



## ***Dombeya rotundifolia* (Hochst.) Planch.: review of its botany, medicinal uses, phytochemistry, and biological activities**

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### ABSTRACT

*Dombeya rotundifolia* is an important medicinal plant throughout its distributional range in tropical Africa. The aim of the current study was to review the botany, medicinal uses, phytochemistry, and biological activities of *D. rotundifolia*. Information on the medicinal uses, phytochemistry, and biological activities of *D. rotundifolia* were undertaken using electronic databases such as Medline, PubMed, SciFinder, SCOPUS, Google Scholar, Science Direct, EThOS, ProQuest, OATD, and Open-thesis. Pre-electronic literature was sourced from the University library. Literature search revealed that *D. rotundifolia* is used as a traditional medicine in 64.3% of the countries where the species is indigenous in tropical Africa. It is mainly used to induce labor and as an herbal medicine for constipation, fever, malaria, infertility, abdominal pains, dyspepsia, chest complaints, pneumonia, nausea, headache, heart problems, palpitations, diarrhea, dysentery, stomach problems, and intestinal ulcers. Pharmacological studies of *D. rotundifolia* extracts revealed that the species have anthelmintic, anti-hypertensive, acetylcholinesterase inhibitory, anti-inflammatory, antimicrobial, and antioxidant properties. Considering its importance as herbal medicine in tropical Africa, there is a need to subject *D. rotundifolia* to detail phytochemical and pharmacological evaluations aimed at elucidating its chemical, pharmacological, and toxicological properties.

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### Introduction

*Dombeya rotundifolia* (Hochst.) Planch. (Fig. 1) is traditionally included in the family Sterculiaceae but now included in the expanded Malvaceae family after phylogenetic studies by the Angiosperm Phylogeny Group [1] and subsequent systematic treatments. The family Malvaceae has economically important species, such as cotton (*Gossypium* spp.), kola nut [*Cola nitida* (Vent.) Schott & Endl.], cocoa (*Theobroma cacao* L.), and ornamental species in various genera such as *Dombeya* Cav., *Hibiscus* L., *Malva* L., and *Tilia* L. [2]. The genus *Dombeya* is a non-monophyletic in its current delimitation with genera such as *Astiria* Lindley, *Helmiopsis* Perr., *Helmiopsiella* Arènes, *Ruizia* Cav., and *Trochetia* Candolle nested in *Dombeya* [2–5]. The genus *Dombeya* has about 230 species in Madagascar, the Mascarenes and Comoros, and Africa

extending into the Arabian Peninsula [6,7]. About 200 of these species have been recorded in Madagascar, representing almost 2% of Malagasy plant diversity [3] and more than 2% of the diversity of species endemic to the Mascarene archipelago [2]. About 12.1% of *Dombeya* species are categorized as threatened on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species [8], primarily because of reduction in population size based on the decline in area of occupancy, the extent of occurrence, and/or quality of habitat, and actual or potential levels of exploitation [2]. Some *Dombeya* species are used as herbal medicines in tropical Africa. For example, the leaf decoction of *Dombeya burgessiae* Gerrard ex Harv. is used as an herbal medicine for malaria and leprosy, while the root decoction is used for stomach problems and diabetes mellitus

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**Figure 1.** *Dombeya rotundifolia*: a branch showing leaves and flowers (photo: BT Wursten).

[9,10]. The flowers and bark of *Dombeya torrida* (J. F. Gmel.) Bamps are used as an herbal medicine for indigestion, while the roots are used for the treatment of chest pains and colds in East Africa [11]. In Tanzania, the root decoction of *D. kirkii* Mast. is used in the treatment of yaws and abdominal pains [12]. Pharmacological evaluations of *D. burgessiae* extracts revealed that the species possesses antioxidant and antidiabetic properties [10], while *D. torrida* extracts exhibited antibacterial and antifungal activities [11], and *D. acutangula* Cav. var. *acutangula*, *D. ficulnea* Baill., *D. pilosa* Cordem., *D. populnea* (Cav.) Baill., and *D. reclinata* Cordem. exhibited free radical scavenging and antioxidant activities [13]. The ethanol and dichloromethane extracts of *D. burgessiae* and *D. cymosa* Harv. showed cyclooxygenase-1 (COX-1) inhibition and antibacterial activities [14]. *Dombeya rotundifolia* is receiving increasing research attention as an herbal medicine in tropical Africa [15–21]. Due to its high demand as traditional medicine, the bark of *D. rotundifolia* is sold as an herbal medicine in informal herbal medicine markets in Gauteng province in South Africa [22,23]. The aim of this study was to review the medicinal uses, phytochemical and pharmacological properties of *D. rotundifolia*.

