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Review Article

COMBRETUM HERERoense SCHINZ (COMBRETACEAE): MEDICINAL USES, PHYTOCHEMISTRY, AND PHARMACOLOGICAL PROPERTIES

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ABSTRACT

Traditional knowledge about *Combretum hereroense* Schinz has been poorly documented, despite the ethnobotanical studies conducted in various parts of tropical Africa. *C. hereroense* is a small deciduous to semi-deciduous tree widely used in traditional medicine throughout its distributional range in tropical Africa. The present review compiles existing information on the medicinal, phytochemical, and pharmacological properties of *C. hereroense.* A search for available information on the medicinal uses, phytochemical, and pharmacological properties of *C. hereroense* 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. This study showed that the bark, fruit, leaf, root, stem, or shoot decoctions or infusions of *C. hereroense* are used as aphrodisiac, and traditional medicine against gastrointestinal problems, infertility in women, respiratory infections, sexually transmitted infections, bilharzia, general body pains, headache, heart diseases, heartburn, malaria, sores, and wounds. The phytochemical evaluation of the plant species revealed that it contains flavonoids, tannins, phenols, stilbenoids, phenanthrenes, and triterpenoids. The pharmacological evaluations showed that the crude extracts and phytochemical compounds isolated from the species have anthelmintic, antibacterial, antimycobacterial, antifungal, anti-inflammatory, and antioxidant activities. To realize the full potential of *C. hereroense* as a traditional medicine, future studies should focus on conducting detailed phytochemical, pharmacological, and toxicological evaluations, *in vivo* and clinical research.

Keywords: Bush willow, Combretaceae, *Combretum hereroense,* Traditional medicine, Tropical Africa.

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INTRODUCTION

Combretum hereroense Schinz (Fig. 1) is a member of the Combretaceae family commonly known as the white mangrove, Indian almond, or bush willow family. *C. hereroense* is a multipurpose species, and these taxa are often associated with use categories such as food, medicines, fuel, timber, ornamental, recreational, and symbolic applications [1-5]. Unlike other *Combretum* species, *C. hereroense* serves as a source of security for communities in rural and peri-urban areas in providing firewood, traditional medicines, windbreaks, shade, and construction materials. Therefore, *C. hereroense* provides numerous ecosystem services and goods that are essential and support human well-being and survival [6-12]. Ecosystem services are the direct and indirect contributions of ecosystems to human well-being through supporting, provisioning, regulating, and cultural services [13-19]. *C. hereroense*is is widely used in traditional medicine throughout its distributional range in tropical Africa [20,21]. *C. hereroense* is an important fodder species in tropical Africa, with its leaves, flowers, fruits, shoots, and young twigs being palatable and browsed by livestock and game, particularly during the dry periods [22-26]. *C. hereroense* 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 tropical Africa, tolerating frost and moderate drought [22,26]. The wood of *C. hereroense* is brown in color, hard, heavy, strong, compact, easily worked, termite- and borer-proof, and makes a useful general-purpose timber as construction material for houses, livestock enclosures, fencing posts, handles of agricultural implements, furniture, and ornaments [22,26,27]. The wood of *C. hereroense* 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 [22,26,28,29]. The fruits and leaves of *C. hereroense* are used as a tea substitute in Botswana and Zimbabwe [22,23,25,26,30,31], but the seeds of the species are also reputed to be poisonous [25]. Therefore, this article reviews the importance of *C. hereroense* in traditional medicine with a holistic approach that includes its botany, phytochemical, and pharmacological properties.

MATERIALS AND METHODS

A search for available information on medicinal uses, phytochemical, and pharmacological properties of *C. hereroense* 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 hereroense,*" "biological activities of *Combretum hereroense,*" "pharmacological properties of *Combretum hereroense,*" "ethnobotany of *Combretum hereroense,*" "medicinal uses of *Combretum hereroense,*" "phytochemistry of *Combretum hereroense,*" and "traditional uses of *Combretum hereroense.*" The search covered publications from 1962 to 2024, a long period to capture literature on the medicinal, phytochemical, and pharmacological properties of *C. hereroense*.

