

## Original Research Article

# Ethnomedicinal uses, phytochemistry and pharmacological properties of the genus, *Kirkia*

**Alfred Maroyi**

Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa

\*For correspondence: **Email:** [amaroyi@ufh.ac.za](mailto:amaroyi@ufh.ac.za)

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### Abstract

**Purpose:** To review the phytochemical, ethnopharmacology and traditional uses of the *Kirkia* species throughout their distributional range.

**Methods:** The information documented in this article is from scientific journals, books, theses and reports obtained from library collections and electronic search engines such as Google, Google scholar, publishing sites such as Elsevier, ScienceDirect, BioMed Central (BMC), PubMed and other scientific database sites such as ChemSpider and PubChem.

**Results:** *Kirkia* species are used as herbal remedies for abdominal pain, cholera, cough, snake bites and toothache in East, Central and Southern Africa. There are similarities in the use of *Kirkia* species as herbal medicines in Central and Southern Africa in terms of plant parts used, herbal preparation, route of administration and dosage. The chemical composition of *Kirkia* species is dominated by fatty acids, flavonols, isocoumarin, lignans, neolignans, nor-carotenoids, phenols and tannins isolated from leaves, stem bark and roots. Major biological activities demonstrated by *Kirkia* species include antimicrobial, antioxidant, antiplasmodial and antiplatelet activities.

**Conclusion:** *Kirkia* species are valuable herbal medicines with multiple pharmacological effects. *Kirkia* extracts and their isolates are potential sources of modern medicines following future detailed studies to elucidate their mechanisms of action, toxicity and clinical trials.

**Keywords:** Africa, Ethnobotanical, Isocoumarin, *Kirkia* species, Lignans, Livelihood needs, Neolignans, Traditional medicine

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## INTRODUCTION

The monotypic genus *Kirkia* Oliver is a member of the dicotyledonous family Kirkiaceae Takhtajan which contains six species [1,2]. The genus *Kirkia* was named after Dr John Kirk (1832 - 1922), an English doctor and plant collector, who accompanied Livingstone on his Zambezi expedition [3]. Genus *Kirkia* is distributed in tropical Africa from Ethiopia and Somalia, south to Madagascar, South Africa and Namibia [4,5]. *Kirkia acuminata* Oliver is the most known and widely distributed species in the genus [4,6]. It is

semi-deciduous, monoecious medium-sized tree, drought resistant and generally grows in hot and dry areas of Angola, Botswana, Democratic Republic of Congo (DRC), Malawi, Mozambique, Namibia, Zambia, Zimbabwe and South Africa [7].

*Kirkia burgeri* Stannard is a shrub or small tree divided into two sub-species, *K. burgeri* subsp. *burgeri* growing mainly on limestone slopes in Ethiopia. *Kirkia burgeri* subsp. *burgeri* is categorized as vulnerable (VUB2ab) (i,ii,iii,iv) on the IUCN Red List [8], primarily because of

reduction in population size based on decline in area of occupancy, extent of occurrence and/or quality of habitat. *Kirkia burgeri* subsp. *somalensis* Stannard is confined to gypsum and anhydrite slopes in northern Somalia where it is categorized as near threatened [9]. *Kirkia burgeri* subsp. *somalensis* is generally rare and threatened by habitat degradation, grazing and over-exploitation of the species as a source of construction timber. *Kirkia dewinteri* Merxm. & Heine is a small tree up to 10 m tall endemic to the limestone and dolomite outcrops in the northwestern part of Namibia [4,6,10].

*Kirkia dewinteri* is categorized as vulnerable (VUD2) on the IUCN Red List in Namibia [11] primarily because of habitat destruction. Ecological research done on *K. dewinteri* showed that the species is generally rare in Namibia, characterized by restricted distributional range and in need of protection from human disturbances and wild fires [10]. *Kirkia leandrii* (Capuron) Stannard, is a tree, endemic to dry deciduous forest of Bemaraha, central Madagascar [5]. *Kirkia tenuifolia* is a shrub or small tree which is common or occasional in sandy or stony bushland in Ethiopia, Kenya and Somalia [4]. *Kirkia wilmsii* Engl. is a deciduous tree endemic to South Africa, found on granite and dolomitic soils in dry bushveld areas or on rocky slopes in Gauteng, Limpopo, Mpumalanga and the North West provinces [4,6,12].

