (family Salicaceae), but "bush willows" and "willows" are not closely related to each other[9]. Other common names of the species include "river bush willow", "river combretum", "sand bush willow" and "Vaal river yellow wood"[9,13]. The synonyms of *C. erythrophyllum* (Burch.) Sond. include *C. erythrophyllum* (Burch.) Sond. var. *obscurum* Van Heurck and Müll.Arg., *C. galpinii* Engl. and Diels, *C. glomeruliflorum* Sond., *C. glomeruliflorum* Sond. var. *obscurum* (Van Huerck. and Müll.Arg.) Burtt Davy, *C. glomeruliflorum* Sond. var. *riparium* (Sond.) Burtt Davy, *C. lydenburgianum* Engl. and Diels, *C. riparium* Sond., *C. sonderi* Gerrand ex Sond. and *Terminalia erythrophylla* Burch.[9,14,15].

Combretum erythrophyllum is a deciduous to semi-deciduous tree reaching 30 m in height with crooked spreading trunks which can be 60 cm in diameter[9,14,15] (Fig. 1a). The crown of the species is dense and elongated to round in shape. In wet areas and along river banks, *C. erythrophyllum* forms thick stands, often several-stemmed from the base, with the trunks reclining and overhanging the water, as a result of annual torrential flooding. The bark is pale grey in colour and smooth on young branches, turning darker grey on older branches and stems, flaking with age to expose paler grey patches and create a mottled appearance. The leaves of

Fig. 1: *Combretum erythrophyllum*: (a) Entire plant, (b) Branch showing leaves and flowers and (c) Branch showing leaves and fruits
Photos: (a) C.M. Dzerefos, (b) A. Tjeerd and (c) B.T. Wursten

C. erythrophyllum are opposite, alternate, or occasionally in whorls, elliptic to oblong-elliptic in shape, widest about the middle, with entire margins, tapered at both ends. The young leaves are yellowish in colour, shiny and viscous, maturing to fresh or dull medium-green above and yellowish green below, thinly leathery, usually hairless above and finely hairy below with pockets of hairs in axils of veins below. The flowers are yellowish green in colour (Fig. 1b), with a faint sweet scent and appear as clusters or dense, short and roundish spikes in axils of new leaves and side shoots. The fruits of *C. erythrophyllum* are winged, shiny and pale green when young (Fig. 1c), turning golden brown when mature. The fruits are borne abundantly and remain on the tree when the leaves have fallen and often after the flowers appear. *Combretum erythrophyllum* has been recorded from low to higher altitudes, often gregarious along the banks of rivers and watercourses, occasionally in woodland and in wooded grassland, along streams or near moisture or where groundwater is available at an altitude ranging from 15 to 1525 m above sea level[14]. *Combretum erythrophyllum* has been recorded in Botswana, Eswatini, Mozambique, Namibia, South Africa, Zambia and Zimbabwe[14,15]. *Combretum erythrophyllum* is often confused with *C. kraussii* Hochst., which is typically a tree of mistbelt forests and mountain kloofs, whereas *C. erythrophyllum* grows along rivers and even dry watercourses at a lower altitude[9].

Ethnomedicinal applications of *Combretum erythrophyllum*: *Combretum erythrophyllum* is used as a source of traditional medicines in South Africa, Eswatini and Zimbabwe, that is, 42.9% of the countries where the species is indigenous (Table 1). In South Africa, the roots of *C. erythrophyllum* are sold in informal herbal medicine markets as sources of traditional medicines[16]. *Combretum erythrophyllum* is also categorized as a valuable medicinal plant species in South Africa, as the species is used by the majority of cultural groups in that country. The species has been incorporated into the traditional *materia medica* of that country and *C. erythrophyllum* is included in the South African encyclopedia, namely, "Medicinal and Magical Plants of Southern Africa: An annotated checklist"[17]. This monograph documented the botanical descriptions of medicinal plants that are regarded as major components of the South African *materia medica*, the plant parts used, medicinal applications, preparation, dosage, active ingredients and pharmacological properties of the species[17].

