REVIEW ARTICLE

INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACEUTICAL SCIENCES

Published by JK Welfare & Pharmascope Foundation Journal Home Page: www.ijrps.com

Gardenia ternifolia Schum. & Thonn. (Rubiaceae): Review of medicinal uses, phytochemistry and biological activities

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Article History:

Received on: 03 Aug 2020
Revised on: 01 Sep 2020
Accepted on: 03 Sep 2020

Keywords:

Gardenia Ternifolia, Ethnopharmacology, Herbal Medicine, Indigenous Pharmacopoeia, Rubiaceae, Tropical Africa

ABSTRACT

Gardenia ternifolia Schum. & Thonn. is a shrub or small tree widely used as a traditional medicine throughout its distributional range in tropical Africa. *Gardenia ternifolia* is widespread in tropical Africa, extending from Senegal eastwards to Ethiopia and Kenya, through the Democratic Republic of Congo (DRC) southwards to Namibia, South Africa and Mozambique. This study was aimed at providing a critical review of the medicinal uses, phytochemistry and biological activities of *G. ternifolia*. Documented information on the medicinal uses, phytochemistry and biological activities of *G. ternifolia* was collected from several online sources which included Scopus, Google Scholar, PubMed and Science Direct. Additional information was gathered from pre-electronic sources such as book chapters, books, journal articles and scientific publications obtained from the university library. This study showed that the species is widely used as an aphrodisiac and protective charm, and traditional medicine for headache, migraine, respiratory infections, sore eyes, hypertension, diabetes, gastro-intestinal problems, erectile dysfunction, malaria, convulsions and epilepsy. Phytochemical compounds identified from the species include alkaloids, anthocyanins, coumarins, flavonoids, phenols, quinones, saponins, steroids, stereoisomeric neolignans, tannins and terpenoids. Pharmacological research revealed that *G. ternifolia* extracts and compounds isolated from the species have antibacterial, antiviral, anti-inflammatory, antileishmanial, antioxidant, antiplasmodial, antisickling, antitheilerial, hepatotoxicity, larvicidal and cytotoxicity activities. Future research on *G. ternifolia* should focus on detailed phytochemical evaluations, including toxicological, *in vivo* and clinical studies to corroborate the traditional medical applications of the species.

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ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v11i4.3238

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IJRPS | www.ijrps.com

INTRODUCTION

Gardenia ternifolia Schum. & Thonn. is a shrub or small tree belonging to the Rubiaceae family. The genus *Gardenia* J. Ellis comprises of about 140 species recorded in Africa, Madagascar, East and Southeast Asia, western Pacific and Hawaiian islands (Wong and Low, 2011). The genus name is in honor of Alexander Garden (1730-1791), a Scottish physician, botanist and zoologist who lived in Charleston, South Carolina and was a correspondent of Carl Linnaeus. The species name "*ternifolia*" is derived from the Latin word "*ternifolius*" which means leaves in threes. Three infra specific taxa of *G.*

ternifolia are recognized, and these include *G. ternifolia* subsp. *jovis-tonantis* (Welw.) Verdc., *G. ternifolia* subsp. *jovis-tonantis* var. *jovis-tonantis* (Welw.) Aubrév., *G. ternifolia* subsp. *jovis-tonantis* var. *goetzei* (Stapf & Hutch.) Verdc., and *G. ternifolia* subsp. *ternifolia* (Verdcourt, 1979). In ethnobotanical literature, the infra specific taxa of *G. ternifolia* are rarely mentioned (Gelfand *et al.*, 1985). Therefore, in this study, *G. ternifolia sensu lato* is used throughout the manuscript. The bark of *G. ternifolia* is grey to yellowish-brown in color, smooth or slightly rough and peeling off in round pieces in thicker and older trees. The leaves are usually in whorls of three, clustered near the ends of short rigid branchlets.