*Kirkia* species are characterized by fatty acids, flavonols, isocoumarin, lignans, neolignans, nor-carotenoids, phenols and tannins which are used medicinally. Preliminary chemical and pharmacological studies done so far on *Kirkia* species have shown promising results with the possibility that these phytochemical compounds may be responsible for the medicinal uses and biological activities demonstrated by the species. The genus certainly has a high use value. The present review compiles fragmented information on the phytochemical, ethnopharmacological and traditional uses of the *Kirkia* species, hoping that this information will highlight the ethnopharmacological importance of the genus and will provide baseline information for future researchers intending to do further work on the genus.

### Vernacular names and traditional uses

*Kirkia* species are known by various vernacular names in different geographical areas in Eastern, Central and Southern Africa (Table 1). Insight into the societal value of *Kirkia* species in East, Central and Southern Africa can be gained by examining these vernacular names. A survey of literature showed at least 39 vernacular names for *K. acuminata* in Southern Africa (Table 1). *Kirkia burgeri* subsp. *burgeri* is known by two vernacular names in Ethiopia (Table 1), while *Kirkia tenuifolia* is known by one vernacular name in Ethiopia (Table 1).

**Table 1:** Vernacular names of *Kirkia* species

Vernacular name(s), Language or geographical region in brackets	Country	Reference(s)
<b><i>Kirkia acuminata</i> Oliv.</b>		
<i>Ivomena, modumela, motsemodumo, mozumina, muzumina</i> (Setswana), <i>white syringa</i> (English)	Botswana	[13,14]
<i>Mtumbu, mtumbwi, mzumba, ntungundwa</i> (Nyanja)	Malawi	[15]
<i>Mtumbui</i> (Changana); <i>n'tun'gundua</i> (Sena); <i>poko poko</i> (Tsonga)	Mozambique	[16]
<i>Mountain kirkia, white syringa</i> (English)	Namibia	[7,10]
<i>Modumela</i> (Northern Sotho, Tswana); <i>mvumayila</i> (Tsonga); <i>mubvumala, mubvumela</i> (Venda); <i>umsila-omhlophe, umsilinga</i> (Zulu), <i>white kirkia, white seringa</i> (English), <i>witsering</i> (Afrikaans)	South Africa	[6,17,18]
<i>Mtumbwi</i> (Nyanja); <i>mzumba</i> (Senga, Tumbuka); <i>musanta</i> (Tonga), <i>white syringa</i> (English)	Zambia	[19]
<i>Bastard marula, white seringa, white syringa</i> (English); <i>mubvumira, mutsakatidze, mutuhwa, mutuva</i> (Shona); <i>musanta</i> (Tonga); <i>umvumila, umvumile</i> (Ndebele); <i>vumaila</i> (Hlengwe, Shangaan)	Zimbabwe	[7,20-24]
<b><i>Kirkia burgeri</i> Stannard subsp. <i>burgeri</i></b>		
<i>Bisdhugaa</i> (Borana); <i>musdhugaa</i> (Afan Oromo)	Ethiopia	[25,26]
<b><i>Kirkia dewinteri</i> Merxm. &amp; Heine</b>		
<i>Kaoko syringa</i> (English)	Namibia	[10]
<b><i>Kirkia tenuifolia</i> Engl.</b>		
<i>Hudhaa sawwaa</i> (Afan Oromo)	Ethiopia	[26]
<b><i>Kirkia wilmsii</i> Engl.</b>		
<i>Bastard pepper tree, mountain kirkia, mountain seringa, wild pepper tree</i> (English); <i>basterpeperboom, bergsering, slaploot, wildepeperboom</i> (Afrikaans); <i>legaba, modumela</i> (Northern Sotho)	South Africa	[6,17]

*Kirkia dewinteri* is known by one vernacular name in Namibia (Table 1), while *Kirkia wilmsii* is known by nine vernacular names in South Africa (Table 1). Local people rarely name plant species that they do not use. The long list of vernacular names for *K. acuminata* and *K. wilmsii* indicates that local people in Central and Southern Africa have an active interest in these species.

