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Review Article

LANNEA DISCOLOR: ITS BOTANY, ETHNOMEDICINAL USES, PHYTOCHEMISTRY, AND PHARMACOLOGICAL PROPERTIES

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ABSTRACT

Lannea discolor is an important component of the traditional, complementary, and alternative medicine health-care systems in several countries. This study is aimed at reviewing the botany, ethnomedicinal uses, phytochemical and biological activities of *L. discolor*. Information on its botany, medicinal uses, chemistry and pharmacological properties was undertaken using electronic databases such as Pubmed, SCOPUS, Medline, SciFinder, ScienceDirect, Google Scholar, EThOS, ProQuest, OATD and Open-thesis. Pre-electronic literature was sourced from the University Library. The species is used as herbal medicine for 24 human diseases. The major diseases and ailments treated using concoctions prepared from *L. discolor* include gastrointestinal problems, gonorrhea, infertility in women, convulsions, dizziness, injury, and wounds. Different aqueous and organic extracts of *L. discolor* exhibited anthelmintic, antibacterial, antimycobacterial, antifungal, antioxidant, antiplasmodial, and nematicidal activities. Detailed studies on the phytochemistry, pharmacological, and toxicological properties of *L. discolor* are required to correlate the medicinal uses of the species with its phytochemistry and pharmacological properties.

Keywords: Alternative, complementary and traditional medicine, Anacardiaceae, Ethnopharmacology, *Lannea discolor,* Southern Africa.

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INTRODUCTION

Lannea discolor (Sond.) Engl. is an important component of complementary and alternative medicine and traditional primary health-care systems in several countries in Sub-Saharan Africa. The World Health Organization defined traditional medicine as the sum total of traditional or indigenous knowledge, skills, and practices of local cultures used to diagnose, prevent, treat, and maintain physical and mental illnesses [1]. Traditional medicine that has been adopted from other cultures is often referred to as complementary or alternative medicine [1]. The terms traditional, complementary, and alternative medicines are often used interchangeably in some countries. Plants with medicinal properties are popular and widely used in tropical Africa as about 80% of the people in developing countries are still reliant on traditional, complementary, or alternative medicines to fulfill their primary health care needs and also due to cultural tradition or lack of alternatives [2]. Currently, traditional, complementary, or alternative medicines are getting significant attention in ethnopharmacological research as 25% of pharmaceutical drugs and products, 11% of prescription drugs which are regarded by the World Health Organization as essential to human health are prepared from herbal medicines, and also several synthetic drugs on the market today are derived from phytochemical compounds obtained from medicinal plants [3]. Although there is an increasing acceptance of traditional, complementary, or alternative medicines in treating and managing human diseases and ailments in developing countries [4-33], this traditional knowledge on herbal medicines is not adequately documented. *L. discolor* is one of the important medicinal plants in Sub-Saharan Africa [7,34-36], but there is a dearth of information on phytochemical and pharmacological properties of the species. It is within this context that this review was undertaken aimed at summarizing the botany, medicinal uses, and phytochemical and pharmacological properties of *L. discolor* so as to provide baseline data required in evaluating the therapeutic potential of the species.

BOTANICAL PROFILE OF *L. DISCOLOR*

L. discolor is a species of the *Lannea* A. Rich. genus, belonging to the cashew or sumac or Anacardiaceae family. The Anacardiaceae family includes economically important genera such as cashew (*Anacardium* L.), mango (*Mangifera* L.), marula (*Sclerocarya* Hochst.), and sumac (*Rhus* L.), and the family comprises about 800 species in 82 genera [37]. The name of the genus "*Lannea*" is based on a Latin word "*lana*" which translates to "wool" in reference to young plant parts which are densely hairy or possibly to the wool on the roots of some *Lannea* species [38,39]. The specific name "*discolor*" is a Latin word meaning having two different colors in reference to the two colors of the leaflets, that is, glossy dark green above and silvery gray below [38,39]. The genus *Lannea* consists of approximately 40 species which are usually trees, shrubs, or suffrutices, occupying different habitats in Sub-Saharan Africa, Arabia, and Tropical Asia [40,41].