The flowers are white to yellow while the fruits are oval, finely velvety and yellowish-brown in color. *Gardenia ternifolia* is widespread in tropical Africa, extending from Senegal eastwards to Ethiopia and Kenya, through the Democratic Republic of Congo (DRC) southwards to Namibia, South Africa and Mozambique (Hutchings *et al.*, 1996). *Gardenia ternifolia* has been recorded in poor, rocky, compacted sandy and laterite soils, in wooded grassland, on kopjes, termite mounds, along streams and seasonally inundated vleis at sea level to 2100 m above sea level. The branches of *G. ternifolia* are used as toothbrushes while the young leaves are cooked as leafy vegetables in west Africa. The fruits of *G. ternifolia* are sold as traditional medicines in informal herbal medicine markets in South Africa. It is, therefore, within this context that the current study was undertaken aimed at documenting the pharmacological properties, phytochemistry and medicinal uses of *G. ternifolia.*

MATERIALS AND METHODS

Results of the current study are based on a literature search on phytochemistry, pharmacological properties and medicinal uses of *G. ternifolia* using information derived from several internet databases. The databases included Scopus, Google Scholar, PubMed and Science Direct. Other sources of information such as pre-electronic sources which included journal articles, theses, books, book chapters and other scientific articles were gathered from the university library.

RESULTS AND DISCUSSION

Medicinal uses of *Gardenia ternifolia*

The aerial parts, bark, fruit and roots of *G. ternifolia* are mainly used as an aphrodisiac and protective charm, and traditional medicine for headache, migraine, respiratory infections, sore eyes, hypertension, diabetes, gastro-intestinal problems, erectile dysfunction, malaria, convulsions and epilepsy (Table 1, Figure 1). Other medicinal applications of *G. ternifolia* that have been recorded in two countries and supported by at least two literature records include the use of the species as ethnoveterinary medicine in Cameroon and Ethiopia, and traditional medicine for earache in South Africa and Zimbabwe, infertility (Benin and Zimbabwe), insanity (Malawi and Uganda), sexually transmitted infections (Ghana and Guinea), skin infections (Ghana and Guinea) and snake bites (Kenya and Uganda) (Table 1).

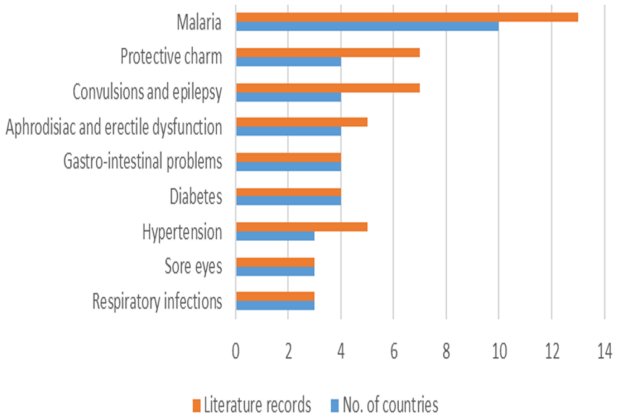

Figure 1: Major medicinal uses of Gardenia ternifolia in tropical Africa.

Nutritional and phytochemical composition of *Gardenia ternifolia*

Several researchers investigated the nutritional and phytochemical properties of *G. ternifolia* (Table 2). A wide variety of nutrients associated with different plant parts of *G. ternifolia* (Table 2) imply that the species could be a source of health-promoting nutrients such as calcium, carbohydrates, copper, crude fibre, fat, iron, magnesium, phosphorus, potassium, proteins, sodium and zinc. Phytochemical compounds identified from the aerial parts, fruits, leaves, roots and stem bark of *G. ternifolia* include alkaloids, anthocyanins, coumarins, flavonoids, phenols, quinones, saponins, steroids, stereoisomeric neolignans, tannins and terpenoids. Some of these chemical compounds may be responsible for the biological activities of the species.

Biological activities of *Gardenia ternifolia*

Pharmacological research revealed that different extracts of *G. ternifolia* and compounds isolated from the species have various biological activities such as antibacterial, antiviral, anti-inflammatory, antileishmanial, antioxidant, antiplasmodial, antisickling, antitheilerial, hepatotoxicity, larvicidal and cytotoxicity activities.