The traditional uses of *Kirkia* species are referred to in many folkloric and ethnobotanical studies done in East, Central and Southern Africa, where the species are still used as primary sources of traditional medicine. A total of 15 human ailments are treated with *Kirkia* species (Table 2). Abdominal pain, cholera, cough, snake bites and toothache are the most commonly treated human diseases and ailments (Table 2). Many similarities can be recognized when the ethnomedicinal uses of *K. acuminata* are compared in Central and Southern Africa in terms of plant parts used, herbal preparation, route of administration and dosage strength (Table 2). For example, bark infusion of *K. acuminata* is taken as a remedy for abdominal pains in South Africa [27] and Zimbabwe [21]. Root decoction is taken as remedy for cough in Botswana [13,14], Mozambique [28], South Africa [27] and Zimbabwe [21]. Fruit juice of *K. acuminata* is used as a snake bite antidote in Botswana [14] and Zimbabwe [21,23,24]. Such similarities may be ascribed to efficacy of the plant species. This observation is supported by Hossan *et al* [33] who argued that a plant species is regarded as effective herbal medicine if it is used by many people in different geographical regions for the same disease or ailment.

The most frequently used plant parts are bark (53 %), roots (23 %), fruits and leaves (12 % each) (Figure 1A). It is well recognized by conservationists that medicinal plants primarily valued for their root parts and those which are intensively harvested for their bark often tend to be the most threatened by over-exploitation [30]. There is need for implementing conservation strategies and mechanisms in East, Central and Southern Africa aimed at conserving *Kirkia* species, given the fact that *K. burgeri* subsp. *burgeri*, *K. burgeri* subsp. *somalensis* and *K. dewinteri* are threatened with extinction [8,9,11]. The population decline of *Kirkia* species is due to habitat degradation and loss [8,9,11], naturally rare and highly localized in distribution [10,11], over-exploitation of the species [9] and medicinal plant trade. According to Moeng and Potgieter [31], *K. wilmsii* roots were observed in 44 % of the medicinal plant (*muthi*) markets in the

Limpopo province, South Africa. Given the widespread usage of *Kirkia* species in traditional medicine resulting in negative impacts on wild populations calls for conservation strategies aimed at halting or reducing these negative impacts. Therefore, conservation of *Kirkia* species and the traditional knowledge associated with their medicinal applications are important for sustainable utilization of the species. It is important to take concrete conservation measures aimed at protecting the species against over-exploitation and habitat loss. *Kirkia* remedies are often utilized in the form of decoction or infusion (60.9 %), bark powder mixed with food (17.4 %), ointments or paste (13.0 %), body and tooth wash (4.3 %) (Figure 1B). Most (70.6 %) of the preparations are prescribed orally (Table 2). All *Kirkia* remedies are used as monotherapies (Table 2).

In addition to the medicinal uses, the swollen roots of *K. acuminata*, *K. tenuifolia* and *K. wilmsii* are used as sources of water during drought [5,7,17,20,34]. Leaves, seeds and twigs of *K. acuminata* and leaves of *K. burgeri* subsp. *burgeri* and *K. wilmsii* are browsed by game and livestock [17,25,45]. The timber or wood of *K. acuminata* and *K. wilmsii* are used for construction poles, carving household utensils and furniture [12,40]. Fibre obtained from the bark, young shoots and roots of *K. acuminata* and *K. wilmsii* used for weaving [6,7,12,17]. *Kirkia acuminata* is grown around homestead boundaries as a barrier or hedge or live fence and also as an ornamental and shade tree. In South Africa, Zambia and Zimbabwe, *K. acuminata* is commonly used as live fence around fields, gardens, homesteads and schools as a form of protection against animals; around enclosures (kraals) for livestock. The poles of *K. acuminata* take root and grow easily [12] explaining the high proportion of study households (23 %) with the species growing around their homesteads as live fence in Malawi [41].