L. discolor is a deciduous tree growing up to an average height of 15 m with a rounded crown with a single upright or forked trunk [38]. The trunk is gray or reddish-gray and smooth with thick bark, smooth grayish branches, and sturdy, blunt, wrinkled, and hairy twigs. The branchlets are thick and densely covered with whitish hairs. The leaves are compound, oval- to egg-shaped, or almost round in shape. The young leaves are soft, pink, and furry; the adult leaflets are dark green above and velvety whitish gray below with conspicuous midrib and lateral veins [42]. The flowers are small, sweet-scented, creamy-yellow in color and occur in spike-like inflorescence, grouped together, and crowded at the end of branches [43]. The fruit is smooth, fleshy, roundish- to egg-shaped, reddish to purple-black in color when ripe. *L. discolor* has been recorded in Namibia, Malawi, Swaziland, Angola, Mozambique, Zimbabwe, Botswana, Zambia, the Democratic Republic of Congo, and South Africa [44-50] in open grassland, bushveld, woodland, and often on rocky ridges or termitaria [38,42,43].

MEDICINAL USES OF *L. DISCOLOR*

The bark, fruit pulp, leaves, stem bark, and roots of *L. discolor* possess medicinal properties and are used to treat and manage human ailments and diseases (Table 1). Based on literature, *L. discolor* is used to treat and manage 24 human diseases and ailments (Table 1). The leaf, bark, and root infusion of *L. discolor* is applied as poultices for abscesses in South Africa [35], boils in South Africa and Zambia [35,51], and

sore eyes in South Africa and Zimbabwe [7,22,35]. The leaf, bark, and root infusion of *L. discolor* are taken orally against gastrointestinal problems including constipation, diarrhea, dysentery, and stomach ailments in Zimbabwe, Botswana, Zambia, South Africa, Malawi, Mozambique, Swaziland, and Namibia [7,9,34-36,51-55]. The root, leaf, and bark maceration of *L. discolor* are taken orally for convulsions, cough, fever, female infertility, gonorrhea, and menstrual problems in Zimbabwe, Malawi, Zambia, Mozambique, Swaziland, and South Africa [7,34-36,52,53,55-60]. In Zimbabwe, South Africa, and Namibia, the twigs and fibers of *L. discolor* are used as bandages for fractures and wounds, and root powder is also applied topically on swollen legs [7,35,54]. In Zimbabwe, bark, leaf, and root decoction of *L. discolor* are taken orally as a remedy for bilharzia, bladder problems, and malaria [36,61,62] and the species is also used for protection against lightning and witchcraft [7]. In Swaziland, bark and root maceration of *L. discolor* is taken orally for bladder problems [34], while in Zambia, the leaf, bark, and root maceration of the species are taken orally for fits and applied topically for smallpox [4,51]. The major diseases treated using concoctions made from *L. discolor* include gastrointestinal problems, gonorrhea, infertility in women, convulsions, dizziness, injury, and wounds (Fig.1). Gastrointestinal disorders are a major concern in Tropical Africa as these medical conditions are characterized by high mortality rates when left untreated [63,64]. Research by Chinsembu [55] and Chinsembu *et al*. [53] revealed that traditional healers in Tropical Africa have good knowledge of how sexually transmitted infections including gonorrhea are treated and managed using herbal medicines. Similarly, antimicrobial evaluation of 25 medicinal plants used against gonorrhea in Rwanda showed that 64.0% of the tested species were active against *Neisseria gonorrhoeae* and other related pathogens that cause gonorrhea in humans [65].

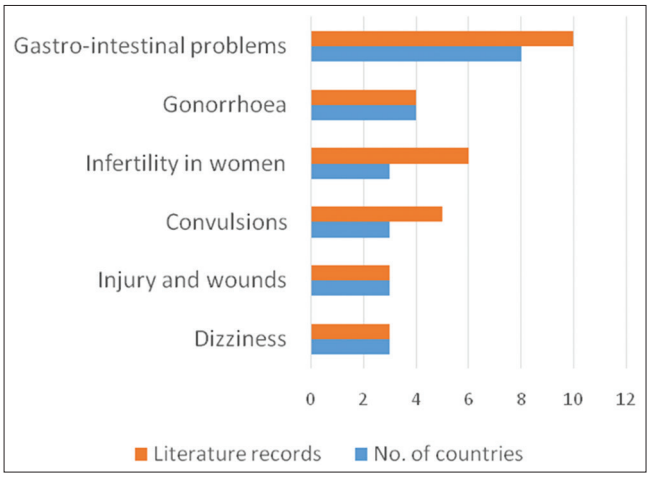

Fig. 1: Diseases treated by *Lannea discolor*

BIOLOGICAL ACTIVITIES AND PHYTOCHEMISTRY OF *L. DISCOLOR*

Some of the biological activities of *L. discolor* listed in literature include anthelmintic [66], antibacterial [67], antimycobacterial [68], antifungal [67], antioxidant [69], antiplasmodial [70], and nematicidal activities [71]. These biological activities of various parts of the species are summarized below.