### Botanical Profile and Description of *Dombeya rotundifolia*

The genus *Dombeya* was named in honor of Joseph Dombey (1742–1793), a French botanist, medical doctor, and explorer who collected the plant specimens

in Chile and Peru [24]. The specific name “*rotundifolia*” means “round-leaved” in reference to large and almost circular or rounded leaves of the species [24]. Synonyms of *D. rotundifolia* are *D. cerasiflora* Exell, *D. cuanzensis* (Hiern) Welw. ex K. Schum., *D. damarana* K. Schum., *D. densiflora* Planch. ex Harv., *D. dinteri* Schinz, *D. multiflora* Planch var. *vestita* K. Schum., *D. reticulata* K. Schum., and *Xeropetalum rotundifolium* Hochst. [24–30]. *Dombeya rotundifolia* is divided into two varieties, *D. rotundifolia* var. *rotundifolia* which occurs over most of the distribution range of the species and *D. rotundifolia* var. *velutina* I. Verd. which has been recorded only from the Naukluft mountains near Rehoboth in Namibia [24,26,28]. The name “*velutina*” means velvety in reference to velvety texture of the leaves of the variety [24]. The two species differ mainly in the habit and geographical distribution. The var. *velutina* is a tall, slender, several-stemmed, and wand-shaped stems with velvety textured leaves [24,26,28]. *Dombeya rotundifolia* var. *rotundifolia* is the most widespread taxon and most published ethnobotanical literature focused on this taxon. The taxon has been recorded in Angola, Botswana, the Democratic Republic of Congo (DRC), Ethiopia, Kenya, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe [24–30].

*Dombeya rotundifolia* var. *rotundifolia* is a deciduous shrub or a small tree, usually with a single stem growing up to 15 m tall [24,26,28,31]. The bark is dark gray-brown, rough with deep and longitudinal furrows. The crown is light and usually rounded, young branches reddish and hairy, older ones dark brown to purplish. Leaves are alternate in arrangement, simple, large, leathery, broadly ovate to almost circular or rounded in shape with a dark green and rough upper surface and a paler, hairy lower surface with prominent net veins arising from the base [28]. The flowers are bisexual, white, or pale pink in color which are in axillary clusters [24,26,28,31]. *Dombeya rotundifolia* is sun-loving, hardy, and resistant to drought, frost, and fire. It has been recorded at an altitude ranging from 60 to 2,250 m above sea level in grassland, bushveld, woodland and forest, often on termite mounds in areas often with moderate to low rainfall [24,29].

### Medicinal Uses

The bark, fibers, flowers, leaves, roots, stems, and wood of *D. rotundifolia* are reported to possess diverse medicinal properties and cure various human and animal diseases throughout the distributional range of the species (Table 1). Medicinal

uses of the species have been recorded in Botswana, Kenya, Malawi, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe, representing 64.3% of the countries where the species are indigenous. Major diseases and ailments

recorded in at least two countries and literature sources include constipation, fever and malaria, infertility, abdominal pains, dyspepsia, chest complaints and pneumonia, induce labor, nausea, headache, heart problems and palpitations,