### Phytochemical studies

Over the last 50 years, there have been numerous attempts to scientifically validate the ethnomedicinal uses of *Kirkia* species. However, most of these studies concentrated on *K. acuminata*, possibly because of its availability when compared with other *Kirkia* species which are highly localized with restricted distribution. Some ethnopharmacological studies have also been carried out on *K. wilmsii*, a South African endemic species. Based on literature records documenting traditional and potential medicinal uses of *K. acuminata* and *K. wilmsii*, researchers

have also investigated their phytochemical and pharmacological properties aimed at identifying the compounds responsible for their wide use in traditional medicine. Multiple classes of phytochemicals including tannins [43,46,47], quercetin, caffeic acid, ellagic acid and gallic acid [54], flavonol, lignans, neolignans, nor-carotenoids and isocoumarin [49], phenols, acetic acid, propionic acid, iso butyric acid, butyric acid and valeric acid [50] have been identified from *K. acuminata* and *K. wilmsii* leaves, roots, seeds and twigs.

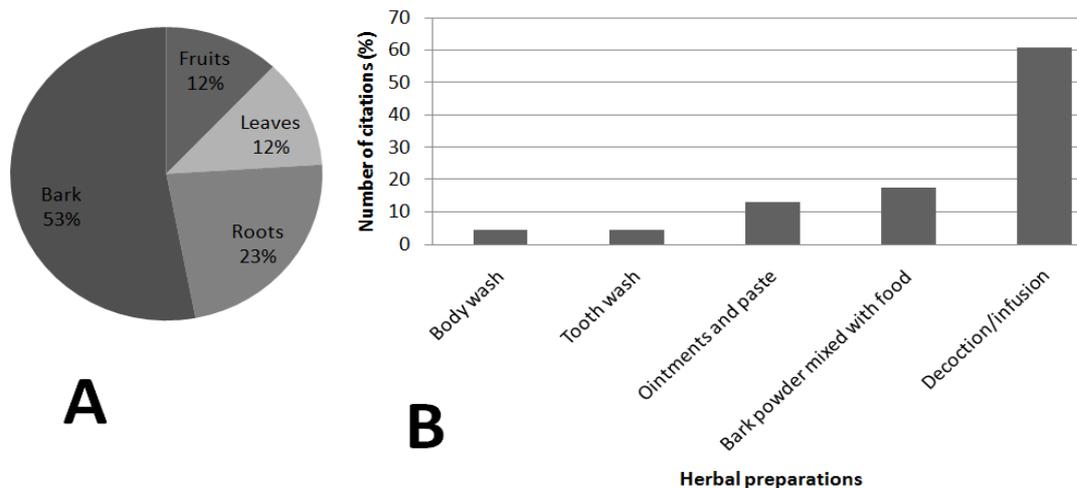
Fresh leaves and twigs of *K. acuminata* have a wide variety of nutrients such as minerals, fibre, proteins and fat [43,46,47]. *Kirkia acuminata* leaves, seeds and twigs are a good source of minerals such as calcium, copper, iron, magnesium, manganese, phosphorus, sodium and zinc [43,45,47]. According to Aganga and Mosase [43], *K. acuminata* seeds have adequate quantities of phosphorus, calcium, magnesium, potassium, iron and copper required for beef, sheep and goat growth and production, while the content of sodium, manganese and zinc are below the recommended levels required by ruminants for growth and productivity. Some of these nutrients are present in low concentrations, but may have significant impact on animal health as both *K. acuminata* and *K. wilmsii* are important stock feed in southern Africa [17,20,43,46,47].

Nooteboom [48] isolated quercetin, caffeic acid, ellagic acid and large quantities of gallic acid from hydrolysed leaf extracts of *K. wilmsii* (Figure 2). Similarly, Gemeda and Hassen [50] isolated acetic acid, propionic acid, iso butyric acid, butyric acid and valeric acid from both *K.*