Table 1: Medicinal uses of *Gardenia ternifolia.*

Medicinal use	Part used	Country	Reference
Amebiasis	Leaves	DRC	(Ngbolua *et al.*, 2014)
Aphrodisiac and erectile dysfunction	Roots	Angola, DRC, Mali and Tanzania	(Ahua *et al.*, 2007; Göhre *et al.*, 2016)
Boost immune system	Bark	Uganda	(Anywar *et al.*, 2020)
Breast cancer	Root	Togo	(Kola *et al.*, 2020)
Convulsions and epilepsy	Bark, leaves and roots	Angola, South Africa, Tanzania and Togo	(Moshi *et al.*, 2004; Kantati *et al.*, 2016)
Diabetes	Leaves	Angola, Côte d'Ivoire, Guinea and Nigeria	(Olabanji *et al.*, 2008; Göhre *et al.*, 2016)
Earache	Fruits	South Africa and Zimbabwe	(Gelfand *et al.*, 1985; Hutchings *et al.*, 1996)
Fever	Leaves	Togo	(Koudouvo *et al.*, 2011)
Gastro-intestinal problems (diarrhoea, dysentery and stomach pains)	Bark, leaves and roots	Angola, Guinea-Bissau, Mali and Mozambique	(Silva *et al.*, 1996; Bruschi *et al.*, 2011)
Haemorrhoids	Fruits	Ethiopia	(Yineger and Yewhalaw, 2007)
Headache and migraine	Leaves and roots	Togo, Uganda and Zimbabwe	(Gelfand *et al.*, 1985; Koudouvo *et al.*, 2011)
Hernia	Leaves	Angola	(Göhre *et al.*, 2016)
Hypertension	Aerial parts and roots	Cameroon, Tanzania and Togo	(Moshi *et al.*, 2004; Koudouvo *et al.*, 2011)
Induce labour	Bark and roots	Mozambique	(Bruschi *et al.*, 2011)
Infertility	Roots	Benin and Zimbabwe	(Gelfand *et al.*, 1985; Klotoé *et al.*, 2020)
Insanity	Roots	Malawi and Uganda	(Gelfand *et al.*, 1985)
Jaundice	Roots	Mali	(Ahua *et al.*, 2007)
Malaria	Fruits, leaves, roots, root bark and stem bark	Angola, Burkina Faso, Ethiopia, Ghana, Guinea, Kenya, Mali, Rwanda, South Africa and Togo	(Nadembega *et al.*, 2011; Lautenschläger *et al.*, 2018)
Malnutrition	Fruits	Burkina Faso	(Nadembega *et al.*, 2011)
Measles	Fruits, leaves and stems	Angola	(Göhre *et al.*, 2016; Lautenschläger *et al.*, 2018)
Menstrual problems	Roots	Zimbabwe	(Gelfand *et al.*, 1985)

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Table 1 continued

Medicinal use	Part used	Country	Reference
Pain	Leaves and stems	Angola	(Lautenschläger *et al.*, 2018)
Parasites	Fruits	Angola	(Lautenschläger *et al.*, 2018)
Parkinson diseases	Leaves	Togo	(Kantati *et al.*, 2016)
Protective charm (evil spirits, lightning and witchcraft)	Bark, branches, roots and twigs	Angola, Mozambique, South Africa and Zimbabwe	(Gelfand *et al.*, 1985; Bruschi *et al.*, 2011)
Respiratory infections (asthma, pneumonia and tuberculosis)	Bark, fruits and roots	Cameroon, Mozambique and Zimbabwe	(Gelfand *et al.*, 1985; Bruschi *et al.*, 2011)
Sexually transmitted infections (including syphilis)	Leaves and root bark	Ghana and Guinea	(Larsen *et al.*, 2015)
Skin infections	Leaves	Ghana and Guinea	(Larsen *et al.*, 2015)
Snake bites	Roots	Kenya and Uganda	(Anywar *et al.*, 2020)
Sore eyes	Fruits and roots	Ethiopia, Kenya and Zimbabwe	(Gelfand *et al.*, 1985)
Toothache	Fruits	Angola	(Lautenschläger *et al.*, 2018)
Trypanosomiasis	Fruits	Angola	(Vahekeni *et al.*, 2020)
Typhoid fever	Bark	Cameroon	(Tsobou *et al.*, 2013)
Ulcers	Leaves	Ghana	(Larsen *et al.*, 2015)
Urinary infections	The root decoction is taken orally	Guinea-Bissau	(Silva *et al.*, 1996)
Ethnoveterinary medicine (anthelmintic and ulcerative lymphangitis)	Leaves and roots	Cameroon and Ethiopia	(Yineger and Yewhalaw, 2007; Tsobou *et al.*, 2013)

