Alfred Maroyi /J. Pharm. Sci. & Res. Vol. 11(8), 2019, 2980-2985

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

# *Zanha africana* (Radlk.) Exell: review of its botany, medicinal uses and biological activities

**Alfred Maroyi**

*Medicinal Plants and Economic Development (MPED) Research Centre, Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa*

**Abstract**

*Zanha africana* is a medium-sized tree widely used as herbal medicine throughout its distributional range in east, central and southern Africa. This study was aimed at providing a critical review of the botany, medicinal uses and biological activities of *Z. africana*. Documented information on the botany, biological activities and medicinal uses of *Z. africana* was collected from several online sources which included BMC, Scopus, SciFinder, Google Scholar, Science Direct, Elsevier, Pubmed and Web of Science. Additional information on the botany, biological activities and medicinal uses of *Z. africana* was gathered from pre-electronic sources such as book chapters, books, journal articles and scientific publications sourced from the University library. This study showed that the bark, leaves, rootbark and roots of *Z. africana* are mainly used as herbal medicine for body pains, convulsions, epilepsy, reproductive problems, fever, malaria, gastro-intestinal problems, headache, migraine, heart and hypertension problems, painful legs, rheumatoid arthritis, rheumatism and respiratory problems. Pharmacological research revealed that *Z. africana* extracts, cyclitols and saponins isolated from the species have antibacterial, antifungal, antiviral, antidiabetic, anti-inflammatory, insecticidal, anti-trypanosomal and cytotoxicity activities. *Zanha africana* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological activities of the species.

**Keywords**: Ethnopharmacology, herbal medicine, indigenous pharmacopeia, Sapindaceae, *Zanha africana*

## INTRODUCTION

*Zanha africana* (Radlk.) Exell is a medium-sized tree belonging to the Sapindaceae family. *Zanha africana* is a multipurpose tree species used as a source of edible fruits, timber for construction, household furniture, agricultural implements and also widely collected as firewood and herbal medicine.[1] The fruits of *Z. africana* are eaten by humans in Mozambique,[2] Tanzania[3,4] and throughout the distributional range of the species in east, central and southern Africa and said to have a pleasant taste comparable to the taste of appricot, *Prunus armeniaca* L. (family Rosaceae).[1] Seeds of *Z. africana* contain 10.5% acid saponin[5] and are generally believed to be poisonous if swallowed, and fruits are reported to cause severe diarrhoea if eaten in large quantities[1]. Research by Dery et al.[6] and Rao et al.[7] showed that *Z. africana* is among the 10 priority medicinal plants in Shiyanga region of Tanzania and recommended domestication of the species in home gardens in the country. Similarly, research by Nahashon[8] showed that *Z. africana* is widely used as herbal medicine in Tanzania and in need of conservation. Research by Muzila et al.[9] showed that *Z. africana* is now rare in Machakos district in Kenya due to over-exploitation as herbal medicine. In Malawi, Bundschuh et al.[10] argued that *Z. africana* is increasingly becoming scarce in Karonga district and other regions of the country. The bark, roots and stems of *Z. africana* are sold as herbal medicines in informal herbal medicine markets in Malawi[11,12] and Tanzania.[13-15] It is within this context that the current study was undertaken aimed at reviewing the botany, medicinal uses and biological activities of *Z. africana*.

### Botanical profile of *Zanha africana*

The name *Zanha* is probably in honour of Karl Hermann Zahn (1865 - 1940), a German plant collector and botany professor[16] and the specific name *africana* means from Africa. The synonym of *Z. africana* is *Dialiopsis africana* Radik. and the English common name of the species is velvet-fruited zanha.[5] The genus *Zanha* comprises three species, namely *Z. golungensis* Hiern., whose distribution overlaps with that of *A. africana* and *Z. suaveolens* Capuron, a small tree species that is endemic to Madagascar.[1] *Zanha africana* is a deciduous dioecious shrub or small tree growing to a height of 17 metres.[1,5] The bole is cylindrical, branchless, sometimes crooked with reddish to dark brown bark, which usually flakes off revealing an orange to reddish inner bark. The leaves are alternate, paripinnately compound, ovate to elliptic in shape with reddish brown short-hairs. The inflorescence is a terminal or axillary panicle with a dense cluster of small and inconspicuous flowers that are regular, unisexual, sweet-scented and greenish in colour. The fruits are ellipsoid fleshy drupe with velvet hairs that are yellow to bright orange in colour. The species has been recorded in Angola, Botswana, Kenya, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe.[1,5,17] *Zanha africana* has been recorded in open woodland, often among rocks and on koppies or ridges, sometimes in riverine forest at an altitude ranging from 600 m to 1550 m above sea level.[1,5]