The traditional medicines prepared from the bark, gum powder, leaf, root and stem decoction or infusion of *C. erythrophyllum* are used to treat and manage 19 human and animal diseases and ailments (Table 1). The main ailments and diseases treated by *C. erythrophyllum* extracts (Fig. 2) include the use of roots as aphrodisiac, purgative and ethnoveterinary medicine and use of the bark, gum powder, leaf, root and stem decoction or infusion as traditional medicine against pregnancy-related problems,

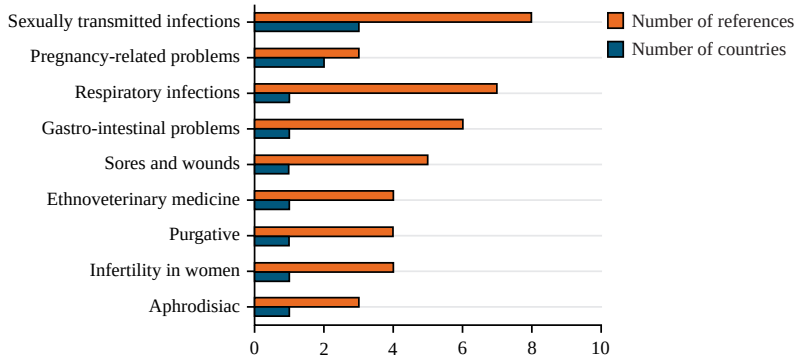

Fig. 2: Main diseases and ailments treated and managed using *Combretum erythrophyllum* extracts

Table 1. Medicinal uses of *Combretum erythrophyllum*

Medicinal use	Part used	Country	References
Mono-therapeutic applications			
Aphrodisiac	Root decoction taken orally	Zimbabwe	Quattrocchi[13], Gelfand *et al.*[19] and Hutchings *et al.*[20]
Gastrointestinal problems (abdominal pain, diarrhoea, dysentery and stomach pains)	Leaf infusion taken orally	South Africa	Maroyi[1], Silén *et al.*[8], Hutchings *et al.*[20], Martini *et al.*[21] and Cock and van Vuuren[22]
Infertility in women	Bark decoction taken orally	South Africa	Silén *et al.*[8], Hutchings *et al.*[20] and Cock and van Vuuren[22]
Leprosy	Bark, root or stem decoction applied topically	Not specified	Silén *et al.*[8] and Martini *et al.*[21]
Pregnancy-related problems (antenatal, facilitate labour and reduce size of vaginal orifice)	Bark decoction taken orally or root powder inserted into vagina	South Africa and Zimbabwe	Veale *et al.*[18], Gelfand *et al.*[19] and Hutchings *et al.*[20]
Purgative	Root decoction taken orally	South Africa	Watt and Breyer-Brandwijk[7], Palmer and Pitman[9], Venter and Venter[10] and Quattrocchi[13]
Respiratory infections (colds, coughs and tuberculosis)	Leaf decoction taken orally	South Africa	Silén *et al.*[8], Schmidt *et al.*[11], Hutchings *et al.*[20], Martini *et al.*[21], Cock and van Vuuren[22] and Semenya and Maroyi[23]
Sexually transmitted infections (used as prophylactic and against venereal diseases)	Bark and root decoction taken orally	Eswatini, South Africa and Zimbabwe	Silén *et al.*[8], Schmidt *et al.*[11], van Wyk and Gericke[12], Quattrocchi[13], Gelfand *et al.*[19], Hutchings *et al.*[20] and Cock and van Vuuren[22]
Sores and wounds	Gum powder applied topically	South Africa	Silén *et al.*[8], Venter and Venter[10], Martini *et al.*[21] and Cock and van Vuuren[22]
Ethnoveterinary medicine (fattening tonic for dogs and purge dogs of intestinal worms)	Roots	South Africa	Watt and Breyer-Brandwijk[7], Palmer and Pitman[9], Gelfand *et al.*[19] and Hutchings *et al.*[22]
Used in combination with other species			
Infertility in women	Bark mixed with roots of *Combretum imberbe* Wawra, *Sclerocarya birrea* (A.Rich.) Hochst. (Anacardiaceae family) and *Diospyros lycioides* Desf. (Ebenaceae family)	South Africa	Silén *et al.*[8]

gastro-intestinal problems, infertility in women, respiratory infections, sexually transmitted infections, sores and wounds. In South Africa, the bark of *C. erythrophyllum* is mixed with roots of *Combretum imberbe* Wawra, *Sclerocarya birrea* (A.Rich.) Hochst. (Anacardiaceae family) and *Diospyros lycioides* Desf. (Ebenaceae family) as traditional medicine for infertility in women[8]. Similarly, research conducted by Veale *et al.*[18] showed that in South Africa, some unspecified parts of *C. erythrophyllum* are often used as ingredients of a herbal concoction which is usually taken during pregnancy to facilitate labour.