RESULTS AND DISCUSSION

Botanical description of *C. hereroense*

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), who used it in reference to an unknown plant [22,26]. The name was also reused by the Swedish botanist Pehr Löfling (31 January 1729–22 February 1756) for the *Combretum* genus [22,26]. The species name "*hereroense*" means "from Hereroland" or "inhabited by the Herero people" [32], and this name is in honor of the Herero people of Namibia [22]. 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 [22]. Other common names of the species include "mouse-eared bush willow," "mouse-eared combretum," and "russet bush willow" [22,24-26]. The synonyms of *C. hereroense* Schinz include *C. borumense* Engl. and Diels, *C. bruchhausenianum* Engl. and Diels, *C. cufodontii* Chiov., *C. eilkerianum* Schinz, *C. erlangerianum* Engl. and Diels, *C. greenwayi* Exell, *C. grotei* Exell, *C. hereroense* Schinz var. *villosissimum* Engl. and Diels, *C. parvifolium* Engl., *C. porphyrolepis* Engl. and Diels, *C. rautanenii* Engl. and Diels, *C. rhodesiacum* Baker f., *C. sambesiacum* Engl. and Diels, *C. transvaalesnse* Schinz, *C. transvaalesnse* Schinz var. *ochrolepidotum* Dümmer, *C. transvaalesnse* Schinz var. *villosissimum* (Engl. and Diels) Burtt Davy, *C. usaramense* Engl., *C. villosissimum* (Engl. and Diels) Engl. and *C. volkensii* Engl. [22,24,33-41]. Four infraspecific taxa of *C. hereroense* (Table 1) are recognized, and these are *C. hereroense* Schinz subsp. *grotei* (Exell) Wickens, *C. hereroense* Schinz subsp. *hereroense*, *C. hereroense* Schinz var. *parvifolium* (Engl.) Wickens and *C. hereroense* Schinz subsp. *volkensii* (Engl.) Wickens [33-44]. Ethnopharmacological and ethnobotany research rarely makes any reference to these infraspecific taxa; therefore, *C. hereroense sensu lato* is adopted throughout the manuscript.

C. hereroense is a small semi-deciduous to deciduous tree growing up to 11 m in height [22,24,26]. The species is usually single or many-stemmed (Fig. 1a), the trunk often crooked, up to about 23 cm in diameter, with a light or dark brown, thick, rough, fissured bark, which is dark grey in color. The bark on young branches and branchlets is stringy, hairy, and peeling in strips, but rough and longitudinally fissured on older branches and stems [22,26]. The leaves are opposite to sub-opposite, simple, coarse-textured, on short lateral twigs, narrowly to broadly elliptic or broadly obovate, widest about or above the middle, varying from glabrous to grey, long-hairy above and, below, from densely golden brown scaly to green with only a few scales on the veins. The leaves often turn red–brown late in the rainy season, apex and base are broadly tapering to rounded, with tertiary veins that are notably raised below. The flowers are greenish-yellow (Fig. 1b), sweet-scented, borne in dense axillary spikes, and appear before the new leaves. The fruits are winged (Fig. 1c), brown in color, borne in such abundance that they weigh down the branches, and strikingly rich, deep brown between the wings. *C. hereroense* has been recorded in Angola, Botswana, Eswatini, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Somalia, South Africa, South Sudan, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe [22,33-49] (Fig. 2). *C. hereroense* has been recorded in low to medium altitudes in woodland, bushveld, grassland, wooded grassland, in stony, shallow or brack soil, in sandy or red loam, on hillsides or valleys, sometimes on stream banks, termite mounds and on Vlei margins, often several together at an altitude ranging from 30 m to 1465 m above sea level [22,24,37,40].