### Medicinal uses of *Zanha africana*

The bark, leaves, rootbark and roots of *Z. africana* are mainly used as herbal medicines for body pains, convulsions, epilepsy, reproductive problems, fever, malaria, gastro-intestinal problems, headache, migraine, heart and hypertension problems, painful legs, rheumatoid arthritis, rheumatism and respiratory problems (Table 1, Figure 1). Other medicinal applications recorded in a single country but supported by at least two literature records include use of rootbark and roots against fungal

infections, oral and vaginal candidiasis,[3,18-20] helminthiasis and intestinal worms,[3,19] use of roots against hernia[3,19,21] and skin problems,[9,22,23] use of bark, leaves and roots for mental illness[3,6,7,24] and use of rootbark as an insecticide[25-28] (Table 1).

**Table 1: Medicinal uses of *Zanha africana***

| Medicinal use | Parts used | Country | References |
|---|---|---|---|
| Body pains | Roots | Kenya and Zimbabwe | Wanzala et al.[23]; Gelfand et al.[29] |
| Convulsions and epilepsy | Bark, leaves, rootbark and roots | Malawi and Tanzania | Ruffo et al.[3]; Dery et al.[6]; Rao et al.[7]; Chhabra et al.[18]; Chhabra et al.[19]; Augustino and Gillah[21]; Mathias[24]; Kokwaro[30]; Morris[31]; Kitula[32]; Augustino et al.[33]; Iancu[34] |
| Dizziness | Roots | Zimbabwe | Gelfand et al.[29] |
| Elephantiasis | Bark and roots | Tanzania | Augustino et al.[33] |
| Female reproductive problems (abortion, dysmenorrhoea, facilitating childbirth, infertility, menorrhagia, pregnancy edema and disorders) | Bark, rootbark and roots | Kenya, Malawi, Tanzania and Zimbabwe | Ruffo et al.[3]; Muzila et al.[9]; Hilonga et al.[15]; Chhabra et al.[18]; Chhabra et al.[19]; Augustino and Gillah[21]; Wanzala et al.[23]; Gelfand et al.[29]; Kokwaro[30]; Morris[31]; Kaingu et al.[35] |
| Fever, typhoid fever and malaria | Bark, leaves and roots | Kenya, Malawi, Tanzania and Zimbabwe | Ruffo et al.[3]; Muzila et al.[9]; Augustino and Gillah[21]; Wanzala et al.[23]; Gelfand et al.[29]; Lukwa et al.[36]; Fowler[37]; Chinsembu[38]; Waiganjo et al.[39] |
| Fungal infections, oral and vaginal candidiasis | Rootbark and roots | Tanzania | Ruffo et al.[3]; Chhabra et al.[18]; Chhabra et al.[19]; Runyoro et al.[20] |
| Gastro-intestinal problems (abdominal pains, constipation, diarrhoea, dysentery and stomachache) | Bark, leaves, rootbark and roots | Kenya, Mozambique, Tanzania and Zimbabwe | Ruffo et al.[3]; Dery et al.[6]; Rao et al.[7]; Muzila et al.[9]; Chhabra et al.[18]; Chhabra et al.[19]; Augustino and Gillah[21]; Wanzala et al.[23]; Gelfand et al.[29]; Kokwaro[30]; Kitula[32]; Augustino et al.[33]; Kapundu et al.[40]; Stark et al.[41] |
| Haematuria | Roots | Kenya | Wanzala et al.[23] |
| Haemorrhoids | Roots | Malawi | Morris[31] |
| Hernia | Roots | Tanzania | Ruffo et al.[3]; Chhabra et al.[19]; Augustino and Gillah[21] |
| Headache and migraine | Bark, leaves and roots | Malawi, Mozambique, Tanzania and Zimbabwe | Ruffo et al.[3]; Hilonga et al.[15]; Gelfand et al.[29]; Morris[31]; Kitula[32]; Augustino et al.[33]; Iancu[34]; Fowler[37]; Stark et al.[41]; Wild and Gelfand[42]; Mbereko and Mahlatini[43] |
| Heart and hypertension problems | Roots | Kenya and Malawi | Wanzala et al.[23]; Morris[31] |
| Helminthiasis and intestinal worms | Rootbark and roots | Tanzania | Ruffo et al.[3]; Chhabra et al.[19] |
| Inflammation | Rootbark | Tanzania | Chhabra et al.[19] |
| Insecticide | Rootbark | Tanzania | Mkoga et al.[25]; Moshi and Matoju[26]; Stevenson et al.[27]; Stevenson et al.[28] |
| Magical purposes (prevent witchcraft) | Whole plant | Zimbabwe | Gelfand et al.[29] |
| Male reproductive problems (aphrodisiac, hydrocele, impotence and libido disorder and prostatitis) | Bark, rootbark and roots | Malawi, Mozambique, Tanzania and Zimbabwe | Ruffo et al.[3]; Hilonga et al.[15]; Chhabra et al.[18]; Chhabra et al.[19]; Gelfand et al.[29]; Morris[31]; Augustino et al.[33]; Luoga et al.[44]; Moshi and Mbwambo[45] |
| Mental illness | Bark, leaves and roots | Tanzania | Ruffo et al.[3]; Dery et al.[6]; Rao et al.[7]; Mathias[24] |
| Nausea | Roots | Zimbabwe | Gelfand et al.[29] |
| Nose bleeding | Roots | Kenya | Muzila et al.[9] |
| Oedema | Roots | Kenya | Wanzala et al.[23] |
| Painful legs, rheumatoid arthritis and rheumatism | Leaves, rootbark and roots | Kenya, Malawi, Mozambique, Tanzania and Zimbabwe | Chhabra et al.[18]; Chhabra et al.[19]; Wanzala et al.[23]; Gelfand et al.[29]; Kokwaro[30]; Morris[31]; Chinemana et al.[46] |
| Peptic ulcers | Roots | Kenya | Wanzala et al.[23] |
| Purgative | Roots | Tanzania | Mathias[24] |
| Respiratory problems (asthma, chest pains, colds, cough, flu, pneumonia and tuberculosis) | Bark, leaves and roots | Kenya, Malawi, Tanzania and Zimbabwe | Ruffo et al.[3]; Nahashon[8]; Muzila et al.[9]; Hilonga et al.[15]; Augustino and Gillah[21]; Wanzala et al.[23]; Gelfand et al.[29]; Augustino et al.[33]; Otieno et al.[47]; Kareji[48] |
| Skin problems (abscesses and scabies) | Roots | Kenya | Muzila et al.[9]; Kisangau and Herrmann[22]; Wanzala et al.[23] |
| Sexually transmitted diseases | Bark | Zimbabwe | Kambizi and Afolayan[49] |