Antibacterial activities

Silva *et al.* (1996) evaluated the antibacterial activities of ethanol extract of *G. ternifolia* roots against *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Shigella dysenteriae, Salmonella typhimurium, Streptococcus faecalis, Vibrio cholera, Campylobacter jejuni, Campylobacter coli* and *Staphylococcus aureus* using agar diffusion method. The extract exhibited activities against *Campylobacter jejuni, Campylobacter coli* and *Staphylococcus aureus* with zones of inhibition ranging from 9.0 mm to 14.0 mm (Silva *et al.*, 1996).

Magassouba *et al.* (2007) evaluated the antibacterial activities of methanol extract of *G. ternifolia* root bark mixed with those of *Swartzia madagascariensis* Desv., *Isoberlinia Doka* Craib & Stapf, *Annona senegalensis* Pers., *Terminalia glaucescens* Planch. Ex Benth., and leaves of *Erythrina senegalensis* DC. against *Staphylococcus aureus* using broth dilution method with rifampicin as a positive control. The extract exhibited activities against tested pathogens with minimum inhibitory concentration (MIC) value of 62.5 μl/ml (Magassouba *et al.*, 2007).

Pesewu *et al.* (2008) evaluated the antibacterial activities of ethanol, water, chloroform and blender extracts of *G. ternifolia* leaves against *Escherichia coli, Staphylococcus aureus, Proteus Vulgaris, Pseudomonas aeruginosa* and *Streptococcus pyogenes* using agar-well diffusion and microdilution methods. The ethanol, water and blender extracts exhibited activities against *Staphylococcus aureus* and *Streptococcus pyogenes* with inhibition zones ranging from 8.0 mm to 18.0 mm, and MIC and minimum bactericidal concentration (MBC) values ranging from 12.5 mg/ml to >50.0 mg/ml (Pesewu *et al.*, 2008).

Ngbolua *et al.* (2014) evaluated the antibacterial activities of anthocyanins and organic acids isolated from *G. ternifolia* leaves against *Lactobacillus fermentum, Staphylococcus aureus, Enterococcus faecalis, Salmonella typhimurium* and *Escherichia coli* using agar disc diffusion and broth micro-dilution methods. The anthocyanin and organic acid extracts exhibited activities with MIC and MBC values ranging from 62.5 μg/mL to >500.0 μg/mL (Ngbolua *et al.*, 2014).

Roger *et al.* (2015) evaluated the antibacterial activities of ethanol extract of *G. ternifolia* bark against *Salmonella typhi* and *Salmonella paratyphi* using agar well diffusion and microdilution methods with ciprofloxacin (10.0 μl/ml) as a positive control. The extract exhibited weak activities against *Salmonella typhi* with inhibition zone ranging from 9.5 mm to 11.0 mm, MIC value of 512.0 μl/ml and MBC value of 2048.0 μl/ml (Roger *et al.*, 2015).

Antiviral activities

Silva *et al.* (1997) evaluated the antiviral activities of ethanol extract of *G. ternifolia* roots against Herpes simplex virus type 1 (HSV-1) and African swine fever virus (ASFV). The extract exhibited activities with HSV-1 and ASFV exhibiting inhibition effect of 60.0% and 80.0%, respectively.

Anti-inflammatory activities

Larsen *et al.* (2015) evaluated the anti-inflammatory activities of ethanol extract of *G. ternifolia* leaves using the cyclooxygenase-1 assay. The extract exhibited inhibitory activities over 90.0% in the final concentration of 0.1 μg/μL (Larsen *et al.*, 2015).

Pompermaier *et al.* (2018) evaluated the anti-inflammatory activities of methanol extract of *G. ternifolia* seeds at 10.0 μg/mL, 50.0 μg/mL and 100.0 μg/mL concentrations to assess their inhibition of cyclooxygenase (COX)−2 expression and on nitric oxide (NO) release in lipopolysaccharide (LPS)-stimulated J774A.1 macrophages. At a concentration of 10.0 μg/mL to 100.0 μg/mL, inhibition on COX-2 expression and NO release ranged from 61.7% to 91.1% (Pompermaier *et al.*, 2018).