Fig. 1: *Combretum hereroense*: (a) Entire plant, (b) branch showing flowers, and (c) branch showing leaves and fruits (photos: BT Wursten)

Ethnomedicinal applications of *C. hereroense*

C. hereroense is used as a source of traditional medicines in South Africa, Eswatini, Angola, Botswana, Kenya, Tanzania, Somalia, Namibia, and Zimbabwe, that is, 56.3% of the countries where the species is indigenous (Table 2). In South Africa, the roots of *C. hereroense* are sold in informal herbal medicine markets as sources of traditional medicines [50]. *C. hereroense* 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. hereroense* is included in two South African encyclopedias, namely, "medicinal and magical plants of southern Africa: An annotated checklist" [51] and "medicinal plants of South Africa" [52]. These two monographs 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 [51,52].

The traditional medicines prepared from the bark, fruit, leaf, root, stem, or shoot decoctions or infusions of *C. hereroense* are used to treat and manage 34 human and animal diseases and ailments (Table 1). The main ailments and diseases treated by *C. hereroense* extracts (Fig. 3) include the use of roots as aphrodisiac, and use of the bark, fruit, leaf, root, stem, or shoot decoctions or infusions as traditional medicine against gastro-intestinal problems, infertility in women, respiratory infections, sexually transmitted infections, bilharzia, general body pains, headache, heart diseases, heartburn, malaria, sores and wounds. In Kenya, the roots of *C. hereroense* are mixed with those of *Uvaria leptacladon* Oliv. (Annonaceae family) as a remedy for erectile dysfunction [53,54], menstrual problems [53], postpartum [53], and retained placenta [53]. Similarly, the roots of *C. hereroense* are mixed with those of *Balanites aegyptiaca* (L.) Delile (Zygophyllaceae family) is a traditional medicine for infertility in women [55].

Phytochemistry and pharmacological properties of *C. hereroense*

Qualitative and quantitative phytochemical analyses of *C. hereroense* fruits and leaves revealed the presence of flavonoids, tannins,

Table 1: Main morphological characters of *Combretum hereroense* subspecies

Subspecies	Key morphological features	Distribution	References
grotei	Leaves <2.0 cm long, fruits 1.5–2.0 cm long and scales on leaf contiguous	Kenya, South Sudan, Sudan, Tanzania and Uganda	[33,34,42,43]
hereroense	Leaves >2.0 cm long, fruits >2.0 cm long, and scales on the leaf contiguous	Angola, Botswana, Namibia, Kenya, South Africa, Malawi, Mozambique, Eswatini, Tanzania, Zambia, Zimbabwe	[33,34,40,44]
parvifolium	Leaves pubescent, fruits 2.5 cm long, and scales on the leaf not impressed	Ethiopia, Kenya, and Tanzania	[33,34,36]
volkensii	Leaves glabrous, up to 8.0 cm long, fruits 1.5–2.5 cm long, scales on leaf impressed and not contiguous	Kenya, Somalia, Tanzania, and Uganda	[33,34,42]

Fig. 2: Distribution of *Combretum hereroense* in tropical Africa

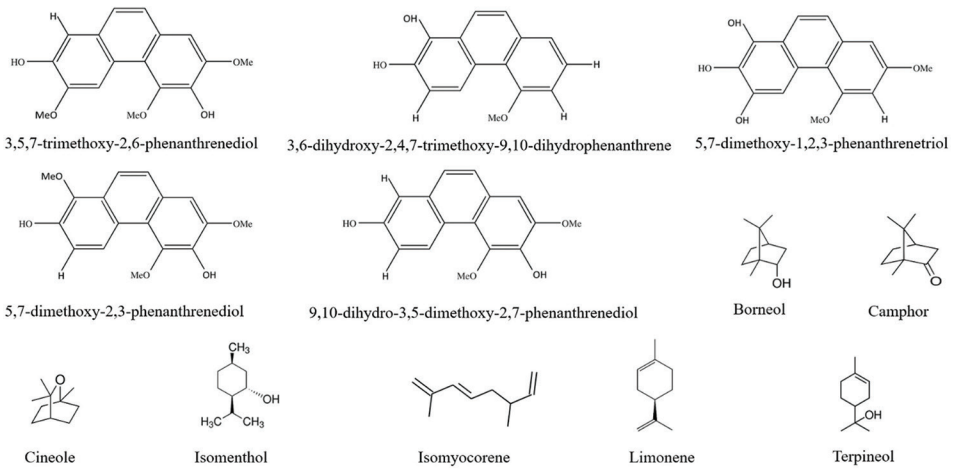

Fig. 3: Chemical structures of phytochemical compounds isolated from *Combretum hereroense*