Anthelmintic activities

Mølgaard *et al*. [66] evaluated the anthelmintic activities of water root, stem, leaf and root bark extracts of *L. discolor* against newly excysted (cestodes) tapeworms, *Hymenolepis diminuta*. All the extracts killed the newly excysted cysticercoids during the 1st h of incubation in a culture medium. The lethal concentrations of *L. discolor* extracts varied from 1.2 to 12.9 mg/mL after 24 h [66] as shown in Table 2. These findings are of ethnopharmacological importance in the traditional application of *L. discolor* as herbal medicine against bilharzia in Zimbabwe [61] and future research aimed at controlling and managing schistosomiasis in Sub-Saharan Africa and other regions [72].

Table 1: Ethnomedicinal applications of *L. discolor*

Medicinal use	Parts of the plant used	Country	References
Abscesses	Bark and leaf infusion applied topically	South Africa	[35]
Bilharzia	Root decoction taken orally	Zimbabwe	[61]
Bladder problems	Leaf, bark, and root infusion taken orally	Zimbabwe, Swaziland	[34,36]
Boils	Bark, leaf, and root maceration applied topically	Zambia, South Africa	[35,51]
Constipation	Bark, leaf, and root maceration taken orally	Zimbabwe	[36]
Convulsions	Leaf, bark, and root infusion taken orally	Zimbabwe, South Africa, Swaziland	[7,34-36,59]
Cough	Root decoction taken orally	South Africa, Zimbabwe	[7,35]
Diarrhea	Bark, fruit pulp, root, and stem bark decoction taken orally	Zimbabwe, Malawi, Botswana, South Africa, Mozambique, Swaziland, Namibia, Zambia, Zimbabwe	[7,9,34-36,52-55]
Dizziness	Leaf, bark, and root infusion taken orally	South Africa, Swaziland, Zimbabwe	[34-36]
Dysentery	Leaf and bark infusion taken orally	Zambia	[51]
Fever	Leaf, bark, and root infusion taken orally	Zambia, Zimbabwe	[36,56]
Fits	Bark and leaf decoction taken orally	Zambia	[4,51]
Fractures	Twigs and fibers used as bandage	South Africa, Zimbabwe	[7,35]
Gonorrhea	Roots mixed those of *Dalbergia melanoxylon* Guill. and Perr.	Malawi	[52]
Gonorrhea	Root decoction taken orally	South Africa, Zambia, Zimbabwe	[7,35,55]
Infertility in women	Leaf, bark, and root infusion taken orally	Zimbabwe, South Africa, Mozambique	[7,35,36,53,57,58]
Malaria	Leaf, bark, and root infusion taken orally	Zimbabwe	[36,62]
Menstrual problems	Root and bark infusion taken orally	Zimbabwe, South Africa	[7,35,60]
Smallpox	Root decoction taken orally	Zambia	[51]
Sore eyes	Leaf and root infusion applied to eyes	South Africa, Zimbabwe	[7,22,35]
Stomach problems	Leaf, bark, and root infusion taken orally	Zimbabwe, Malawi, Swaziland	[34,36,52]
Swollen legs	Root powder applied topically	South Africa, Zimbabwe	[7,35]
Witchcraft/lightning	Root powder taken orally or ointment buried around homestead	Zimbabwe	[7]
Wounds	Fibers used as bandage	Namibia, Zimbabwe	[7,54]