**Table 1.** Medicinal uses of *Dombeya rotundifolia*.

Medicinal use	Parts of the plant used	Country	References
Abdominal pains	Root decoction taken orally	South Africa and Tanzania	[15,37,38]
Abortifacient	Bark decoction taken orally	South Africa	[15,18,21]
Abscesses	Leaf powder applied topically	Zambia	[15]
Broken limbs	Fibers applied topically	South Africa	[33]
Chest complaints and pneumonia	Bark and leaf decoction taken orally	Kenya and South Africa	[19,21,33,39]
Cleanse blood	Root decoction taken orally	Tanzania	[38]
Constipation	Root decoction taken orally	Tanzania and Zambia	[40,41]
Colic	Root infusion taken orally	South Africa	[15,18,19,28,42]
Diarrhea, dysentery, and stomach problems	Bark, root and wood decoction taken orally	Kenya and South Africa	[15,17–19,21,28,33,42–46]
Diuretic	Root decoction taken orally	Tanzania	[38]
Dyspepsia	Root maceration taken orally	South Africa and Tanzania	[18,38,43]
Fainting	Bark infusion taken orally	Swaziland	[47]
Fatigue	Root decoction taken orally	South Africa	[48]
Fever and malaria	Root and stem decoction taken orally	Kenya and South Africa	[42,49]
Headache	Bark, leaf and wood decoction taken orally	South Africa and Swaziland	[15,18,28,21]
Headache	Powdered bark of <i>Euclea undulata</i> Thunb. applied to a strip of <i>D. rotundifolia</i> leaf and the head bandaged	South Africa	[15,18,24,32]
Hemorrhoids	Bark and wood maceration applied rectally	South Africa	[15,18,19,21,28,33]
Heart problems and palpitations	Bark and root decoction taken orally	Botswana and South Africa	[19,21,33,43,50–52]
Hemorrhage	Bark decoction taken orally	South Africa	[15]
Hypertension	Bark decoction taken orally	South Africa	[53]
Induce labor	Bark and root decoction taken orally	South Africa and Tanzania	[15,21,28,41,43]
Infertility	Root decoction taken orally	South Africa and Zimbabwe	[42,54]
Intestinal ulcers	Bark, root and wood decoction taken orally	South Africa, Swaziland and Tanzania	[15,18,19,21,28,33,38,47]
Madness	Fiber maceration taken orally	Malawi	[16]
Menstrual problems	Bark decoction taken orally	South Africa	[33]
Nausea	Bark, leaf and stem decoction taken orally	Namibia and South Africa	[19,21,33,43,52,55]
Purgative	Root maceration taken orally	Swaziland	[47]
Rheumatism	Bark and root decoction taken orally	Kenya	[17]
Schistosomiasis	Root decoction taken orally	Tanzania	[56]
Syphilis	Root infusion taken orally	Zimbabwe	[16]
Tonic	Root decoction taken orally	South Africa	[15]
Vomiting	Bark maceration taken orally	Swaziland	[47]
Wounds	Fibers applied topically	South Africa	[33]
Ethnoveterinary medicine			
Broken limbs in livestock	Fibers applied topically	South Africa	[33]
Diarrhea in cattle	Leaf decoction taken orally	South Africa	[34]
Infectious diseases in cattle	Leaf and flower maceration taken orally	South Africa	[36]
Newcastle disease in chickens	Leaf and flower decoction taken orally	South Africa	[35]

diarrhea, dysentery and stomach problems, and intestinal ulcers (Fig. 2). In South Africa, headache is treated by applying powdered bark of *Euclea undulata* Thunb. to a strip of *D. rotundifolia* leaf and the head bandaged for a couple of hours [15,18,32]. In South Africa, the fibers, leaves, and flowers of *D. rotundifolia* are used as an ethnoveterinary medicine for broken limbs in livestock, diarrhea in cattle, infectious diseases in cattle, and newcastle disease in chickens [33–36].