Phytochemistry and pharmacological properties of *Combretum erythrophyllum*: Qualitative and quantitative phytochemical analyses of *C. erythrophyllum* leaves and stem bark revealed the presence of fatty acids, flavonoids,

Table 2. Phytochemical composition of *Combretum erythrophyllum*

Phytochemical compound	Formula	Part	References
1,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a, 14,14a,14b-octadecahydro-2H-picen-3-one	$C_{30}H_{48}O$	Leaves and stem bark	Bantho *et al.*[29]
1-heptacosanol	$C_{27}H_{56}O$	Leaves and stem bark	Bantho *et al.*[29]
2-ethylhexyl ester	$C_{10}H_{20}O$	Leaves and stem bark	Bantho *et al.*[29]
2-methyloctacosane	$C_{29}H_{60}$	Leaves and stem bark	Bantho *et al.*[29]
3-oxo-cycloart-11-en-21-oic acid	$C_{30}H_{46}O_3$	Leaves	Rogers[24]
3-oxo-cycloart-1,11,25(26)-trien-24(R),21-olide	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
4,4,6a,6b,8a,11,11,14b-Octamethyl-	$C_{30}H_{48}O$	Leaves and stem bark	Bantho *et al.*[29]
5-hydroxy-7,4'-dimethoxyflavone	$C_{17}H_{16}O_5$	Leaves	Martini *et al.*[26] and Seepe *et al.*[28]
9-Octadecen-1-ol, (Z)-	$C_{18}H_{36}O$	Leaves and stem bark	Bantho *et al.*[29]
9,19-Cyclolanost-25-en-3-ol	$C_{30}H_{50}O$	Leaves	Bantho *et al.*[29]
12β-hydroxy-3-oxo-cycloart-1,24-dien-21-oic acid	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
12β,24(S)-dihydroxy-3-oxo-cycloart-1,25(26)-dien-21-oic acid	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	Leaves and stem bark	Bantho *et al.*[29]
21-acetoxy-3-oxo-cycloart-1,11,24- triene	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
21-hydroxy-3-oxo-olean-12-en-28-oic acid	$C_{30}H_{46}O_4$	Leaves	Seepe *et al.*[28]
23-hydroxy-cycloart-11-en-21-oic acid	$C_{30}H_{48}O_3$	Leaves	Rogers[24]
24(R/S)-acetoxy-3-oxo-cycloart-1,11,25(26)-trien-21-oic acid	$C_{32}H_{44}O_5$	Leaves	Rogers[24]
24(R/S)-hydroxy-3-oxo-cycloart-1,11,25(26)-trien-21-oic acid	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
Androst-5-en-17-ol, 4,4-dimethyl	$C_{21}H_{34}0$	Leaves and stem bark	Bantho *et al.*[29]
Apigenin	$C_{15}H_{10}O_5$	Leaves	Martini *et al.*[26]
Borneol	$C_{10}H_{18}O$	Leaves	Grimsey *et al.*[30]
Camphor	$C_{10}H_{16}O$	Leaves	Grimsey *et al.*[30]
Cineole	$C_{10}H_{18}O$	Leaves	Grimsey *et al.*[30]
cis,cis,cis-7,10,13-Hexadecatrienal	$C_{16}H_{26}O$	Leaves	Bantho *et al.*[29]
(-)-combretastatin	$C_{18}H_{22}O_6$	Leaves	Schwikkard *et al.*[25]