*acuminata* and *K. wilmsii* leaves and young stems. Diakanamwa *et al* [51] isolated 3,3'-di-O-methylellagic acid 4-O- $\beta$ -D-xylopyranoside from *K. acuminata* roots. From *K. acuminata* hexane stem bark extract, Mulholland *et al* [49] isolated (+)-(6S,7E,9R)-blumenol A and (+)-(6S,7E)-dehydrovomifoliol and (+)-de-O-methylsiodiplodin. The methanol stem bark extract of *K. acuminata* yielded neolignan, (-)-4',9,9'-trihydroxy-3'-methoxy-3-O.8',4-O.7'-neolignan while dichloromethane extract yielded (+)-dihydrodehydrodiconiferyl alcohol, (+)-lyoniresinol and (-)-*ent*-isolariciresinol [49]. The dichloromethane extract of *K. wilmsii* yielded (+)-(6S,7E,9R)-blumenol A, (+)-(6S,7E)-dihydrovomifoliol, (+)-4-ethanone-3,4-dihydro-6,8-dihydroxy-5-methylisocoumarin and (+)-(2R,3R)-7-O-methylaromadendrin. Although there is a possibility that these phytochemical compounds may be responsible for the medicinal uses and biological activities demonstrated by both *K. acuminata* and *K. wilmsii*, but no studies were found in literature with details of biological activities of these compounds isolated from *Kirkia* species.

### Pharmacological activities

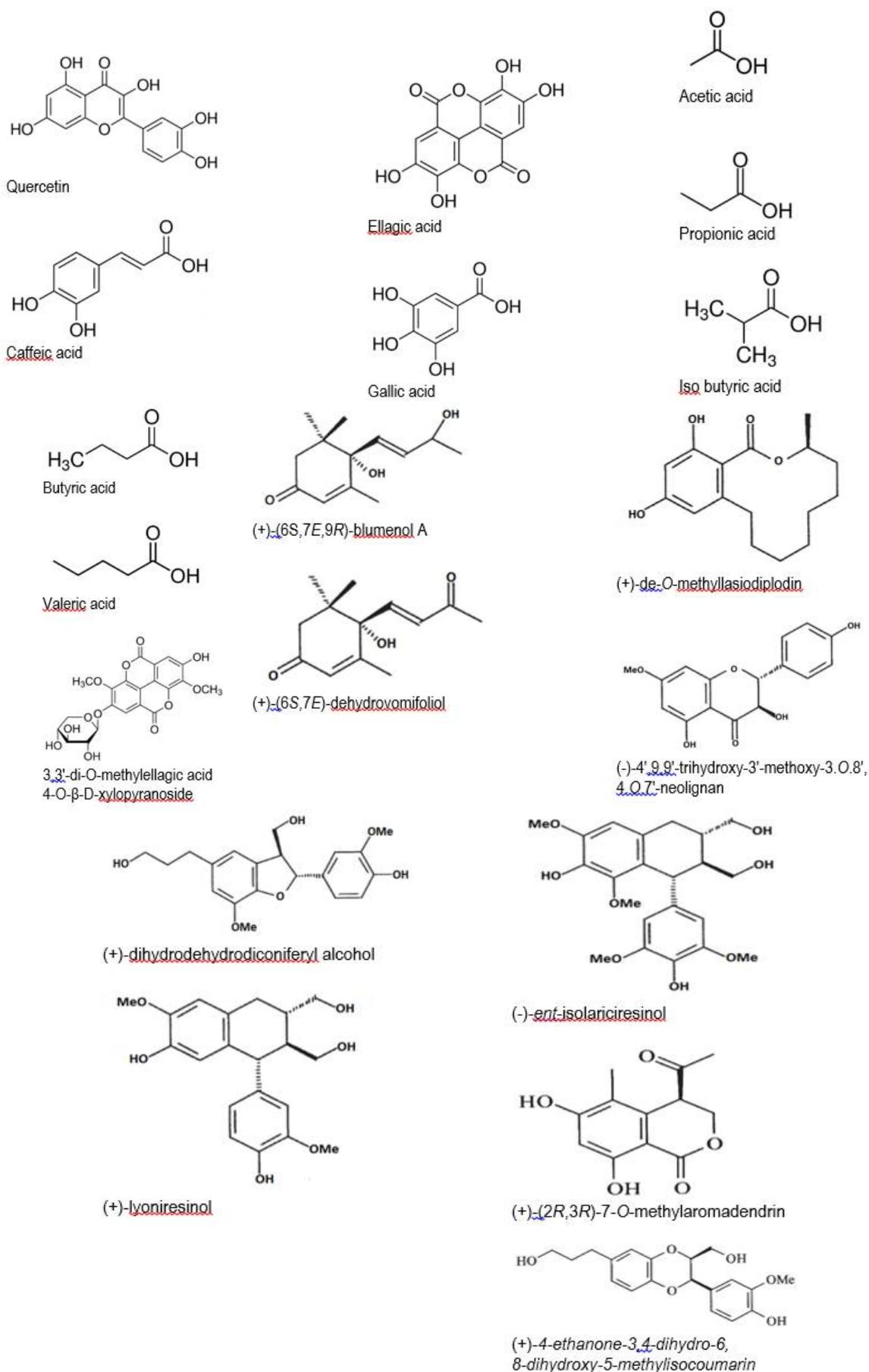
Some of the pharmacological activities of *K. acuminata* and *K. wilmsii* reported in literature correlate with some of their ethnomedicinal uses listed in Table 2. While some of these pharmacological activities may not relate directly to their ethnomedicinal uses, they may provide some insight into potential therapeutic value and bioactive properties of *K. acuminata* and *K. wilmsii*. The biological activities that have been reported so far include antimicrobial [52-55], antioxidant [56], antiplasmodial [36] and antiplatelet [56] activities.