**Table 2: Phytochemical composition of *Zanha africana***

| Phytochemical | Value | Plant parts | References |
|---|---|---|---|
| 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene | - | Rootbark | Stevenson et al.[27] |
| 3β,6β,11α-trihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene | - | Rootbark | Stevenson et al.[27] |
| 11α-acetoxy-3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene | - | Rootbark | Stevenson et al.[27] |
| 3β,6β-dihydroxy-7β,11α-di[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene | - | Rootbark | Stevenson et al.[27] |
| 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-24-norhopa-4(23),17(21)-diene | - | Rootbark | Stevenson et al.[27] |
| 3β,6β,11α-trihydroxy-7β-[(4-hydroxybenzoyl)oxy]-24-norhopa-4(23),17(21)-diene | - | Rootbark | Stevenson et al.[27] |
| 6β,11α-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-3-oxo-24-norhopa-4(23),17(21)-diene | - | Rootbark | Stevenson et al.[27] |
| 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-β-D-xylopyranosyl(1→2)-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-β-D-xylopyranosyl(1→3)-β-D-xylopyranosyl (1→2)-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| Alkaloids (mg/g) | 56.5 ± 7.8 | Leaves | Abdirahman et al.[50] |
| Arsenic (μg/g) | 0.05 ± 0.01 | Leaves | Abdirahman et al.[50] |
| Bornesitol | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| Calcium (μg/g) | 50.8 ± 0.6 | Leaves | Abdirahman et al.[50] |
| Cadmium (μg/g) | 7.0 ± 0.9 | Leaves | Abdirahman et al.[50] |
| Chlorine (μg/g) | 143.2 ± 1.9 | Leaves | Abdirahman et al.[50] |
| Chromium (μg/g) | 0.01 ± 0.0 | Leaves | Abdirahman et al.[50] |
| Copper (μg/g) | 0.23 ± 0.01 | Leaves | Abdirahman et al.[50] |
| Flavonoids (mg/g quercetin equivalent (QE)) | 1.58 ± 0.3 | Leaves | Abdirahman et al.[50] |
| Iron (μg/g) | 16.3 ± 0.2 | Leaves | Abdirahman et al.[50] |
| Lead (μg/g) | 0.08 ± 0.01 | Leaves | Abdirahman et al.[50] |
| Magnesium (μg/g) | 205.9 ± 41.7 | Leaves | Abdirahman et al.[50] |
| Manganese (μg/g) | 2.41 ± 0.05 | Leaves | Abdirahman et al.[50] |
| Nickel (μg/g) | 0.57 ± 0.02 | Leaves | Abdirahman et al.[50] |
| Pinitol | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| Potassium (μg/g) | 1474.6 ± 13.7 | Leaves | Abdirahman et al.[50] |
| Quebrachitol | - | Rootbark | Cuéllar et al.[51]; Cuéllar et al.[52] |
| Saponins (mg/g) | 52.3 ± 4.0 | Leaves | Abdirahman et al.[50] |
| Selenium (μg/g) | <0.03 | Leaves | Abdirahman et al.[50] |
| Sodium (μg/g) | 1893.3 ± 128.2 | Leaves | Abdirahman et al.[50] |
| Tannins (mg/g gallic acid equivalent (GAE)) | 0.77 | Leaves | Abdirahman et al.[50] |
| Titanium (μg/g) | 0.41 ± 0.05 | Leaves | Abdirahman et al.[50] |
| Total phenols (mg/g gallic acid equivalent (GAE)) | 1.85 ± 0.08 | Leaves | Abdirahman et al.[50] |
| Vanadium (μg/g) | 0.16 ± 0.03 | Leaves | Abdirahman et al.[50] |
| Zinc (μg/g) | 1.36 ± 0.03 | Leaves | Abdirahman et al.[50] |