### Phytochemical and Biological Activities of *Dombeya rotundifolia*

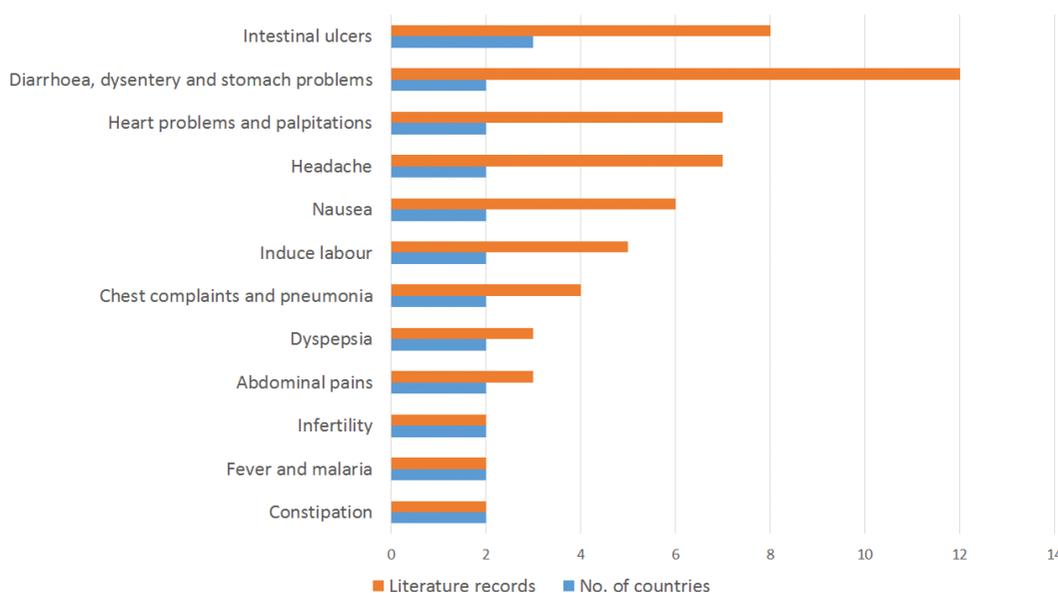
Multiple classes of phytochemical compounds, including cardiac glycosides, fatty acids, flavonoids, iridoids, phenolics, saponins, steroids, tannins, and terpenoids have been isolated from the leaf extracts of *D. rotundifolia* [14,57–60] (Table 2, Fig. 3). Ndwigah et al. [57] identified lupeol **1** and  $\beta$ -sitos-terol **2** from *D. rotundifolia* stem bark extract using infrared, nuclear magnetic resonance, and mass spectrometry, while Reid et al. [14] isolated lauric acid **3**, myristic acid **4**, palmitic acid **5**, and stearic

acid **6** (Fig. 2) from the ethanolic leaf extracts of *D. rotundifolia* using vacuum liquid chromatography and preparative thin-layer chromatography. Kudumela and Masoko [59] identified cardiac glycosides, flavonoids, saponins, steroids, tannins, and terpenoids (Table 2) from the aqueous acetone leaf extracts of *D. rotundifolia*.

A wide range of pharmacological activities, including anthelmintic [61], anti-hypertensive [62], acetylcholinesterase inhibitory [58], anti-inflammatory [43,63], antimicrobial [43,59,61,63–66], and antioxidant [58,59] activities.

### Anthelmintic Activities

McGaw et al. [61] evaluated the anthelmintic activities of aqueous, hexane, and methanol aerial parts extracts of *D. rotundifolia* against the free-living nematode *Caenorhabditis elegans*. The methanol extracts exhibited weak activities by killing 20% of nematodes at a concentration of 1.0 and 2.0 mg/ml [61]. This pharmacological assessment is of importance in the traditional use of *D. rotundifolia* roots as an herbal medicine against urinary schistosomiasis in Tanzania



**Figure 2.** Diseases treated by *Dombeya rotundifolia* extracts.

**Table 2.** Phytochemical composition of *Dombeya rotundifolia*.

Phytochemical composition	Values	Plant parts	References
Condensed tannin (%)	6.2	Leaves	[60]
Crude protein (%)	14.7	Leaves	[60]
Flavonoid [mg of quercetin equivalent (QE)/g]	19.90–35.4	Leaves	[58,59]
Iridoids ( $\mu$ g harpagoside equivalent/g of dry weight)	7076.6–9499.6	Leaves	[58]
Neutral detergent fiber (%)	45.3	Leaves	[60]
Total phenolics [mg of gallic acid equivalent (GAE)/g]	45.3–259.0	Leaves	[58,59]
Tannin [mg of gallic acid equivalent (GAE)/g]	330.33 $\pm$ 15.63	Leaves	[59]

[56] and future research focusing on control and management of schistosomiasis in the tropics [67].