Antileishmanial activities

Ahua *et al.* (2007) evaluated the antileishmanial activities of dichloromethane, water and methanol extracts of *G. ternifolia* root bark against both extracellular and intracellular forms of *Leishmania major* using an antileishmanial assay with amphotericin B as a positive control. The water extract exhibited activities that were comparable to activities exhibited by the positive control.

Antioxidant activities

Mpiana *et al.* (2015) evaluated the antioxidant activities of methanol, ethyl acetate and anthocyanin extracts of G. ternifolia leaves using the 1,1-diphenyl-2- picrylhydrazyl (DPPH) free radical scavenging assay with ascorbic acid as a positive control. The extracts exhibited activities with half-maximal effective concentration (EC_{50}) values ranging from 0.9 μg/ml to 1.3 μg/ml (Mpiana *et al.*, 2015).

Awas *et al.* (2016) evaluated the antioxidant activities of the compounds 3,5,3′-trihydroxy-7,4′-dimethoxy flavone, 5,7-trihydroxy-4′-methoxy flavone, 5,7-dihydroxy-3,4′-dimethoxy flavone, 5,4′-dihydroxy-7-methoxyflavanone and 3,4′dimethoxy-5,7-diacetyl flavone isolated from the leaves of *G. ternifolia* using the DPPH free radical scavenging assay with quercetin as the positive control.

Table 2: Nutritional and phytochemical composition of *Gardenia ternifolia.*

Nutritional and phytochemical components	Value	Plant part	Reference
Nutritional components			
Aluminium (ppm)	1010.0	Leaves	(Olabanji *et al.*, 2008)
Ash (%)	3.5	Fruit pulp	(Jacob *et al.*, 2016)
Bromine (ppm)	24.0	Leaves	(Olabanji *et al.*, 2008)
Calcium (mg/100g)	66.0	Fruit pulp	(Jacob *et al.*, 2016)
Carbohydrates (%)	57.8	Fruit pulp	(Jacob *et al.*, 2016)
Chlorine (ppm)	3270.0	Leaves	(Olabanji *et al.*, 2008)
Cobalt (ppm)	<11.0	Leaves	(Olabanji *et al.*, 2008)
Copper (mg/100g)	0.3	Fruit pulp	(Jacob *et al.*, 2016)
Crude fat (%)	2.2	Fruit pulp	(Jacob *et al.*, 2016)
Crude fibre (%)	19.7	Fruit pulp	(Jacob *et al.*, 2016)
Crude protein (%)	5.2	Fruit pulp	(Jacob *et al.*, 2016)
Energy (kcal/100g)	280.5	Fruit pulp	(Jacob *et al.*, 2016)
Iron (mg/100g)	1.9	Fruit pulp	(Jacob *et al.*, 2016)
Magnesium (mg/100g)	71.1	Fruit pulp	(Jacob *et al.*, 2016)
Manganese (mg/100g)	2.5	Fruit pulp	(Jacob *et al.*, 2016)
Moisture (%)	10.8	Fruit pulp	(Jacob *et al.*, 2016)
Nickel (ppm)	10.0	Leaves	(Olabanji *et al.*, 2008)
Phosphorus (ppm)	1440.0	Leaves	(Olabanji *et al.*, 2008)
Potassium (mg/100g)	343.3	Fruit pulp	(Jacob *et al.*, 2016)
Rubidium (ppm)	27.0	Leaves	(Olabanji *et al.*, 2008)
Silicon (ppm)	2650.0	Leaves	(Olabanji *et al.*, 2008)
Sodium (mg/100g)	231.5	Fruit pulp	(Jacob *et al.*, 2016)
Strontium (ppm)	179.0	Leaves	(Olabanji *et al.*, 2008)
Sulfur (ppm)	2120.0	Leaves	(Olabanji *et al.*, 2008)
Titanium (ppm)	47.0	Leaves	(Olabanji *et al.*, 2008)
Vitamin C (mg/100g)	12.5	Fruit pulp	(Jacob *et al.*, 2016)
Zinc (mg/100g)	1.3	Fruit pulp	(Jacob *et al.*, 2016)