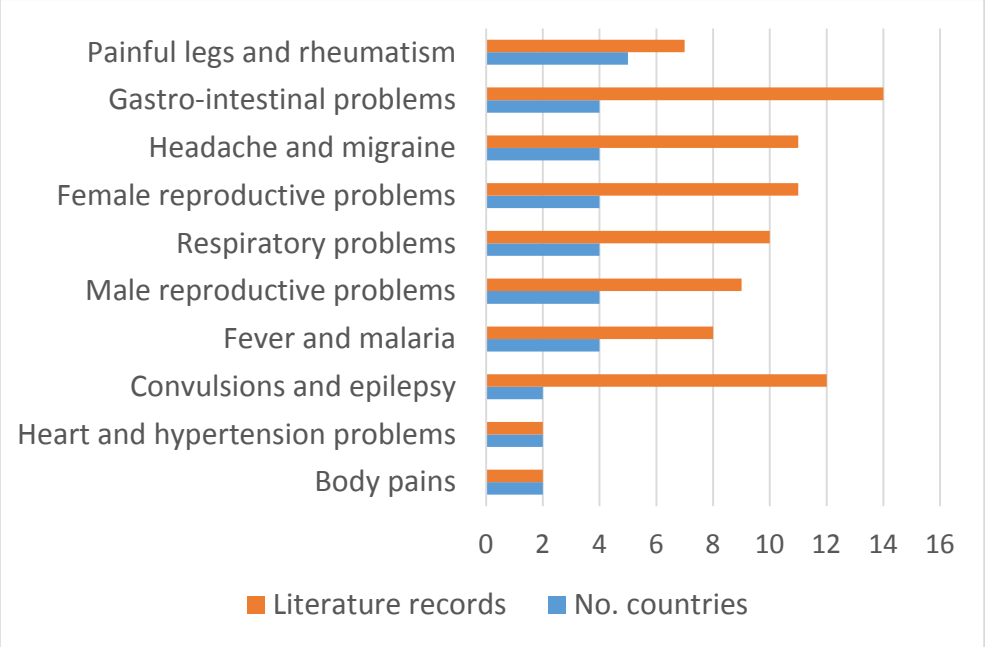


**Figure 1. Medicinal applications of *Zanha africana* derived from literature records**

**Phytochemical and nutritional composition of *Zanha africana***

Very little attention has been paid to the macro- and micro-elements of *Z. africana*. One report done by Abdirahman et al.[50] partly studied this subject and reported values of the nutritional composition of leaves of *Z. africana* (Table 2). A phytochemical screening of the rootbark of *Z. africana* revealed the presence of anthocyanins, coumarins, saponins, steroids, triterpenoids, tannins and volatile oils.[18] Cuéllar et al.[51] and Cuéllar et al.[52] identified cyclitols and saponins while Stevenson et al.[27] identified nor-hopanes from the rootbark of *Z. africana* (Table 2). Future research should focus on evaluating the biological activities of the isolated compounds.

**Biological activities of *Zanha africana***

The following biological activities have been reported from the bark, leaves and rootbark extracts of *Z. africana*, cyclitols and saponins isolated from the species: antibacterial,[49] antifungal,[53,54] antiviral,[55] antidiabetic,[50] anti-inflammatory,[51,56] insecticidal,[27] anti-trypanosomal,[57] cytotoxicity[55,57-60] activities.