### Anti-hypertensive Activities

Duncan et al. [62] evaluated the anti-hypertensive activities of aqueous and ethanolic leaf extracts of *D. rotundifolia* by using the angiotensin-converting enzyme (ACE) assay. The extracts exhibited 83% ACE inhibitory activity [62]. These findings corroborate the traditional use of *D. rotundifolia* extracts as an herbal medicine against hypertension in South Africa [53]

### Acetylcholinesterase Inhibitory Activities

Amoo et al. [58] evaluated acetylcholinesterase inhibitory properties of *D. rotundifolia* using colorimetric assay with galanthamine at 20  $\mu\text{M}$  as a positive control. Acetylcholinesterase inhibition (%) at 1.0 mg/ml was 84.1%–87.6% [58]. These results suggest that *D. rotundifolia* extracts deserve further investigation as they may provide secondary metabolites which can act as natural acetylcholinesterase inhibitors required for the treatment of neurodegenerative disorders.

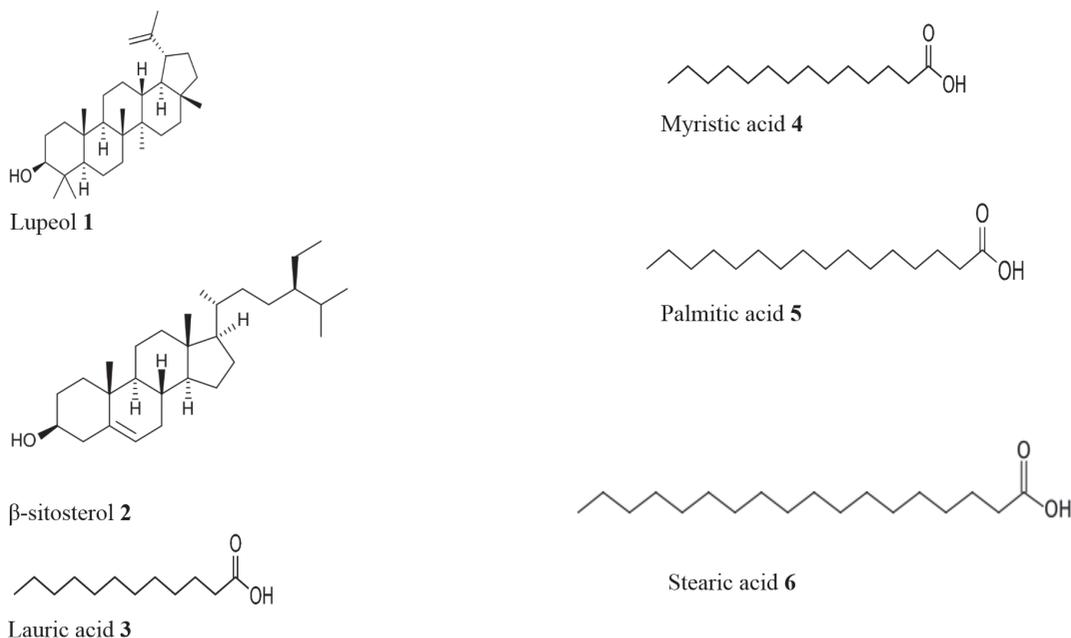
### Anti-inflammatory Activities

Reid et al. [43] evaluated the anti-inflammatory activity of aqueous, dichloromethane and ethanol bark, and leaf and shoot extracts of *D. rotundifolia* using the prostaglandin-synthesis inhibitor

cyclooxygenase-1 (COX-1) assay. The leaf and shoot extracts exhibited high anti-inflammatory activities ranging from 55% to 97% [43]. Kudumela et al. [63] evaluated the anti-inflammatory activities of acetone leaf extracts of *D. rotundifolia* extracts using the dichloro-dihydrofluorescein diacetate  $\text{H}_2\text{DCF-DA}$  assay by assessing its ability to inhibit the production of reactive oxygen species (ROS) in lipopolysaccharide-induced RAW 264.7 macrophage cells with curcumin (50  $\mu\text{M}$ ) was used as a positive control. The extracts demonstrated anti-inflammatory potential by inhibiting the production of ROS in a dose-dependent manner with better anti-inflammatory potential than curcumin at the highest concentration tested [63]. Results of these pharmacological evaluations support the traditional use of *D. rotundifolia* against various inflammatory ailments and diseases, such as abdominal pains in South Africa and Tanzania [15,37,38], abscesses in Zambia [15], hemorrhoids in South Africa [15,18,19,21,28,33], intestinal ulcers in South Africa, Swaziland, and Tanzania [15,18,19,21,28,33,38,47], and wounds in South Africa [33].