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Table 2 continued

Nutritional and phytochemical components	Value	Plant part	Reference
Phytochemical component			
3,4′dimethoxy-5,7-diacetylflavone	-	Leaves	(Awas *et al.*, 2016)
3,5,3′-trihydroxy-7,4′-dimethoxyflavone	-	Leaves	(Awas *et al.*, 2016)
4,5-Dihydroxy-6,7-dimethoxyflavanone	-	Aerial parts	(Ochieng *et al.*, 2010)
5,4′-dihydroxy-7-methoxyflavanone	-	Leaves	(Awas *et al.*, 2016)
5,7-dihydroxy-3,4′-dimethoxyflavone	-	Leaves	(Awas *et al.*, 2016)
5,7-trihydroxy-4′-methoxy flavone	-	Leaves	(Awas *et al.*, 2016)
Alkaloid (%)	8.0	Leaves	(Dahiru, 2015)
β-amyrin	-	Fruits	(Ghazali *et al.*, 2004)
Geniposide	-	Fruits	(Ghazali *et al.*, 2004)
Gardenifolins A − H	-	Stem bark	(Tshitenge *et al.*, 2017)
Kaempferol-7-O-methyl ether	-	Aerial parts	(Ochieng *et al.*, 2010)
Naringenin-7-O-methyl ether	-	Aerial parts	(Ochieng *et al.*, 2010)
Naringenin-4,7-O-dimethyl-ether	-	Aerial parts	(Ochieng *et al.*, 2010)
Oleanolic acid	-	Fruits	(Ghazali *et al.*, 2004)
Phenols (%)	2.3	Leaves	(Dahiru, 2015)
Quercetin-4,7-O-dimethyl ether	-	Aerial parts	(Ochieng *et al.*, 2010)
Saponins (%)	12.0	Leaves	(Dahiru, 2015)
β-sitosterol	-	Aerial parts and leaves	(Ochieng *et al.*, 2010; Awas *et al.*, 2016)
Stigmasterol	-	Aerial parts and leaves	(Ochieng *et al.*, 2010; Awas *et al.*, 2016)
Tannins (%)	10.0	Leaves	(Dahiru, 2015)
Terpenoids (%)	10.0	Leaves	(Dahiru, 2015)
Total flavonoids (μg/g)	5.0 – 15.0	Roots	(Klotoé *et al.*, 2020)
Total polyphenols (mg/g)	19.0 – 25.0	Roots	(Klotoé *et al.*, 2020)

The compounds exhibited activities with half-maximal inhibitory concentration (IC_{50}) values ranging from 40.3 μM to >100.0 μM in comparison to IC_{50} value of 20.1 μM exhibited by the positive control (Awas *et al.*, 2016). Klotoé *et al.* (2020) evaluated the antioxidant activities of aqueous, hydro-ethanolic and ethanolic extracts of G. ternifolia roots using the DPPH free radical scavenging assay and ferric reducing antioxidant power assay (FRAP) with butylhydroxytoluene and vitamin C as positive controls. The extracts exhibited activities with IC_{50} values in DPPH and FRAP, ranging from 1.5 mg/ml to 21.0 mg/ml (Klotoé *et al.*, 2020).

Antiplasmodial activities

Ochieng *et al.* (2010) evaluated the anti-plasmodial activities of acetone and methanol extracts of G. ternifolia aerial parts and the compounds naringenin-7-O-methyl ether, quercetin-4,7-O-dimethyl ether, kaempferol-7-O-methyl ether, 4,5-dihydroxy-6,7-dimethoxyflavanone, naringenin-4,7-O-dimethyl-ether, stigmasterol and β-sitosterol isolated from the aerial parts of the species against chloroquine-resistant and chloroquine-sensitive strains of *Plasmodium falciparum* using an automated microdilution technique with crude extract of *Artemisia annua* and chloroquine as positive controls. The extracts and the compounds β-sitosterol, quercetin-4,7-O-dimethyl ether, kaempferol-7-O-methyl ether and naringenin-7-O-methyl ether exhibited activities with IC_{50} values ranging from 0.9 μg/mL to 17.0 μg/mL (Ochieng *et al.*, 2010). Nureye *et al.* (2018) evaluated the antiplasmodial activities of methanol crude extract, aqueous, butanol and chloroform fractions of *G. ternifolia* root bark using a 4-day suppressive test against *Plasmodium berghei* (ANKA strain) in Swiss albino mice. The chemo suppressive effect exerted by the crude extract and fractions ranged from 14.0% to 59.0% (Nureye *et al.*, 2018).