Combretastatin A-1	$C_{18}H_{22}O_6$	Leaves	Schwikkard e*t al.*[25]
Decanedioic acid, dibutyl ester	$C_{18}H_{34}O$	Leaves and stem bark	Bantho *et al.*[29]
Di(4-methylhept-3-yl) ester	$C_{24}H_{38}O_4$	Leaves and stem bark	Bantho *et al.*[29]
Eicosane	$C_{20}H_{42}$	Leaves and stem bark	Bantho *et al.*[29]
Eicosanoic acid	$C_{20}H_{40}O_2$	Leaves	Bantho *et al.*[29]
Erythrophyllic acid	$C_{30}H_{42}O_3$	Leaves	Rogers[24]
Friedelin	$C_{30}H_{50}O$	Leaves	Mtunzi *et al.*[27]
Genkwanin	$C_{16}H_{12}O_5$	Leaves	Martini *et al.*[26]
n-Heptadecanol-1	$C_{17}H_{36}O$	Leaves and stem bark	Bantho *et al.*[29]
Isomenthol	$C_{10}H_{20}O$	Leaves	Grimsey *et al.*[30]
Isomyocorene	$C_{10}H_{16}$	Leaves	Grimsey *et al.*[30]
Kaempferol	$C_{15}H_{10}O_6$	Leaves	Martini *et al.*[26]
Limonene	$C_{10}H_{16}$	Leaves	Grimsey *et al.*[30]
Lup-20(29)-en-3-ol, acetate, (3β)	$C_{30}H_{50}O$	Leaves and stem bark	Bantho *et al.*[29]
Lupeol	$C_{30}H_{50}O$	Leaves and stem bark	Bantho *et al.*[29]
Methyl erythropyllate	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
Methyl-24(R/S)-acetoxy-3-oxo-cycloart-1,11,25(26)-trien-21-oate	$C_{33}H_{46}O_5$	Leaves	Rogers[24]
Methyl-24(R/S)-hydroxy-3-oxo-cycloart-1,11,25(26)-trien-21-oate	$C_{30}H_{40}O_3$	Leaves	Rogers[24]
n-Nonadecanol-1	$C_{19}H_{40}O$	Leaves and stem bark	Bantho *et al.*[29]
Octadecanoic acid	$C_{18}H_{36}O_2$	Leaves and stem bark	Bantho *et al.*[29]
n-Pentadecanol	$C_{15}H_{32}O$	Leaves and stem bark	Bantho *et al.*[29]
Pentadecanoic acid	$C_{15}H_{30}O_2$	Leaves and stem bark	Bantho *et al.*[29]
Phenol, 2,4-bis(1,1-dimethylethyl)	$C_{17}H_{30}OSi$	Leaves	Bantho *et al.*[29]
Phthalic acid	$C_8H_6O_4$	Leaves and stem bark	Bantho *et al.*[29]
Phytol	$C_{20}H_{40}O$	Leaves	Bantho *et al.*[29]
Phytol, acetate	$C_{22}H_{42}O_2$	Leaves	Bantho *et al.*[29]
Quercetin-5,3'-dimethyl ether	$C_{17}H_{14}O_7$	Leaves	Martini *et al.*[26]
Rhamnazin	$C_{17}H_{14}O_7$	Leaves	Martini *et al.*[26]
Rhamnocitrin	$C_{16}H_{12}O_6$	Leaves	Martini *et al.*[26]
Silane	SiH_4	Leaves and stem bark	Bantho *et al.*[29]
β-Sitosterol	$C_{29}H_{50}O$	Leaves and stem bark	Bantho *et al.*[29]
Terephthalic acid, dodecyl	$C_{27}H_{44}O_4$	Leaves and stem bark	Bantho *et al.*[29]
Terpineol	$C_{10}H_{18}O$	Leaves	Grimsey *et al.*[30]
Tetratetracontane	$C_{44}H_{90}$	Leaves and stem bark	Bantho *et al.*[29]
Thiophene, 2-butyl-5-hexyl-	$C_{14}H_{24}S$	Leaves	Bantho *et al.*[29]

