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

Alfred Maroyi*

Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South 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, gastrointestinal problems, erectile dysfunction, malaria, convulsions and epilepsy. Phytochemical compounds identified from the species include alkaloids, anthocyanins, coumarins, flavonoids, phenols, 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.

*Corresponding Author

Name: Alfred Maroyi
Phone: 0027406022322
Email: amaroyi@ufh.ac.za

ISSN: 0975-7538
DOI: [https://doi.org/10.26452/ijrps.v11i4.3238](https://doi.org/10.26452/ijrps.v11i4.3238)

© 2020 | All rights reserved.
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.](image)

**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, antisykling, 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)                                                  |

Continued on next page
| 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 senegalesis Pers., Terminalia glaucescens Planch. Ex Bent., 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 (EC50) 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-dihydroxy-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)     |

*Continued on next page*
| Phytochemical component | Value | Plant part | Reference |
|-------------------------|-------|------------|-----------|
| 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\textsubscript{50}) values ranging from 40.3 μM to >100.0 μM in comparison to IC\textsubscript{50} value of 20.1 μM exhibited by the positive control (Awas \textit{et al.}, 2016). (Klotöe \textit{et al.}, 2020) evaluated the antioxidant activities of aqueous, hydro-ethanolic and ethanolic extracts of \textit{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\textsubscript{50} values in DPPH and FRAP, ranging from 1.5 mg/ml to 21.0 mg/ml (Klotöe \textit{et al.}, 2020).

\textbf{Antiplasmodial activities}

(Ochieng \textit{et al.}, 2010) evaluated the anti-plasmodial activities of acetone and methanol extracts of \textit{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 \(\beta\)-sitosterol isolated from the aerial parts of the species against chloroquine-resistant and chloroquine-sensitive strains of \textit{Plasmodium falciparum} using an automated microdilution technique with crude extract of \textit{Artemisia annua} and chloroquine as positive controls. The extracts and the compounds \(\beta\)-sitosterol, quercetin-4,7-O-dimethyl ether, kaempferol-7-O-methyl ether and naringenin-7-O-methyl ether exhibited activities with IC\textsubscript{50} values ranging from 0.9 μg/ml to 17.0 μg/ml. (Ochieng \textit{et al.}, 2010). Nureye \textit{et al.} (2018) evaluated the antiplasmodial activities of methanol crude extract, aqueous, butanol and chloroform fractions of \textit{G. ternifolia} root bark using a 4-day suppressive test against \textit{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 \textit{et al.}, 2018).

\textbf{Antisickling activities}

(Mpiana \textit{et al.}, 2015) evaluated the antisickling activities of methanol and ethyl acetate fractions, and anthocyanin crude extracts of \textit{G. ternifolia} leaves on sickle erythrocytes by the Emmel’s test. The extracts exhibited antisickling activities (Mpiana \textit{et al.}, 2015). (Ngbolua \textit{et al.}, 2014) evaluated the antisickling activities of anthocyanins, and organic acids isolated from \textit{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 \textit{et al.}, 2014).

\textbf{Antitheilerial activities}

(Hayat \textit{et al.}, 2012) evaluated the antitheilerial activities of aqueous extracts of \textit{G. ternifolia} fruits against \textit{Theileria lestoquardi} using the lymphocyte cells infected with the parasite. The extract exhibited activities against \textit{Theileria lestoquardi} macroscorizons.

\textbf{Hepatotoxicity activities}

(Dahiru, 2015) evaluated the hepatotoxicity activities of aqueous extracts of \textit{G. ternifolia} leaves against carbon tetra chloride (CC\textsubscript{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 CC\textsubscript{4} exhibited moderate protective effects by lowering the levels of serum enzymes and also revealed moderate necrosis.

\textbf{Larvicidal activities}

(Ochieng \textit{et al.}, 2010) evaluated the larvicidal activities of acetone and methanol extracts of \textit{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 \(\beta\)-sitosterol isolated from the aerial parts of the species against second-instar larva of \textit{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\textsubscript{50}) values ranging from 18.3 μg/ml to 81.6 μg/ml (Ochieng \textit{et al.}, 2010).

\textbf{Cytotoxicity activities}

(Moshi \textit{et al.}, 2004) evaluated the cytotoxicity activities of 20.0% aqueous ethanol extract of \textit{G. ternifolia} roots against the brine shrimp lethality test. The extract exhibited activities with an LC\textsubscript{50} value of 54.5 μg/ml (Moshi \textit{et al.}, 2004). (Tshibangu \textit{et al.}, 2016) evaluated the cytotoxicity activities of chloroform, ethyl acetate, 80% methanol, methanol petroleum ether and paclitaxel extracts of \textit{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\textsubscript{50}) values ranging from 9.7 μg/ml to >100.0 μg/ml (Tshibangu \textit{et al.}, 2016). (Tshitenge \textit{et al.}, 2017) evaluated the cytotoxicity activities of the compounds gardenofolin A to H isolated from the stem bark of \textit{G. ternifolia} against human cervical HeLa cell line using the Cell Counting Kit-8 with 5-fluorouracil as reference drug. The
compounds exhibited activities with IC$_{50}$ values ranging from 21.0 M to 105.0 M in comparison to the IC$_{50}$ value of 13.9 M 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.