**Antibacterial activities**

Kambizi and Afolayan[49] evaluated antibacterial activities of acetone, methanol and water bark extracts of *Z. africana* against *Bacillus cereus*, *Bacillus pumilus*, *Bacillus subtilis*, *Enterobacter aerogenes*, *Enterobacter cloacae*, *Escherichia coli*, *Micrococcus kristinae*, *Proteus vulgaris*, *Seratia marcescens* and *Staphylococcus aureus* using microdilution technique. The methanol extracts exhibited activities against all tested pathogens with the exception of *Escherichia coli* with minimum inhibitory concentration (MIC) values ranging from 1.0 mg/ml to 5.0 mg/ml.[49]

**Antifungal activities**

Runyoro et al.[53] evaluated antifungal activities of aqueous methanolic root extracts of *Z. africana* bioautography agar overlay method against a standard strain of Candida albicans. The extract exhibited activities with zone of inhibition ranging from 4 mm to 5 mm.[53] Fabry et al.[54] evaluated antifungal activities of methanol stem bark extract of *Z. africana* against *Aspergillus fumigatus*, *Aspergillus fiavus*, *Aspergillus niger*, *Candida albicans*, *Candida tropicalis*, *Candida parapsilosis*, *Candida glabrata*, *Candida guilliermandii* and *Candida krusei* using serial dilution technique. The extract exhibited activities against all tested pathogens with MIC values ranging from 0.3 mg/ml to >8.0 mg/ml and minimal fungicidal concentration (MFC) values ranging from 1.0 mg/ml to >8.0 mg/ml.[54]

**Antiviral activities**

Beuscher et al.[55] evaluated antiviral activities of dichloromethane root bark extract of *Z. africana* against poliovirus using the plaque reduction assay. The extract exhibited activities with the effective concentration range of 12.5 µg/ml to 25.0 µg/ml with selectivity index for a 50% plaque reduction value of 2.[55]

**Antidiabetic activities**

Abdirahman et al.[50] evaluated antidiabetic activities of *Z. africana* in alloxan induced diabetic male Swiss white albino mice by using oral and intraperitoneal routes. The extract showed antidiabetic activities at dose levels of 50 mg/kg, 100 mg/kg, 200 mg/kg and 300 mg/kg body weight.[50]

**Anti-inflammatory activities**

Recio et al.[56] evaluated the anti-inflammatory activities of methanol rootbark extracts of *Z. africana* by administering the extract topically on 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced mouse ear oedema and orally on carrageenan-induced mouse paw oedema. The extract significantly reduced the oedema 3 hours after carrageenan injection.[56] Cuéllar et al.[51] evaluated the anti-inflammatory activities of methanol root bark extracts of *Z. africana* and the compounds 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside, 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-β-D-xylopyranosyl(1→2)-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside, 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-β-D-xylopyranosyl(1→3)-β-D-xylopyranosyl (1→2)-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside, bornesitol, quebrachitol and pinitol isolated from the species using arachidonic acid induced mouse ear edema, mouse-ear edema induced by multiple topical applications of 12-O-tetradecanoylphorbol 13-acetate, oxazolone-induced contact-delayed hypersensitivity in mouse-ear edema, myeloperoxidase assay and $PLA_2$ assay system. The extract exhibited activities against arachidonic acid acute edema, 12-O-tetradecanoylphorbol 13-acetate induced chronic inflammation, oxazolone delayed-type hypersensitivity in mice and the extract also showed activities as inhibitors of $PLA_2$. The compounds 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside, 3-O-β-D-glucuronopyranosyl-2β,16α-dihydroxyolean-12-ene-23,28-dioic acid 28-O-β-D-xylopyranosyl(1→2)-α-L-rhamnopyranosyl(1→2)-α-L-rhamnopyranoside and pinitol showed activities as inhibitors of $PLA_2$.[51]

**Insecticidal activities**

Stevenson et al.[27] evaluated insecticidal activities of chloroform, methanol and water extracts of *Z. africana* rootbark and the compounds 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene, 3β,6β,11α-trihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene, 11α-acetoxy-3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene, 3β,6β-dihydroxy-7β,11α-di[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene, 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-24-norhopa-4(23),17(21)-diene, 3β,6β,11α-trihydroxy-7β-[(4-hydroxybenzoyl)oxy]-24-norhopa-4(23),17(21)-diene and 6β,11α-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-3-oxo-24-norhopa-4(23),17(21)-diene isolated from the species by evaluating its toxicity on bruchid beetles, *Callosobruchus maculatus* with rotenone as the positive control. The extracts inhibited oviposition and caused significantly higher mortality of *Callosobruchus maculatus* at a rate of application equivalent to that applied by farmers compared to control insects. Two compounds 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-21αH-24-norhopa-4(23),22(29)-diene and 3β,6β-dihydroxy-7β-[(4-hydroxybenzoyl)oxy]-24-norhopa-4(23),17(21)-diene were toxic to and reduced oviposition of *Callosobruchus maculatus* in a dose dependent manner.[27]