### Antimicrobial Activities

McGaw et al. [64] evaluated the antibacterial activities of aqueous, ethanol, and hexane leaf extracts of *D. rotundifolia* against *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* using the disc-diffusion assay with neomycin (5  $\mu\text{g}$ ) as the positive control. Ethanol and water extracts were



**Figure 3.** Chemical structures of some compounds isolated from *Dombeya rotundifolia*.

active with minimum inhibitory concentration (MIC) values of 1.6 mg/ml against *B. subtilis* and *S. aureus* [64]. Reid et al. [43] evaluated antibacterial activities of aqueous, ethanol, and ethyl acetate bark, leaf, and shoot extracts of *D. rotundifolia* against *B. subtilis*, *E. coli*, *K. pneumoniae*, *Micrococcus luteus*, *S. aureus*, and *Staphylococcus epidermidis* using the disc-diffusion assay with neomycin ( $\mu\text{g/ml}$ ) as a positive control. The extracts exhibited activities with MIC values ranging from 6.3 to 12.5 mg/ml [43]. McGaw et al. [61] evaluated the antibacterial activities of aqueous, methanol, and hexane aerial parts extracts of *D. rotundifolia* against *Enterococcus faecalis*, *E. coli*, *Pseudomonas aeruginosa*, and *S. aureus* using the serial microplate dilution method with neomycin as the positive control. The extracts exhibited activities with MIC values ranging from 0.4 to >12.5 mg/ml [61]. Mahlo and Chauke [65] evaluated antibacterial activities of acetone leaf extracts of *D. rotundifolia* with or without polyethylene glycol (PEG) against *Bacillus cereus*, *E. faecalis*, *E. coli*, and *P. aeruginosa* using the serial dilution assay with tetracycline as a positive control. The MIC values of extracts without PEG ranged from 0.4 to 0.8 mg/ml while the addition of PEG resulted in reduction of antibacterial activities with MIC values ranging from 1.6 to 3.1 mg/ml [65]. Kudumela and Masoko [59] evaluated antibacterial activities of acetone, dichloromethane, n-hexane, and methanol leaf extracts of *D. rotundifolia* against *E. faecalis*, *E. coli*, *P. aeruginosa*, and *S. aureus* using the micro-broth dilution assay with ampicillin (2.5–0.02 mg/ml) as a positive control. The extracts showed activities with MIC values ranging from 0.3 to 2.5 mg/ml and total activity ranging from 20.0 to 456.0 ml/g. These findings were comparable to MIC values of 0.02 to 0.08 mg/ml and total activity ranging from 52.0 to 215.0 ml/g [59]. Kudumela et al. [63] evaluated antibacterial activities of acetone leaf extracts of *D. rotundifolia* alone or in combination with leaves of *Commelina africana* L. var. *africana*, *Elephantorrhiza elephantina* (Burch.) Skeels, and whole plant of *Schkuhria pinnata* (Lam.) Kuntze ex Thell against *E. faecalis*, *E. coli*, *P. aeruginosa*, and *S. aureus* using the micro-broth dilution assay with ampicillin (2.5–0.02 mg/ml) as a positive control. When used alone, *D. rotundifolia* extracts exhibited activities with MIC values ranging from 0.4 to 1.3 mg/ml, when in combination with other species, the extracts exhibited MIC values of 0.04–1.7 mg/ml which was comparable to MIC values of 0.02–0.08 mg/ml exhibited by the control [63]. Kudumela et al. [63] also evaluated the synergistic or antagonistic interactions between the plant species by determining the fractional