REFERENCES

Ahua, K. M., Ioset, J.-R., Ioset, K. N., Diallo, D., Mauël, J. 2007. Antileishmanial activities associated with plants used in the Malian traditional medicine. *Journal of Ethnopharmacology*, 110(1):99–104.

Anywar, G., Kakudidi, E., Byamukama, R., Mukonzo, J., Schubert, A., Oryem-Origa, H. 2020. Medicinal plants used by traditional medicine practitioners to boost the immune system in people living with HIV/AIDS in Uganda. *European Journal of Integrative Medicine*, 35:101011–101011.

Awas, E., Omosa, L. K., Midwo, J. O., Ndakala, A., Mwaniki, J. 2016. Antioxidant Activities of Flavonoid Aglycones from Kenyan Gardenia ternifolia Schum and Thonn. *IOSR Journal of Pharmacy and Biological Sciences*, 11(3):136–141.

Bruschi, P., Morganti, M., Mancini, M., Signorini, M. A. 2011. Traditional healers and laypeople: A qualitative and quantitative approach to local knowledge on medicinal plants in Muda (Mozambique). *Journal of Ethnopharmacology*, 138(2):543–563.

Dahiru, Y. Y. D. 2015. Effect of aqueous leaves extracts of Gardenia ternifolia plant on carbon tetrachloride-induced hepatotoxicity in rats.

IOSR Journal of Pharmacy and Biological Sciences, 10:73–82.

Gelfand, M., Mavi, S., Drummond, R. R., Ndemera, B. 1985. The traditional medical practitioners in Zimbabwe. *principles of practice and pharmacopoeia*, 17.

Ghazali, G. E., Abdalla, W. E., Egami, A. E., Magboul, A. Z. I., Hamed, A. A. 2004. Aromatic Plants of Sudan. *National Centre for Research, Ministry of Science and Technology*.

Göhre, A., Álvaro Bruno Toto-Nienguессe, Futuro, M., Neinhuis, C. 2016. Plants from disturbed savannah vegetation and their usage by Bakongo tribes in Ulge. *Journal of Ethnobiology and Ethnomedicine*, 12(1):42–42.

Hayat, M. F., Tigani, H. E. A., Hassan, S. K., Shawgi, M. H., Abdel, R. M. E. H. 2012. In vitro activity of the aqueous extract of Gardenia ternifolia fruits against Theileria luestoquardi. *Journal of Medicinal Plants Research*, 6(41):5447–5451.

Hutchings, A., Scott, A. H., Lewis, G., Cunningham, A. B. 1996. Zulu medicinal plants: An inventory. *University of Natal Press, Pietermaritzburg*, page 21.

Jacob, J. O., Mann, A., Adeshina, O. I., Ndamitso, M. M. 2016. Nutritional composition of selected wild fruits from Mina area of Niger State. *Nigeria. International Journal of Nutrition and Food Engineering*, 10(1):37–42.

Kantati, Y. T., Kodjo, K. M., Dogbeavou, K. S., Vaudry, D., Leprince, J., Gbeassor, M. 2016. Ethnopharmacological survey of plant species used in folk medicine against central nervous system disorders in Togo. *Journal of Ethnopharmacology*, 181:214–220.

Klotoé, J. R., Agbodjento, E., Dougnon, V. T., Yovo, M. 2020. Exploration of the Chemical Potential and Antioxidant Activity of Some Plants Used in the Treatment of Male Infertility in Southern Benin. *Journal of Pharmaceutical Research International*, 32:1–12.

Kola, P., Metowogo, K., Kantati, Y. T., Lawson-Evi, P., Kpemissi, M., El-Hallouy, S. M. 2020. Ethnopharmacological Survey on Medicinal Plants Used by Traditional Healers in Central and Kara Regions of Togo for Antitumor and Chronic Wound Healing Effects. *Evidence-Based Complementary and Alternative Medicine*, 2020:1–12.

Koudouvo, K., Karou, D. S., Kokou, K., Essien, K., Alikokou, K., Gliho, I. A. 2011. An ethno-botanical study of antimalarial plants in Togo Maritime Region. *Journal of Ethnopharmacology*, 134(1):183–190.
Larsen, B. H. V., Soelberg, J., Jäger 2015. AK COX-1 inhibitory effect of medicinal plants of Ghana. *South African Journal of Botany*, 99:129–131.

Lautenschläger, T., Monizi, M., Pedro, M., JL Man-dombe 2018. First large-scale ethnobotanical survey in the province of Uige, northern Angola. *Journal of Ethnobiology and Etnomedicine*, 14(1):51–51.

Magassouba, F. B., Diallo, A., Kouyaté, M., Mara, F., Mara, O., Bangoura, O. 2007. Ethnobotanical survey and antibacterial activity of some plants used in Guinean traditional medicine. *Journal of Ethnopharmacology*, 114(1):44–51.