**Anti-trypanosomal activities**

Nibret et al.[57] evaluated the in vitro anti-trypanosomal activities of dichloromethane and methanol root extracts of *Z. africana* against the bloodstream form of *Trypanosoma brucei brucei*. The dichloromethane extract exhibited activities with half maximal inhibitory concentration ($IC_{50}$) value of 12.6 µg/ml while methanol extract exhibited $IC_{50}$ value of 33.5 µg/ml.[57]

**Cytotoxicity activities**

Chapuis et al.[58] evaluated the cytotoxicity activities of dichloromethane and methanol leaf, root bark and stem bark extracts of *Z. africana* using a calorimetric assay to determine cell survival of human colon carcinoma Co115 cells. The dichloromethane root bark extract exhibited activities with half maximal effective dose ($ED_{50}$) value of 6.8 µg/ml.[58] Beuscher et al.[55] evaluated cytotoxicity activities of dichloromethane, methanol and 25% ethanol root bark extracts of *Z. africana* on HeLa cells using a fluorescence assay with 4-methylumbelliferyl heptanoate (4-MeUH). The dichloromethane extract exhibited non-toxic limit concentration of 12.5 µg/ml.[55] Runyoro et al.[59] evaluated the cytotoxicity activities of aqueous methanolic root extracts of *Z. africana* against HeLa (human cervical carcinoma) cells using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-tetrazolium bromide (MTT) dye reduction assay. The extract at a concentration of 10 µg/ml inhibited cell proliferation by 75.7%.[59] Nibret et al.[57] evaluated the cytotoxicity activities of dichloromethane and methanol root extracts of *Z. africana* against human leukaemia HL-60 cells with diminazene aceturate as the standard drug. The dichloromethane extract exhibited activities with $IC_{50}$ value of 133.2 µg/ml and methanol extract exhibited $IC_{50}$ value of 152.7 µg/ml while diminazene aceturate exhibited $IC_{50}$ value of 128.9 µg/ml.[57] Munissi[60] evaluated the cytotoxicity activities of petroleum ether, dichloromethane, ethanol, methanol:chloroform (1:1) and water root back extracts of *Z. africana* using the brine shrimp (*Artemia salina* Leach) nauplii lethality test. The extract exhibited activities with half maximal lethal concentration ($LC_{50}$) values ranging from 41.1 µg/mL and 240.0 µg/mL.[60]

**Toxicity activities**

Abdirahman et al.[50] evaluated toxicity activities of *Z. africana* in male Swiss white albino mice by orally and intraperitoneally administering 1 g/kg body weight of extract daily for 28 days and assessing changes in body and organ weights, hematological and biochemical parameters. The dose of 1 g/kg body weight caused toxicological effects as demonstrated by the body and organ weight changes, hematological and biochemical parameters.[50]

## CONCLUSION

The present review summarizes the ethnomedicinal uses, phytochemistry and biological activities of the bark, leaves, rootbark and roots extracts of *Z. africana*. The historical traditional usage of *Z. africana* as herbal medicine in east, central and southern Africa calls for detailed phytochemical and pharmacological studies aimed at correlating its documented ethnomedicinal uses with the phytochemical and pharmacological properties of the species. There is need for clinical and toxicological evaluations since *Z. africana* contains potentially toxic compounds. Therefore, future research should focus on identification of toxic compounds, the possible side effects caused by taking *Z. africana* as herbal medicine, and mechanisms of how potential toxic components of the species can be managed when the species is used as herbal medicine.

### Conflict of interest

The author declares that he has no conflict of interest.

### Acknowledgements

I would like to express my gratitude to Govan Mbeki Research and Development Centre (GMRDC), University of Fort Hare for financial support to conduct this study.