alkaloids, tannins, sterols, phenols, lactones, stilbenoids and triterpenoids[24-30] (Table 2). Some of the documented chemical compounds that have been isolated from *C. erythrophyllum* and the crude extracts of the species demonstrated antifungal, antibacterial, antioxidant, anti-inflammatory and cytotoxicity activities.

Antibacterial activities: Martini and Eloff[31] evaluated the antibacterial activities of water, butanol, methanol, hexane and carbon tetrachloride extracts of *C. erythrophyllum* leaves against *Escherichia coli, Staphylococcus aureus, Enterococcus faecalis* and *Pseudomonas aeruginosa* using the microdilution assay with ampicillin and chloramphenicol as positive controls. The extracts exhibited activities against the tested pathogens with minimum inhibitory concentration (MIC) values ranging from 0.05 to 50.0 mg/mL[31]. Eloff[32] assessed the antibacterial properties of the acetone extracts of *C. erythrophyllum* leaves against *Staphylococcus aureus, Escherichia coli, Enterococcus faecalis* and *Pseudomonas aeruginosa* using the twofold serial dilution with gentamicin as a positive control. The extracts exhibited antibacterial properties against the tested pathogens with MIC values that ranged from 0.4 to 3.0 mg/mL[32]. Martini *et al.*[21] also evaluated the antibacterial properties of the phytochemical compounds rhamnazin, genkwanin, 5-hydroxy-7,4'-dimethoxyflavone, rhamnocitrin and quercetin-5,3'-dimethylether isolated from *C. erythrophyllum* leaves against *Escherichia coli, Micrococcus luteus, Staphylococcus aureus, Vibrio cholerae, Shigella sonnei, Enterococcus faecalis* and *Pseudomonas aeruginosa* using the serial dilution microplate assay. The compounds exhibited activities against the tested pathogens with MIC values ranging from 25.0 to >100.0 µg/mL[21]. Cock and Van Vuuren[22] evaluated the antibacterial activities of aqueous and methanol extracts of *C. erythrophyllum* leaves against *Alcaligenes faecalis, Aeromonas hydrophila, Bacillus cereus, Bacillus subtilis, Citrobacter freundii, Escherichia coli, Klebsiella pneumonia, Proteus mirabilis, Proteus vulgaris, Pseudomonas aeruginosa, Pseudomonas fluorescens, Salmonella typhimurium, Serratia marcescens, Shigella sonnei, Staphylococcus aureus* and *Staphylococcus epidermidis* using the disc diffusion assay. The extracts exhibited activities against the tested pathogens with MIC values ranging from 130.0 to 4327.0 µg/mL[22]. Mtunzi *et al.*[27] evaluated the antibacterial activities of the phytochemical compound friedelin isolated from *C. erythrophyllum* leaves against *Pseudomonas aeruginosa, Staphylococcus aureus, Enterococcus faecalis* and *Escherichia coli* using the microtitre dilution method with gentamicin as a positive control. The phytochemical compound exhibited activities against the tested pathogens with MIC values ranging from 0.32 to 0.63 µg/mL[27]. Mtunzi *et al.*[33] evaluated the antibacterial activities of water, ethyl acetate, acetone, hexane and dichloromethane extracts of *C. erythrophyllum* leaves against *Staphylococcus aureus, Escherichia coli, Enterococcus faecalis* and *Pseudomonas aeruginosa* using the microtitre dilution method with gentamicin as a positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.08 to 2.5 mg/mL[33]. Anokwuru *et al.*[34] evaluated the antibacterial activities of methanol extracts of *C. erythrophyllum* leaves against *Staphylococcus aureus, Staphylococcus epidermidis, Bacillus cereus, Staphylococcus epidermidis, Klebsiella pneumoniae, Enterococcus faecalis, Pseudomonas aeruginosa, Escherichia coli, Salmonella typhimurium* and *Shigella sonnei* using the microdilution assay with ciprofloxacin as a positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.5 to 3.0 mg/mL[34]. Grimsey *et al.*[30] evaluated the antibacterial activities of methanol extracts of *C. erythrophyllum* against *Staphylococcus aureus, Klebsiella pneumoniae* and *Escherichia coli* using the broth microdilution assay with ciprofloxacin, ampicillin, gentamicin, oxacillin and methicillin as positive controls. The extracts exhibited activities against the tested pathogens with MIC values ranging from 813.0 to 1625.0 µg/mL[30].

Antifungal activities: Cock and van Vuuren[22] assessed the antifungal properties of methanol and aqueous extracts of *C. erythrophyllum* leaves against *Candida albicans, Aspergillus niger* and *Rhizopus stolonifer* using the disc diffusion assay. The extracts demonstrated antifungal activities against the tested pathogens with MIC values ranging from 200.0 to 4000.0 µg/mL[22]. Seepe *et al.*[28] assessed the antifungal properties of the phytochemical compounds 21-hydroxy-3-oxo-olean-12-en-28-oic acid and 5-hydroxy-7,4′-dimethoxyflavone isolated from *C. erythrophyllum* leaves against *Fusarium oxysporum, Fusarium verticillioides, Fusarium proliferatum, Fusarium graminearum, Fusarium subglutinans, Fusarium chlamydosporum* and *Fusarium solani* using the microplate dilution with amphotericin B as a positive control. The phytochemical compounds demonstrated antifungal activities against the tested pathogens with MIC values that ranged from 0.01 to 1.25 mg/mL[28]. Mtunzi *et al.*[33] evaluated the antifungal activities of water, ethyl acetate, acetone, hexane and dichloromethane extracts of *C. erythrophyllum* leaves against *Candida albicans, Aspergillus fumigatus* and *Cryptococcus neoformans* using the microtitre dilution method with amphotericin B as a

positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.08 to 1.25 mg/mL[33]. Masoko *et al.*[35] evaluated the antifungal activities of hexane, acetone, methanol and dichloromethane extracts of *C. erythrophyllum* leaves against *Candida albicans, Aspergillus fumigatus, Cryptococcus neoformans, Sporothrix schenckii* and *Microsporum canis* using the microdilution assay with amphotericin B as a positive control. The extracts demonstrated antifungal activities against the tested pathogens with MIC values that ranged from 0.02 to 2.5 mg/mL[35]. Seepe *et al.*[36] assessed the antifungal activities of acetone, ethyl acetate and water extracts of *C. erythrophyllum* leaves against *Fusarium graminearum, Fusarium solani, Fusarium verticillioides* and *Fusarium proliferatum* using the micro-plate dilution assay with amphotericin B as a positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.04 to >2.5 mg/mL[36].

Anti-inflammatory activities: Eloff *et al.*[37] evaluated the anti-inflammatory activities of the acetone extract of *C. erythrophyllum* leaves using the radiochemical cyclooxygenase bioassay against the sheep seminal vesicles. The extract showed 72.0 to 92.0% inhibition of cyclooxygenase activity[37]. McGaw *et al.*[38] evaluated the anti-inflammatory activities of acetone and ethyl acetate extracts of *C. erythrophyllum* leaves in an *in vitro* assay for cyclooxygenase inhibitors with indomethacin as a positive control. The extract exhibited activities by showing inhibition ranging from 67.0 to 92.0%[38].

Antioxidant activities: Masoko and Eloff[39] evaluated the antioxidant activities of acetone and methanol extracts of *C. erythrophyllum* leaves using the 2,2-diphenyl-1-picryl hydrazyl (DPPH) free radical scavenging assay. The extract exhibited moderate antioxidant activities[39]. Mtunzi *et al.*[33] evaluated the antioxidant activities of water, ethyl acetate, acetone, hexane and dichloromethane extracts of *C. erythrophyllum* leaves using the 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), DPPH and hydroxyl radical scavenging assays with ascorbic acid as a positive control. The extracts exhibited antioxidant activities through ABTS, DPPH and hydroxyl with half maximum inhibitory concentrations (IC_{50}) values ranging from 0.02 to 0.4 mg/mL[33]. Bantho *et al.*[40] evaluated the antioxidant activities of chloroform, hexane and methanol extracts of *C. erythrophyllum* leaves and stem bark using the power (FRAP) assays. The extracts exhibited antioxidant activities with IC_{50} values ranging from <1.0 to >1000.0 µg/mL in both DPPH and FRAP[40].

Cytotoxicity activities: Bantho *et al.*[40] evaluated the cytotoxicity activities of chloroform, hexane and methanol extracts of *C. erythrophyllum* leaves and stem bark using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay against three cell lines, human embryonic kidney cells (HEK293), human breast adenocarcinoma cells (MCF-7) and human cervical carcinoma cells (HeLa). The extracts exhibited activities against the three cell lines with IC_{50} values ranging from 18.3 to >1083.1 µg/mL[40].

CONCLUSION

The present review provides a summary of the medicinal uses of *C. erythrophyllum* in Southern Africa as well as its phytochemical and pharmacological properties. To realize the full potential of *C. erythrophyllum* as a medicinal plant, there is a need for detailed evaluations of the phytochemical, pharmacological and toxicological properties of the species. Future studies should therefore focus on evaluating safety, mechanisms of action of the crude extracts of the species and their phytochemical compounds *in vivo* and clinical research.

SIGNIFICANCE STATEMENT

This review provides existing information on medicinal uses, phytochemical and pharmacological properties of *C. erythrophyllum* that could be useful in future research aimed at developing new health-promoting and pharmaceutical products. Results of this study also highlight the importance of *C. erythrophyllum* as the species continues to provide some local communities in Southern Africa with primary sources of medicines. The current research, therefore, is important in the identification of knowledge gaps required to correlate the ethnopharmacological properties of the species. Future research on *C. erythrophyllum* should focus on advanced phytochemical and pharmacological evaluation of the species, including its toxicological properties, *in vivo* and clinical studies.

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