Moshi, M. J., Cosam, J. C., Mbwambo, Z. H., Kapingu, M., Nkunya, M. H. H. 2004. Testing Beyond Ethnomedical Claims: Brine Shrimp Lethality of Some Tanzanian Plants. *Pharmaceutical Biology*, 42(7):547–551.

Mpiana, P. T., Ngbolua, K. N., Tshibangu, D. S. T., Mwanangombo, D. T., Tsalu, P. V. 2015. Antisickling and radical scavenging activities of anthocyanin extracts from the leaves of Gardenia ternifolia subsp. jovis-tonantis (Welw.) Verdc. (Rubiaceae). *In: Lewis, M.E. (ed.), Sickle cell disease*. pp. 61–77.

Nadembega, P., Boussim, J. I., Nikiema, J. B., Poli, F., Antognoni, F, 2011. Medicinal plants in Baskour, Kourittenga Province, Burkina Faso: An ethnobotanical study. *Journal of Ethnopharmacology*, 133(2):378–395.

Ngbolua, K. N., Mpiana, P. T., Mudogo, V., Ngombe, N. K. 2014. Ethnopharmacological survey and floristic study of some medicinal plants. *International Journal of Medicinal Plants Photon*, 106:454–467.

Nureye, D., Assefa, S., Nedi, T., Engidawork, E. 2018. In vivo antimalarial activity of the 80% methanolic root bark extract and solvent fractions of Gardenia ternifolia Schumach. & Thonn. (Rubiaceae) against Plasmodium berghel. *Evidence-Based Complementary and Alternative Medicine*, 2018.

Ochieng, C. O., Mid, J. O., Owu, P. O. 2010. Anti-Plasmodial and Larvicidal Effects of Surface Exudates of Gardenia ternifolia Aerial Parts. *Research Journal of Pharmacology*, 4(2):45–50.

Olabanji, S. O., Omobuwajo, O. R., Ceccato, D., Adebajo, A. C., Buoso, M. C., Moschini, G. 2008. Accelerator-based analytical technique in the study of some anti-diabetic medicinal plants of Nigeria. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, 266(10):2387–2390.

Pesewu, G. A., Cutler, R. R., Humber, D. P. 2008. Antibacterial activity of plants used in traditional medicines of Ghana with particular reference to MRSA. *Journal of Ethnopharmacology*, 116(1):102–111.

Pompermaier, L., Marzocco, S., Adesso, S., Monizi, M., Schwaiger, S., Neinhuis, C., Stupnner, H., Lautenschläger, T. 2018. Medicinal plants of northern Angola and their anti-inflammatory properties. *Journal of Ethnopharmacology*, 216:26–36.

Rogers, T., Pierre-Marie, M., Igor, V., Patrick, V. 2015. Phytochemical screening and antibacterial activity of medicinal plants used to treat typhoid fever in Bamboutos division, West Cameroon. *Journal of Applied Pharmaceutical Science*, 5(6):034–049.

Silva, O., Barbosa, S., Diniz, A., Valdeira, M. L., Gomes, E. 1997. Plant Extracts Antiviral Activity against Herpes simplex Virus Type 1 and African Swine Fever Virus. *International Journal of Pharmacognosy*, 35(1):12–16.

Silva, O., Duarte, A., Cabrita, J., Pimentel, M., Diniz, A., Gomes, E. 1996. Antimicrobial activity of Guinea-Bissau traditional remedies. *Journal of Ethnopharmacology*, 50(1):55–59.

Tshibangui, D., Divakar, S., Ramanathan, M., Syamala, G. 2016. In vitro Screening of the Leaf Extracts from Gardenia ternifolia (Forest Gardenia) for their Anticancer Activity. *Journal of Complementary and Alternative Medical Research*, 1(2):1–7.

Tshitenge, D. T., Feineis, D., Awale, S., Bringmann, G. 2017. Gardenifolins A–H, Scalemic Neolignans from Gardenia ternifolia. *Journal of Natural Products*, 80(5):1604–1614.

Tsobou, R., Mapongmetsem, P. M., Damme, P. V. 2013. Medicinal plants used against typhoid fever in Bamboutos division, western Cameroon. *Ethnobotany Research and Applications*, 11:163–174.

Vahekeni, N., Neto, P. M., Kayimbo, M. K., Mäser, P., Josenando, T., da Costa, E. 2020. Use of herbal remedies in the management of sleeping sickness in four northern provinces of Angola. *Journal of Ethnopharmacology*, 256:112382–112382.

Verdant, B. 1979. Notes on African Gardenia (Rubiaceae). *Kew Bulletin, 34*(2):345–345.

Wong, K. M., Low, Y. W. 2011. A revision of Philippine Gardenia (Rubiaceae). *Edinburgh Journal of Botany*, 68(1):11–32.

Yineger, H., Yewhalaw, D. 2007. Traditional medicinal plant knowledge and use by local healers in Sekoru District, Jimma Zone, Southwestern Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, 3(1):1–7.