inhibitory concentrations (FIC) values. Synergistic effects were only exhibited against *P. aeruginosa* with FIC index values of 0.24 and 0.19 for *D. rotundifolia* in combination with *S. pinnata* and *E. elephantina*, respectively. The antagonistic effects were observed against *E. coli* with FIC value 4.6 for the combination of *D. rotundifolia* with *C. africana* var. *africana* [63]. Shikwambana and Mahlo [66] evaluated antifungal activities of leaf, root and bark extracts of *D. rotundifolia* against *Trichophyton rubrum*, *Microsporium canis*, and *Candida albicans*. The extracts showed activities with MIC values ranging from 0.02 to 0.48 mg/ml [66]. These antimicrobial activities exhibited by different extracts of *D. rotundifolia* somehow confirm the species' antimicrobial potential and its usefulness in the treatment and management of microbial infections, such as abscesses in Zambia [15], chest complaints and pneumonia in Kenya and South Africa [19,21,33,39], diarrhea, dysentery, and stomach problems in Kenya and South Africa [15,17–19,21,28,33,42–46], syphilis in Zimbabwe [16], and wounds in South Africa [33].

### Antioxidant Activities

Amoo et al. [58] evaluated antioxidant activities of leaf extracts of *D. rotundifolia* using the 2,2-diphenyl-1-picryl-hydrazyl (DPPH) free radical scavenging and  $\beta$ -carotene-linoleic acid model assays after long-term storage in comparison with freshly collected materials with ascorbic acid and butylated hydroxytoluene as positive controls. The extracts showed radical scavenging activities ranging from 93.6% to 96.5% and half-maximal effective concentration ( $\text{EC}_{50}$ ) values ranging from 5.9 to 6.1  $\mu\text{g/ml}$ . Antioxidant activities based on  $\beta$ -carotene bleaching model ranged from 51.8% to 58.9% [58]. Kudumela and Masoko [59] evaluated the antioxidant activities of aqueous acetone leaf extracts of *D. rotundifolia* using the DPPH free radical scavenging and the reducing power assays. The extracts exhibited activities against DPPH with the  $\text{EC}_{50}$  value of 0.27 while the reducing power method also revealed antioxidant activities of the extracts [59]. These documented antioxidant activities exhibited by *D. rotundifolia* are probably due to flavonoids and phenolics that have been identified from the leaves [58,59].

### Cytotoxicity Activities

Kudumela et al. [63] evaluated the cytotoxicity activities of acetone leaf extracts of *D. rotundifolia* on African green monkey kidney (Vero) cells

using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide assay. The extracts were not toxic to Vero cells with a median lethal concentration ( $LC_{50}$ ) value of 466.1  $\mu\text{g/ml}$  and selectivity index values ranging from 0.4 to 1.5 [63]. In order to ascertain *D. rotundifolia*'s toxicological properties, the different plant parts of the species should be evaluated against a wide range of cell lines as well as using other *in vitro* toxicological assays and *in vivo* studies.

## Conclusion

*Dombeya rotundifolia* is an important medicinal plant throughout its distributional range in tropical Africa. Preliminary pharmacological studies carried out so far provide supporting evidence for some of the documented ethnomedicinal uses of the species, particularly for abdominal pains, abscesses, chest complaints, diarrhea, dysentery, hemorrhoids, hypertension, intestinal ulcers, pneumonia, stomach problems, schistosomiasis, syphilis, and wounds. But there are still some research gaps regarding correlating the medicinal uses of the species with the chemical compounds that have been identified so far from the extracts of the species. Therefore, it is premature to draw firm conclusions about the alleged therapeutic effects of *D. rotundifolia*. More detailed research is needed, aimed at assessing several parts of the species used as traditional medicines, evaluating their chemical compounds, biological, and toxicological properties. Detailed clinical trials are also required aimed at evaluating the efficacy of crude extracts of *D. rotundifolia* or compounds isolated from the species. Detailed pharmacological, molecular, and cellular mechanisms of action are needed for *D. rotundifolia* when used alone or mixed with other plant species to confirm synergistic, additive, efficacy, and safety of such combinations and usage.

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## Conflict of interest

There are no conflicts of interest.

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