L. discolor: Lannea discolor

Table 2: Biological properties of *L. discolor* extracts

Activity tested	Extract	Plant part	Model	Effect	Reference
Anthelmintic	Water	Leaves and stem	Cestode model	Active against cestodes of *Hymenolepis diminuta*, lethal concentration varying from 10.0 to 2.5 mg/ml	[70]
		Root and root bark	Cestode model	Active against cestodes of *Hymenolepis diminuta*, lethal concentration varying from 12.9 to 1.2 mg/ml	[70]
Antibacterial	Dichlomethane: methanol (1:1)	Leaf	Microtiter plate dilution	Active against *Brevibacillus agri* with MIC value of 1.0 mg/ml, *Propionibacterium acnes* (1.0 mg/ml), *Pseudomonas aeruginosa* (1.0 mg/ml), *Staphylococcus aureus* (2.0 mg/ml), MRSA (1.0 mg/ml), GMRSA (2.0 mg/ml), and *Staphylococcus epidermidis* (2.0 mg/ml)	[67]
	Water	Leaf	Microtiter plate dilution	Active against *Brevibacillus agri* with MIC value of 4.0 mg/ml, *Propionibacterium acnes* (1.0 mg/ml), *Pseudomonas aeruginosa* (12.0 mg/ml), *Staphylococcus aureus* (16.0 mg/ml), MRSA (16.0 mg/ml), GMRSA (4.0 mg/ml), and *Staphylococcus epidermidis* (16.0 mg/ml)	[67]
Antifungal	Dichlomethane: methanol (1:1)	Leaf	Microtiter plate dilution	Active against *Candida albicans* with MIC value of 2.0 mg/ml, *Microsporum canis* (4.0 mg/ml), and *Trichophyton mentagrophytes* (0.05 mg/ml)	[67]
	Water	Leaf	Microtiter plate dilution	Active against *Candida albicans* with MIC value of 8.0 mg/ml, *Microsporum canis* (2.0 mg/ml), and *Trichophyton mentagrophytes* (16.0 mg/ml)	[67]
Antimycobacterial	Methanol	Leaves	Microdilution assay	Extracts active *Mycobacterium bovis* with MIC value of 0.11 mg/ml, multidrug-resistant *Mycobacterium tuberculosis* (0.52 mg/ml), avirulent strain, H37Ra *Mycobacterium tuberculosis* (0.11 mg/ml), *Mycobacterium smegmatis, Mycobacterium fortuitum,* and *Mycobacterium aurum* with MIC values of 0.21 mg/ml	[68]
Antioxidant	Methanol	Bark, root	DPPH free radical scavenging, reducing power effects, and β-carotene linoleic acid assays	Bark and root extracts showed ability to scavenge DPPH, reduce ferric ions, and delay bleaching of β-carotene	[69]
Antiplasmodial	Dichloromethane	Fruits	pLDH assay	Active against *Plasmodium falciparum* with IC_{50} value of 25 μg/ml	[70]
	Dichloromethane: methanol (1:1)	Fruits	pLDH assay	Weak activity against *Plasmodium falciparum* with IC_{50} value>100 μg/ml	[70]
	Water	Fruits	pLDH assay	Weak activity against *Plasmodium falciparum* with IC_{50} value>100 μg/ml	[70]

(Contd...)

Table 2: *(Continued)*

Activity tested	Extract	Plant part	Model	Effect	Reference
Nematicidal	Acetone	Bark	Growth inhibition	Reduced root galling by 40%	[71]
	Water	Bark	Growth inhibition	Reduced root galling by 45%	[71]
Cytotoxicity	Ethanol	Leaf	MTT assay against Vero, hepatoma, and mouse macrophage cells	Showed low toxicity with LC_{50} value of 0.408 mg/mL and>1.0 mg/mL against liver and murine macrophage cells, respectively	[68]

L. discolor: Lannea discolor, MIC: Minimum inhibitory concentration, MRSA: Methicillin-resistant *Staphylococcus aureus*, GMRSA: Gentamicin-methicillin-resistant *Staphylococcus aureus*, DPPH: 2, 2-diphenyl-1-picrylhdrazyl, MTT: 3-(4, 5-dimethylthiazol)-2, 5-diphenyl tetrazolium bromide, LC_{50}: Median lethal concentration, IC_{50}: Half maximal inhibitory concentration

Table 3: Nutritional and phytochemical composition of bark, leaves, and roots of *L. discolor*