phenols, stilbenoids, phenanthrenes, and triterpenoids [88-90] (Table 3 and Fig. 3). Some of the phytochemical compounds isolated from *C. hereroense* and its crude extracts exhibited anthelmintic, antibacterial, antimycobacterial, antifungal, anti-inflammatory, and antioxidant activities.

Anthelmintic activities

McGaw *et al.* [91] evaluated the anthelmintic activities of acetone extracts of *C. hereroense* leaves against the free-living nematode *Caenorhabditis elegans* var. *Bristol* (N2) with the standard nematocidal drug levamisole as a positive control. The extract exhibited activities against the nematode [91].

Anti-bacterial activities

Cock and Van Vuuren [68] evaluated the antibacterial activities of aqueous and methanol extracts of *C. hereroense* leaves against *Alicaligenes faecalis, Aeromonas hydrophilia, Bacillus cereus, Bacillus subtilis, Citrobacter freundi, Escherichia coli, Klebsiella pneumonia,*

Table 2: Medicinal uses of *Combretum hereroense*

Medicinal use	Part used	Country	References
Mono-therapeutic applications			
Aphrodisiac	Root decoction taken orally	Botswana and Zimbabwe	[30,56]
Bilharzia	Leaf, root, or shoot decoction taken orally	Tanzania	[21,57-64]
Gastrointestinal problems (diarrhea, dysentery, and stomach problems)	Leaf, root, shoot, or young stem decoction or infusion taken orally	Eswatini, Namibia, South Africa, Tanzania, and Zimbabwe	[21,22,26,31,32,52, 56,57,61,62-70]
General body pains	Leaf or root decoction or infusion taken orally	Angola, Botswana, and South Africa	[32,59,66,71]
Headache	Fruit, leaf, root, or shoot decoction taken orally	Botswana, South Africa, Tanzania, and Zimbabwe	[21,57,58,60,61,63,64,66,72]
Heart diseases	Bark decoction taken orally	South Africa	[21,31,32,66,73,74]
Heartburn	Bark decoction taken orally	South Africa	[21,31,32,66,73,74]
Infertility in women	Bark or root powder taken orally	Botswana, South Africa, and Zimbabwe	[52,56,58,60,63,64,66,68,70,72]
Leprosy	Not specified	Not specified	[64]
Malaria	Not specified	South Africa	[64,69]
Penal swellings	Root decoctions applied topically	Botswana	[59]
Respiratory infections (bronchial problems, chest pains, cold, cough, loss of voice, sore throat, tonsillitis, and tuberculosis)	Bark, fruit, leaf, root, shoot, or stem decoction or infusion taken orally	Botswana, Kenya, Namibia, Somalia, South Africa, Tanzania, Zambia, and Zimbabwe	[21,30,31,52, 57,61,63,66-68,70,75-85]
Sexually transmitted infections (chlamydia, gonorrhea, and venereal disease)	Leaf, root, or young stem decoction or infusion taken orally	Botswana, Namibia, South Africa, Zambia, and Zimbabwe	[21,32,52,59,64,67,68,70, 75,85,86]
Skin softening cream	Root decoction taken orally	Botswana	[30]
Sores and wounds	Not specified	South Africa	[52,64,68,70]
Tonic	Not specified	South Africa	[69]
Ulcers	Not specified	Not specified	[64]
Vulval swellings	Root decoctions applied topically	Botswana	[59]
Ethnoveterinary medicine (constipation, cough, dysentery, and pain)	Leaves	South Africa	[87]
Used in combination with other species			
Erectile dysfunction	Roots mixed with those of *Uvaria leptacladon* Oliv. (Annonaceae family)	Kenya	[53,54]
Infertility in women	Roots mixed with those of *Balanites aegyptiaca* (L.) Delile (Zygophyllaceae family)	Kenya	[55]
Menstrual problems, postpartum, and retained placenta	Roots mixed with those of *U. leptacladon* Oliv. (Annonaceae family)	Kenya	[53]