**Figure 1:** Preparation of *Kirkia* herbal medicines in East, Central and Southern Africa. A: Plant parts used and B: Herbal preparations

Table 2: Traditional uses of *Kirkia* species

Use	Plant part(s) used and preparation	Country practised and reference(s)
<b>Medicinal uses</b>		
<b><i>K. acuminata</i></b>		
Abdominal pain	Bark infusion taken by mouth	South Africa [27], Zimbabwe [21]
Antiemetic	Bark infusion taken by mouth	Zimbabwe [21]
Backache	Bark infusion taken by mouth	Zimbabwe [32]
Cholera	Bark decoction drunk or bark powder mixed with food	Zimbabwe [22,24]
Constipation	Bark decoction drunk or bark powder mixed with food	Zimbabwe [22,24]
Cough	Root decoction taken by mouth	Botswana [13,14], Mozambique [28], South Africa [27], Zimbabwe [21]
Diarrhea	Bark decoction drunk or bark powder mixed with food	Zimbabwe [22,24]
Dysentery	Bark decoction drunk or bark powder mixed with food	Zimbabwe [22,24]
Fever	Not specified	Zambia [33]
Snake bite antidote	Fruit juice applied on bitten part	Botswana [14], Zimbabwe [21,23,24]
To bring luck	Powdered inner bark added to bathing water	Botswana [13]
To fatten babies	Baby washed with root infusion	Zimbabwe [21]
Toothache	Tooth washed with decoction of pulverized roots	Zimbabwe [4,7]
Toothache	Burnt root powder rubbed on painful tooth	Zambia [20]
Vomiting	Bark infusion is taken by mouth	South Africa [27]
Wounds	Fruit juice applied to wounds	Zimbabwe [20,23,24]
<b><i>K. tenuifolia</i></b>		
cholera	Bark decoction is taken by mouth	Somalia [34]
<b><i>K. wilmsii</i></b>		
Diabetes mellitus	Root juice taken orally	South Africa [35]
Fever	Leaf decoction	South Africa [36]
Hypertension	Roots eaten raw	South Africa [37,38]
Malaria	Bark/leaf decoction	South Africa [36,39]
Toothache	Tooth washed with root decoction	South Africa [40]
<b>Other uses</b>		
<b><i>K. acuminata</i></b>		
Charcoal	Wood made into charcoal	Malawi [7]
Hedge, ornamental, shade	Grown and managed as hedge, cattle enclosure, live fence, ornamental, stock shade and shade tree in home gardens	Malawi [15,41], South Africa [17], Zambia [20], Zimbabwe [7]
Religious significance	Often planted in grave-yards in memory of the deceased	Zambia [20]
Religious significance	Shona people believe that ancestral spirits live in <i>K. acuminata</i> branches	Zimbabwe [42]
Source of water	Swollen roots are used as a source of water during drought	South Africa [17], Zambia [20], Zimbabwe [7]
Stock feed	Leaves and seeds browsed by game and livestock	Botswana [43], Zambia [20], Zimbabwe [44]
Timber, wood	For construction poles; wood for carving and furniture	Botswana [14], Malawi [41], South Africa [17], Zambia [20], Zimbabwe [7]
Weaving	Root bark made into cloth	Zambia [19,20], Zimbabwe [4,7]
<b><i>K. burgeri</i> subsp. <i>burgeri</i></b>		
Fodder	Browsed by livestock	Ethiopia [25,45]
<b><i>K. tenuifolia</i></b>		
Source of water	Swollen roots are used as a source of water during drought	Kenya [5,34]
<b><i>K. wilmsii</i></b>		
Garden plant	An excellent garden plant which tolerates mild frost	South Africa [6]
Source of water	Swollen roots are used as a source of water during drought	South Africa [5,17]
Stock feed	Foliage often cut as goat fodder and eaten by other wild animals	South Africa [17]
Timber, wood	Wood used for making household utensils	South Africa [12,40]
Weaving	Fibre obtained from the bark, young shoots and roots is strong and used for weaving	South Africa [5,6,12,17]