## REFERENCES

[1] Mojeremane, W., in: Lemmens, R.H.M.J., Louppe, D., Oteng-Amoako, A.A. (Eds.), *Plant Resources of Tropical Africa 7: Timbers 2*, PROTA Foundation, Backhuys Publishers, Leiden 2012, pp. 676-678.
[2] Moreno, B.M., Escobar, J.P., Lopes, G.M., *Rev. Fac. Nac. Agron. Medellín*. 2019, 72, 8829-8840.
[3] Ruffo, C.K., Birnie, A., Tengnas, B., *Edible Plants of Tanzania*, RELMA Technical Handbook Series 27, Regional Land Management Unit, Swedish International Development Cooperation Agency, Nairobi 2002.
[4] Mpasiwakomu, R.A., Nyomora, A.M.S., Gimbi, A., *Huria J*. 2017, 24, 150-168.
[5] Palgrave, C.M., *Keith Coates Palgrave Trees of Southern Africa*, Struik Publishers, Cape Town 2002.
[6] Dery, B.B., Otsyina, R., Ng'tigwa, C., *Indigenous Knowledge of Medicinal Trees and Setting Priorities for their Domestication in Shinyanga Region, Tanzania*, International Center for Research in Agroforestry, Nairobi 1999.
[7] Rao, M.R., Palada, M.C., Becker, B.N., *Agrofor. Syst.* 2004, 61, 107-122.
[8] Nahashon, M., *Conservation of Wild-harvested Medicinal Plant Species in Tanzania: Chain and Consequence of Commercial Trade on Medicinal Plant Species*, MSc Dissertation, Uppsala University, Uppsala 2013.
[9] Musila, W., Kisangau, D., Muema, J., *Conservation Status and Use of Medicinal Plants by Traditional Medical Practitioners in Machakos District, Kenya*, National Museums of Kenya, Nairobi, 2005.
[10] Bundschuh, T.V., Hahn, K., Wittig, R., *Flora Veg. Sudano-Sambesica* 2011, 14, 3-8.
[11] Mander, M., Diederichs, N., Steytler, N., in: Diederichs, N. (Ed.), *Commercialising Medicinal Plants: A Southern African Guide*, Sun Press, Stellenbosch 2012, pp. 167-192.
[12] Meke, G.S., Mumba, R.F.E., Bwanali, R.J., Williams, V.L., *Int. J. Sustain. Develop. World Ecol*. 2017, 24, 73-87.
[13] Mahunnah, R.L.A., Augustino, S., Otieno, J.N., Elia, J., *Med. Pl. Cons.* 2012, 15, 35-41.
[14] Otieno, J., Abihudi, S., Veldman, S., Nahashon, M., Van Andel, T., de Boer, H.J., *J. Ethnobiol. Ethnomed*. 2015, 11, 10.
[15] Hilonga, S., Otieno, J.N., Ghorbani, A., Pereus, D., Kocyan, A., de Boer, H., *S. Afr. J. Bot.* 2018, 122, 214-224.
[16] Quattrocchi, U., *CRC World Dictionary of Plant Names: Common Names, Scientific Names, Eponyms, Synonyms and Etymology*, CRC Press, Boca Raton 2000.
[17] Swanepoel, W., *Bothalia* 2013, 43, 88-89.
[18] Chhabra, S.C., Uiso, F.C., Mshiu, E.N., *J. Ethnopharmacol.* 1984, 11, I57-179.
[19] Chhabra, S.C., Mahunnah, R.L.A., Mshiu, E.N., *J. Ethnopharmacol.* 1991, 33, 143-157.
[20] Runyoro, D.K.B., Ngassapa, O.D., Matee, M.I.N., Joseph, C.C., Moshi, M.J., *J. Ethnopharmacol*. 2006, 106, 158-165.
[21] Augustino, S., Gillah, P.R., *Int. For. Rev.* 2005, 7, 44-58.
[22] Kisangau, D.P., Herrmann, T.M., *Int. J. Biod. Sci. Manag*. 2007, 3, 184-192.
[23] Wanzala, W., Syombua, M., Alwala, J.O., *Indian J. Ethnophytopharmaceut.* 2016, 2, 6-58.
[24] Mathias, M.E., *Taxon* 1982, 31, 488-494.
[25] Mkoga, Z.J., Shetto, R.M., Mkomwa, S., Mwakimbwala, R., Kabungo, D.A., Ndegeulaya, D., *Tanzania Agr Training Newslet.* 2004, 19, 6-8.
[26] Moshi, A.P., Matoju, I., *Crop Prot*. 2017, 92, 16-28.
[27] Stevenson, P.C., Green, P.W.C., Veitch, N.C., Farrell, I., Kusolwa, P., Belmain, S.R., *Phytochem.* 2016, 123, 25-32.
[28] Stevenson, P.C., Isman, M.B., Belmain, S.R., *Indust. Crops Prod*. 2017, 110, 2-9.