Antisickling activities

Mpiana *et al.* (2015) evaluated the antisickling activities of methanol and ethyl acetate fractions, and anthocyanin crude extracts of *G. ternifolia* leaves on sickle erythrocytes by the Emmel's test. The extracts exhibited antisickling activities (Mpiana *et al.*, 2015).

Ngbolua *et al.* (2014) evaluated the antisickling activities of anthocyanins, and organic acids isolated from *G. ternifolia* leaves using Emmel. The anthocyanin and organic acid extracts exhibited activities with normalization rates ranging from 68.0% to 72.0% at a concentration of 6.25 μg/mL (Ngbolua *et al.*, 2014).

Antitheilerial activities

Hayat *et al.* (2012) evaluated the antitheilerial activities of aqueous extracts of *G. ternifolia* fruits against *Theileria lestoquardi* using the lymphocyte cells infected with the parasite. The extract exhibited activities against *Theileria lestoquardi* macroschizonts.

Hepatotoxicity activities

Dahiru (2015) evaluated the hepatotoxicity activities of aqueous extracts of *G. ternifolia* leaves against carbon tetra chloride (CCl_4)-induced hepatotoxicity in albino rats. Pretreatment of rats 100.0 mg/kg, 200.0 mg/kg and 400.0 mg/kg body weight of the extract before administration of CCl_4 exhibited moderate protective effects by lowering the levels of serum enzymes and also revealed moderate necrosis.

Larvicidal activities

Ochieng *et al.* (2010) evaluated the larvicidal activities of acetone and methanol extracts of *G. ternifolia* aerial parts and the compounds naringenin-7-O-methyl ether, quercetin-4,7-O-dimethyl ether, kaempferol-7-O-methyl ether, 4,5-dihydroxy-6,7-dimethoxyflavanone, naringenin-4,7-O-dimethyl-ether, stigmasterol and β-sitosterol isolated from the aerial parts of the species against the second-instar larvae of *Aedes aegypti* larvae using in vitro larvicidal activity assay. The extracts and the compounds quercetin-4,7-O-dimethyl ether, kaempferol-7-O-methyl ether and naringenin-7-O-methyl ether exhibited activities with half-maximal lethal concentration (LC_{50}) values ranging from 18.3 μg/mL to 81.6 μg/mL (Ochieng *et al.*, 2010).

Cytotoxicity activities

Moshi *et al.* (2004) evaluated the cytotoxicity activities of 20.0% aqueous ethanol extract of G. ternifolia roots using the brine shrimp lethality test. The extract exhibited activities with an LC_{50} value of 54.5 μg/ml (Moshi *et al.*, 2004). Tshibangu *et al.* (2016) evaluated the cytotoxicity activities of chloroform, ethyl acetate, 80% methanol, methanol petroleum-ether and paclitaxel extracts of *G. ternifolia* leaves against human prostate cancer (PC-3), breast cancer (MCF-7) and non-cancerous rat skeletal muscle (L6) cell lines using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay. The extracts exhibited activities with half-maximal cytotoxic concentration (CC_{50}) values ranging from 9.7 μg/mL to >100.0 μg/mL (Tshibangu *et al.*, 2016). Tshitenge *et al.* (2017) evaluated the cytotoxicity activities of the compounds gardenifolin A to H isolated from the stem bark of *G. ternifolia* against human cervical HeLa cell line using the Cell Count-

ing Kit-8 with 5-fluorouracil as reference drug. The compounds exhibited activities with IC_{50} values ranging from 21.0 μM to 105.0 μM in comparison to the IC_{50} value of 13.9 μM exhibited by the reference drug (Tshitenge *et al.*, 2017).

CONCLUSIONS

Some reports in the literature indicate that the roots of *G. ternifolia* could be poisonous. Therefore, there is a need for detailed clinical and toxicological evaluations of crude extracts and compounds isolated from the species. Therefore, the use of *G. ternifolia* as traditional medicine for the treatment of human diseases and ailments should be treated with caution and rigorous toxicological and clinical studies are recommended.

ACKNOWLEDGEMENT

I am grateful to the reviewers who kindly commented on my manuscript.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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