Nutritional composition	Values	Plant parts	References
Acid detergent fiber (g/100 g dry matter)	41.2	Leaves	[72]
Acid detergent lignin (g/100 g dry matter)	17.9	Leaves	[72]
As (mg/kg)	0.11–0.12	Leaves, roots	[36]
Ash (g/100 g dry matter)	10.6	Leaves	[72]
Ca (g/100 g dry matter)	2.6	Leaves	[72]
Cellulose (g/100 g dry matter)	23.2	Leaves	[72]
Crude protein (g/100 g dry matter)	14.3	Leaves	[72]
Cu (mg/kg)	0.12–0.19	Leaves, roots	[36]
Dry matter (%)	33.9	Leaves	[72]
Fe (mg/kg)	3.44–4.65	Leaves, roots	[36]
Flavonoid content (mg CTE/g)[a]	2.18–2.97	Bark	[71]
Hemi-cellulose (g/100 g dry matter)	14.2	Leaves	[73]
In vitro of organic matter (%)	49.3	Leaves	[73]
K (g/100 g dry matter)	0.5	Leaves	[73]
Metabolizable energy (MJ/Kg dry matter)	6.7	Leaves	[73]
Mg (g/100 g dry matter)	0.64	Leaves	[73]
Na (g/Kg dry matter)	0.06	Leaves	[73]
Neutral detergent fiber (g/100 g dry matter)	55.4	Leaves	[73]
Ni (mg/kg)	0.01–0.05	Leaves, roots	[36]
P (g/100 g dry matter)	0.13	Leaves	[73]
Pb (mg/kg)	0.55–0.60	Leaves, roots	[36]
Proanthocyanidin (%L CE/g dry matter)[b]	1.25–3.23	Bark	[71]
Tannin content (mg/ml gallic acid equivalent)	4.0	Leaves	[74]
Total phenolic content (mg GAE/g)[c]	21.69–60.0	Bark, roots	[69,71]
Zn (mg/kg)	0.73–0.83	Leaves, roots	[36]

[a]Values expressed as catechin equivalents (CTE) per gram of plant extracts. [b]Values expressed as percentage leucocyanidin equivalents (LCE) per gram of dry matter. [c]Values expressed as gallic acid equivalent (GAE) per gram of dry matter. *L. discolor: Lannea discolor*

Antibacterial activities

Mabona *et al*. [67] evaluated antibacterial activities of water and dichlomethane:methanol (1:1) leaf extracts of *L. discolor* using the micro dilution technique against dermatologically relevant pathogens such as *Brevibacillus agri, Staphylococcus aureus, Propionibacterium acnes, Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus* (MRSA), gentamycin-methicillin-resistant *Staphylococcus aureus* (GMRSA) and *Staphylococcus epidermidis* with ciprofloxacin as positive control and acetone and dimethylsulfoxide (DMSO) as negative controls. All the extracts demonstrated some activities with minimum inhibition concentration (MIC) values ranging from 1.0 mg/mL to 16.00 mg/mL (Table 2). These antibacterial activities exhibited by different extracts of *L. discolor* support the application of the plant as remedy for bacterial pathogens causing abscesses in South Africa [35], boils in South Africa and Zambia [35,51], diarrhoea in Malawi, Botswana, Zimbabwe, Mozambique, Zambia, Namibia, Swaziland and South Africa [7,9,34-36,52-55], dysentery in Zambia [51], gonorrhoea in Zimbabwe, Malawi, Zambia and South Africa [7,35,52,55], stomach problems in Malawi, Swaziland and Zimbabwe [34,36,52] and wounds in Namibia and Zimbabwe [7,54].

Antimycobacterial activities

Kabongo-Kayoka *et al*. [68] evaluated antimycobacterial activities of leaf extracts of *L. discolor* using a microdilution assay against the pathogenic *Mycobacterium bovis*, multidrug resistant *Mycobacterium tuberculosis*, avirulent strain, H37Ra *Mycobacterium tuberculosis, Mycobacterium fortuitum, Mycobacterium smegmatis* and *Mycobacterium aurum* with ciprofloxacin, rifampicin, isoniazid and streptomycin as positive controls. The extracts demonstrated activities with MIC values ranging from 0.11 mg/ml to 0.52 mg/ml (Table 2). These findings corroborate the medicinal use of *L. discolor* in the treatment of respiratory system disorders including cough in South Africa and Zimbabwe [7,35].

Antifungal activities

Mabona *et al*. [67] assessed antifungal properties of water and dichlomethane:methanol (1:1) leaf extracts of *L. discolor* using the microtitre plate dilution technique against dermatologically relevant pathogens such as *Candida albicans, Trichophyton mentagrophytes and Microsporum canis* with amphotericin B as positive control and acetone and dimethylsulfoxide (DMSO) as negative controls. The extracts demonstrated some activities with MIC values ranging from 0.05 mg/mL to 16.00 mg/mL (Table 2). These findings support the medicinal use of *L. discolor* against fungal and microbial infections such as wounds in Namibia and Zimbabwe [7,54].