Table 3: Phytochemical composition of *Combretum hereroense*

Phytochemical compound	Formula	Part	References
3,5,7-trimethoxy-2,6-phenanthrenediol	$C_{17}H_{16}O_5$	Fruits	[89]
3,6-dihydroxy-2,4,7-trimethoxy-9,10-dihydrophenanthrene	$C_{17}H_{18}O_4$	Leaves	[88]
5,7-dimethoxy-1,2,3-phenanthrenetriol	$C_{16}H_{14}O_5$	Fruits	[89]
5,7-dimethoxy-2,3-phenanthrenediol	$C_{16}H_{14}O_4$	Fruits	[89]
9,10-dihydro-3,5-dimethoxy-2,7-phenanthrenediol	$C_{16}H_{16}O_4$	Fruits	[89]
Borneol	$C_{10}H_{18}O$	Leaves	[90]
Camphor	$C_{10}H_{16}O$	Leaves	[90]
Cineole	$C_{10}H_{18}O$	Leaves	[90]
Isomenthol	$C_{10}H_{20}O$	Leaves	[90]
Isomyocorene	$C_{10}H_{16}$	Leaves	[90]
Limonene	$C_{10}H_{16}$	Leaves	[90]
Terpineol	$C_{10}H_{18}O$	Leaves	[90]

Proteus mirabilis, Proteus vulgaris, Pseudomonas aeruginosa, Pseudomonas fluorescens, Salmomnella typhimurin, Serratia marcescens, Shigella sonnei, Stapyylococcus aureus, and *Staphylococcus epidermidis* using the disc diffusion assay. The extracts exhibited activities against the tested pathogens with minimum inhibition concentration (MIC) values ranging from 337.0 µg/ml to 1440.0 µg/ml [68]. Katerere *et al.* [89] evaluated the antibacterial activities of the phytochemical compounds 5,7-dimethoxy-1,2,3-phenanthrenetriol, 5,7-dimethoxy-2,3-phenanthrenediol, 9,10-dihydro-3,5-dimethoxy-2,7-phenanthrenediol, and 3,5,7-trimethoxy-2,6-phenanthrenediol isolated from *C. hereroense* fruits against *Mycobacterium fortuitum, Proteus vulgaris,* and *Staphylococcus aureus* using the microtiter dilution assay with streptomycin as a positive control. The phytochemical compounds exhibited activities against the tested pathogens with MIC values ranging from 25.0 µg/ml to 100.0 µg/ml [89]. Grimsey *et al.* [90] evaluated the antibacterial activities of methanol extracts of *C. hereroense* against *Staphylococcus aureus, Klebsiella pneumoniae,* and *Escherichia coli* using the broth

microdilution assay with ciprofloxacin, ampicillin, gentamycin, oxacillin, and methicillin as positive controls. The extracts exhibited activities against the tested pathogens with MIC values ranging from 813.0 µg/mL to 1625.0 µg/mL [90]. Eloff [92] evaluated the antibacterial activities of acetone extracts of *C. hereroense* leaves against *Escherichia coli, Staphylococcus aureus, Enterococcus faecalis,* and *Pseudomonas aeruginosa* using the twofold serial dilution with gentamycin as a positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.2 mg/mL to 6.0 mg/mL [92]. Fyhrquist *et al.* [93] evaluated the antibacterial activities of methanol extracts of *C. hereroense* leaves against *Sarcina* spp. and *Staphylococcus epidermidis* using the agar diffusion method with ampicillin and streptomycin as positive controls. The extract exhibited activities against *Sarcina* spp. and *Staphylococcus epidermidis* with MIC values of 23.3 mg/ml and 30.0 mg/ml, respectively [93]. Anokwuru *et al.* [94] evaluated the antibacterial activities of methanol extracts of *C. hereroense* leaves against *Staphylococcus aureus, Staphylococcus epidermidis, Bacillus cereus, 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 0.37 mg/mL to >3.0 mg/mL [94].