[29] Gelfand, M., Mavi, S., Drummond, R.B., Ndemera, B., *The Traditional Medical Practitioner in Zimbabwe: His Principles of Practice and Pharmacopoeia*, Mambo Press, Gweru 1985.
[30] Kokwaro, J.O., *Medicinal Plants of East Africa*, University of Nairobi, Nairobi 1993.
[31] Morris, B., *Chewa Medical Botany: A Study Of Herbalism in Southern Malawi*, International African Institute, London 1996.
[32] Kitula, R.A., *J. Ethnobiol. Ethnomed*. 2007, 3, 7.
[33] Augustino, S., Hall, J.B., Makonda, F.B.S., Ishengoma, R.C., *J. Med. Pl. Res*. 2011, 5, 6352-6372.
[34] Iancu, M., *Local Use of Traditional and Modern Medicine: A Case Study in Babati District, Tanzania*, BSc Honours Dissertation, Södertörn University College, Flemingsberg 2011.
[35] Kaingu, C.K., Oduma, J.A., Kanui, T.I., *J. Ethnopharmacol.* 2011, 137, 495-502.
[36] Lukwa, N., Mutambu, S.L., Makaza, N., Molgaard, P., Furu, P., *Niger. J. Natural Prod. Med.* 2001, 5, 4-7.
[37] Fowler, D.G., *Traditional Fever Remedies: A List of Zambian Plants*, Royal Botanic Gardens, Kew, London 2006.
[38] Chinsembu, K.C., *Acta Trop*. 2015, 152, 32-48.
[39] Waiganjo, B.W., Githae, E.W., Warui, C.M., Opiyo, E.A., *Int. J. Med. Pl. Res* 2015, 4, 157-167.
[40] Kapundu, M., Warin, R., Delaude, C., *Bull. Soc. Chim. Belg.* 1992, 101, 283-286.
[41] Stark, T.D., Mtui, D.J., Balemba, O.B., *Animals* 2013, 3, 158-227.
[42] Wild, H., Gelfand, M., *Central Afr. J. Med*. 1959, 5, 292-305.
[43] Mbereko, A., Mahlatini, P. *Int. J. Sociol. Anthropol*. 2014, 6, 136-145.
[44] Luoga, E.J., Witkowski, E.T.F., Balkwill, K., *Econ. Bot.* 2000, 54, 328-343.
[45] Moshi, M.J., Mbwambo, Z.H., *Pharmaceut. Biol.* 2002, 40, 552-560.
[46] Chinemana, F., Drummond, R.B., Mavi, S., De Zoysa, I., *J. Ethnopharmacol.* 1985,14, 159-172.
[47] Otieno, J.N., Magadula, J.J., Kakudidi, E., Kirimhuzya, C., Orodho, J., Okemo, P., *Int. J. Biod. Cons.* 2011, 3, 610-617.
[48] Kareji, A.E., *Int. J. Herbal Med.* 2013, 1, 85-87.
[49] Kambizi, L., Afolayan, A.J., *J. Ethnopharmacol*. 2001, 77: 5-9.
[50] Abdirahman, Y.A., Juma, K.K., Makori, W.A., Agyirifo, D.S., Ngugi, M.P., Gathumbi PK, Ngeranwa, J.J.N., Njagi E.N.M., *Pharm. Anal. Acta.* 2015, 6, 9.
[51] Cuéllar, M.J., Giner, R.M., Recio, M.C., Just, M.J., Manez, S., Cerda, M., Hostettmann, K., Rios, J.L., *J. Nat. Prod*. 1997, 60, 1158-1160.
[52] Cuéllar, M.J., Giner, R.M., Recio, M.D., Just, M.J., Manez, S., Rios, J.L., Bilia, A.R., Msonthi, J., Hostettmann, K., *J. Nat. Prod*. 1997, 60, 191-194.
[53] Runyoro, D.K.B, Matee, M.I.N., Ngassapa, O.D., Joseph, C.C., Mbwambo, Z.H., *BMC Compl Alt Med* 2006, 6, 11.
[54] Fabry, W., Okemo, P., Ansorg, R., *Mycoses* 1996, 39, 67-70.
[55] Beuscher, N., Bodinet, C., Neumann-Haefelin, D., Marston, A., Hostettmann, K., *J. Ethnopharmacol.* 1994, 42, 101-109.
[56] Recio, M.C., Giner, R.M., Manez, S., Rios, J.L., Marston, A., Hostettmann, K., *Phytother. Res.* 1995, 9, 571-574.
[57] Nibret, E., Ashour, M.L., Rubanza, C.D., Wink, M., *Phytother. Res.* 2010, 24, 945-947.
[58] Chapuis, J.-P., Sordat, B., Hostettmann, K., *J. Ethnopharmacol*. 1988, 23, 273-334.
[59] Runyoro, D.K.B., Kamuhabwa, A., Ngassapa, O.D., de Witte, P., *East Central Afr. J. Pharmaceut. Sci.* 2005, 8, 35-39.
[60] Munissi, J.J.E., *Tanzania J. Sci.* 2019, 45, 44-52.