**Figure 2:** Chemical structures of compounds isolated from leaves, stem bark and roots of *Kirkia* species

## Antimicrobial activity

One of the most common ethnomedicinal uses of *Kirkia* species, *K. acuminata*, *K. tenuifolia* and *K. wilmsii* is in the treatment of a wide range of infectious diseases caused by microorganisms. Such diseases or ailments include symptoms such as cholera [22,24,34], diarrhoea [22,24], dysentery [22,24], fever and malaria [33,36,39], toothache [4,7,20] and wounds [21,23,24]. Such wide use of *Kirkia* species against microbial infections in traditional medicine prompted Masoko [54] to evaluate antibacterial effects of acetone, dichloromethane, hexane and methanol leaf extracts of *K. acuminata* against *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* with ampicillin as the positive control. In this study, *E. faecalis* was the most sensitive microorganism with average MIC value of 0.1 mg/ml followed by *E. coli* (0.31 mg/mL) while *S. aureus* and *P. aeruginosa* were resistant with MIC values of 0.97 mg/mL and 1.25 mg/ml respectively [54]. Similarly, Mmushi *et al* [52] evaluated acetone, dichloromethane, hexane and methanol leaf extracts of *K. acuminata* against *Mycobacterium smegmatis* using rifampicin as a positive control. The acetone, dichloromethane, hexane and methanol extracts demonstrated antimycobacterial activity with MIC values ranging between 0.31 to 0.63 mg/mL against *M. smegmatis* [52].

Suleiman *et al* [53,57] evaluated the hexane, acetone, dichloromethane and methanol extracts of *K. wilmsii* against *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* using the bioautographic procedure and a two-fold serial microdilution method. The authors found 18 inhibition bands against bacteria. Suleiman *et al* [53,57] also evaluated the hexane, acetone, dichloromethane and methanol extracts of *K. wilmsii* against *Aspergillus fumigatus*, *Candida albicans*, *Cryptococcus neoformans*, *Microsporium canis* and *Sporothrix schenckii* using the bioautographic procedure and a two-fold serial microdilution method. The authors found 11 inhibition bands against fungi. The acetone, dichloromethane, hexane and methanol extracts of *K. wilmsii* had antibacterial and antifungal activities with MIC values ranging from 0.07 to 2.50 mg/mL against the tested bacteria and fungi [53,57]. The leaves of the *K. wilmsii* further showed biological activity against the animal fungal pathogen *Aspergillus fumigatus* and the MIC ranged from 0.17 to 2.11 mg/mL [57]. In another study, Chigayo *et al* [55] evaluated the

antimicrobial activity of aqueous root extracts of *K. wilmsii* using an HPLC gradient elution method with kanamycin as the positive control. The extracts showed antimicrobial activities against *Aeromonas hydrophilia*, *Candida albicans*, *Enterobacter aerogenes*, *Escherichia coli*, *Proteus mirabilis*, *Salmonella typhi*, *Shigella dysenteriae*, *Staphylococcus aureus*, *Vibrio cholerae* with minimum inhibitory concentration (MIC) ranging from 0.08 mg/mL to 3.445 mg/ml. Results of these studies implies that *K. acuminata* and *K. wilmsii* may be used as a broad spectrum antibiotics.