Antimycobacterial activities

Masoko and Nxumalo [95] evaluated the antimycobacterial activities of dichloromethane, hexane, acetone, and methanol extracts of *C. heroroense* leaves against Mycobacterium smegmatis using the microdilution assay with rifampicin as a positive control. The extracts exhibited activities against the tested pathogen with MIC values ranging from 0.5 mg/ml to 1.9 mg/ml [95]. Komape *et al.*[96] evaluated the antimycobacterial activities of dichloromethane, hexane, acetone and methanol extracts of *C. heroroense* leaves against *Mycobacterium smegmatis* using the serial microplate dilution method with rifampicin as a positive control. The extracts exhibited activities against the tested pathogen with MIC values ranging from 0.6 mg/ml to 1.6 mg/ml [96].

Antifungal activities

Cock and Van Vuuren [68] evaluated the antifungal activities of aqueous and methanol extracts of *C. hereroense* leaves against *Aspergillus niger, Candida albicans,* and *Rhizopus stolonifer* using the disc diffusion assay. The extracts exhibited activities against the tested pathogens with MIC values ranging from 287.0 µg/ml to 5567.0 µg/ml [68]. Katerere *et al.* [89] evaluated the antifungal activities of the phytochemical compounds 5,7-dimethoxy-1,2,3-phenanthrenetriol, 5,7-dimethoxy-2,3-phenanthrenediol, 9,10-dihydro-3,5-dimethoxy-2,7-phenanthrenediol, and 3,5,7-trimethoxy-2,6-phenanthrenediol isolated from *C. hereroense* fruits against *Candida albicans* using the microtiter dilution assay with fluconazole as a positive control. The phytochemical compounds exhibited activities against the tested pathogen with an MIC value of 50.0 µg/ml [89]. Masoko *et al.*[97] evaluated the antifungal activities of hexane, acetone, methanol, and dichloromethane extracts of *C. hereroense*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 exhibited activities against the tested pathogens with MIC values ranging from 0.02 mg/ml to 2.5 mg/ml [97].

91 Anti-inflammatory activities

McGaw *et al.* [91] evaluated the anti-inflammatory activities of water, acetone, and ethyl acetate extracts of *C. hereroense* leaves in an *in vitro* assay for cyclooxygenase inhibitors with indomethacin as a positive control. The extracts exhibited activities by showing cyclooxygenase inhibition ranging from 70.0% to 81.0% [91]. Eloff *et al.* [98] evaluated the anti-inflammatory activities of the acetone extract of *C. hereroense* leaves using the radiochemical cyclooxygenase bioassay against sheep seminal vesicles. The extract showed from 76.0% to 84.0% inhibition of cyclooxygenase [98].

Antioxidant activities

Masoko and Eloff [99] evaluated the antioxidant activities of acetone and methanol extracts of *C. hereroense* leaves using the 2,2-diphenyl-1-picryl hydrazyl-free radical scavenging assay. The extract exhibited moderate antioxidant activities [99].

CONCLUSION

The current review provides a summary of the medicinal uses, phytochemical, and pharmacological properties of *C. hereroense*. However, there is a need for detailed studies focusing on phytochemical and pharmacological properties, toxicity and safety, mechanisms of action *in vivo*, and clinical research of the species aimed at corroborating the ethnomedicinal applications of *C. hereroense*. There is also a need for ethnopharmacological studies aimed at examining the combinational effects of *C. hereroense* extracts with other plant species such as *B. aegyptiaca* and *U. leptacladon*.

AUTHOR CONTRIBUTION

AM conceptualized the research and wrote the manuscript.

CONFLICT OF INTEREST

No conflict of interest is associated with this research.

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