Antioxidant activities

Chakuma *et al*. [69] evaluated antioxidant activities of root and bark extracts of *L. discolor* using 2, 2-diphenyl-1-picrylhdrazyl (DPPH) free radical scavenging, reducing power effects and β-carotene linoleic acid assays with ascorbic acid as the standard. The bark extracts exhibited better ability to scavenge DPPH when compared to the root extract and ascorbic acid, the standard. Therefore, root and bark extracts of *L.*

discolor were able to donate hydrogen and consequently reduce DPPH radicals [69]. The bark extract had better reducing power activities in comparison with the root extract, and the root, bark extracts, and the standard demonstrated concentration-dependant reducing power properties. The reducing power activities of the extracts and the standard increased as the concentration of the samples increased. The bark extracts exhibited the best ability to delay bleaching of β-carotene while the standard, ascorbic acid exhibited the least properties [69]. These documented antioxidant activities of the species are probably caused by the flavonoids and phenolics that have been identified from the bark (Table 3) of the species by Chakuna *et al*. [69] and Nyoni *et al*. [71].

Antiplasmodial activities

Clarkson *et al*. [70] evaluated the antiplasmodial activities of dichloromethane, water and dichloromethane/methanol (1:1) fruit extracts of *L. discolor* against *Plasmodium falciparum* using the parasite lactate dehydrogenase assay. The dichloromethane extract showed weak activities with half maximal inhibitory concentration (IC50) value of 25 µg/ml. The weak antiplasmodial activities exhibited by *L. discolor* show that the plant could serve as an antimalarial agent. *L. discolor* is used as a remedy for malaria in Zimbabwe [36,62].

Nematicidal activities

Nyoni *et al*. [71] evaluated the nematicidal activities of acetone and aqueous bark extracts of *L. discolor* against *Meloidogyne javanica.r plant*. The extracts were screened on nematode inoculated tomato variety red khaki (*Solanum lycopersicum* L.) at a rate of 30 ml per plant with fenamiphos (nemacur 400 g/l) used as a positive control at a rate of 30 ml per plant. The extracts reduced the formation of root knot galls by 40–45% (Table 2). These findings revealed that *L. discolor* extracts have potential as nematicides and the species can be used by resource-poor rural farmers to suppress and control the attack of tomato plants by nematodes.

CYTOTOXICITY

Kabongo-Kayoka *et al*. [68] evaluated cytotoxicity activities of leaf extracts of *L. discolor* using a 3-(4, 5-dimethylthiazol)-2, 5-diphenyl tetrazolium bromide (MTT) assay against Vero African monkey kidney cells, cancer liver cells and mouse macrophage cells (Table 2). The extracts exhibited low toxicity against the three cell lines with the median lethal concentration values ranging from 0.408 mg/mL to >1.0 mg/mL (Table 2). These results may serve as an indication that *L. discolor* may be safe to use as herbal medicine.

A variety of minerals such as arsenic (As), calcium (Ca), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), nickel (Ni), phosphorus (P), potassium (K) and Zinc (Zn) have been identified from the leaves and roots of *L. discolor* [36,73] (Table 3). It has been reported that minerals such as Ca, Cu, Fe, Mg, P, K, and Zn are essential nutrients required for various biochemical and physiological processes [75]. However, heavy metals such as As, Ni, and Pb have no established biological functions and considered non-essential elements [36,75-78]. Therefore, rigorous quality control of *L. discolor* products for toxic heavy metals is required aimed at ensuring that heavy metal contamination is kept to a minimum.

CONCLUSION

Based on its wide use as traditional medicine in southern Africa, *L. discolor* should be subjected to rigorous ethnopharmacological evaluation aimed at elucidating its chemical, pharmacological, and toxicological properties. Non-essential heavy metals such as arsenic, lead, and nickel were identified from leaves and roots, the plant parts which are used to prepare herbal concoctions. This calls for detailed target-organ toxicity studies involving *L. discolor* and its derivatives aimed at establishing any side effects associated with utilization of the species as herbal medicine.

AUTHORS' CONTRIBUTIONS

I declare that this work was done by the author named in this article.

CONFLICTS OF INTEREST

No conflict of interest is associated with this work.

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