## Antiplasmodial activity

Clarkson *et al* [36] evaluated leaf extracts of *K. wilmsii* against *Plasmodium falciparum* using the parasite lactate dehydrogenase (pLDH) assay. The dichloromethane/methanol (1:1) was highly active and showed promising antiplasmodial activity with IC<sub>50</sub> of 3.7 µg/mL, while water extra showed a weak activity with IC<sub>50</sub> of >100 µg/mL [36]. These pharmacological evaluations are important as the bark and leaf decoctions of *K. wilmsii* are used as herbal medicine for fever and malaria in South Africa [36,39]. Such pharmacological evaluations are also important for future research focusing on control and management of parasites and mosquito vectors in the tropics.

## Antioxidant and antiplatelet activities

Extracts of *K. wilmsii* exhibited antioxidant properties in the qualitative assay using DPPH with EC<sub>50</sub> value of 3.57 ± 0.41 µg/mL [56]. In the quantification of antioxidation using ABTS, the extracts of *K. wilmsii* showed low antioxidant activities with respect to TEAC values of 0.67. *Kirkia wilmsii* showed low antiplatelet activity with EC<sub>50</sub> value of 0.22 ± 0.02 µg/mL [56]. The documented antioxidant and antiplatelet activities of *K. wilmsii* may be attributed to the presence of phytochemicals since compounds such as flavonols and phenolics are known to have antioxidant properties [58] and also lower the risk of cancer, heart diseases, hypertension and stroke [59]. Detailed anti-hypertensive studies of *K. wilmsii* are recommended based as ethnopharmacological studies by Semanya and Potgieter [37] revealed that 97 % of traditional healers in the Limpopo province, South Africa use *K. wilmsii* in a similar manner as hypertension remedy in terms of herbal preparation, route of administration and dosage strength.

## Toxicity studies

*Kirkia wilmsii* extracts showed comparably low toxicity when compared with the reference agent berberine (cytotoxic agent) with hemagglutination assay titre value of 0.80 and agglutination value of 1.25 mg/mL [56]. Toxicological evaluations carried out so far on *Kirkia* are preliminary considering their widespread usage as herbal medicines in southern Africa. It is important to ascertain any toxicological effects that can occur as a result of chronic or sub-chronic usage of *Kirkia* species, and the different plant parts should be tested against a wide range of cell lines as well as using other *in vitro* toxicological assays and *in vivo* studies.

## CONCLUSION

Of the six *Kirkia* species, only *K. acuminata*, *K. wilmsii* and to some extent *K. tenuifolia* have been studied so far under different ethnobotanical and ethnopharmacological aspects. The others are either threatened with extinction or are highly localized, naturally rare and in need of human intervention to save them from extinction. There is therefore need to develop conservation strategies and mechanisms for *Kirkia* species that are threatened with extinction as well develop micropropagation protocols as an alternative and viable means to provide sufficient plants to meet the herbal medicine needs and at the same time protecting the natural populations.

From literature, it is clear that both *K. acuminata* and *K. wilmsii* have been used for centuries in southern Africa as herbal medicines for microbial infections in humans and scientific studies carried out so far have validated some of their traditional antimicrobial uses. Up to now, only a few pharmacological studies directly dealing with the documented traditional uses of *K. acuminata* and *K. wilmsii* have been performed. Phytochemical studies led to the identification of a large number of fatty acids, flavonols, isocoumarin, lignans, neolignans, nor-carotenoids, phenols and tannins. Most of these phytochemicals have not been evaluated, therefore, these compounds must be evaluated biologically in more detail. Further investigations should focus on phytochemical studies of these isolated compounds and try to link such pharmacological properties to documented ethnomedicinal uses.

Concerning toxicological information, no significant data are reported. A weak cytotoxic

activity is described only for *K. wilmsii* [56]. Future research should focus on assessing biological and toxicological aspects of the leaves, stem bark and roots of *Kirkia* species used as herbal medicines as well as both their bioactive extracts and isolated compounds. There is no doubt that results presented in this review may provide useful clues to promote further investigations of ethnopharmacological properties as well as potential use of phytochemicals isolated from *Kirkia* species.

## DECLARATIONS

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### Conflict of Interest

No conflict of interest associated with this work.

### Contribution of Authors

The authors declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by them.

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