

Evaluation of Chemical Properties, Biological Activities and Ethnomedicinal uses of *Cladostemon kirkii*

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Abstract: *Cladostemon kirkii* (Oliv.) Pax & Gilg is a shrub or a small tree widely used as traditional medicine in tropical Africa. This study is aimed at evaluating the chemical properties, biological activities and ethnomedicinal uses of *C. kirkii*. Results of the current study are based on data derived from several online databases such as Scopus, Google Scholar, PubMed and Science Direct, and pre-electronic sources such as scientific publications, books, dissertations, book chapters and journal articles. The articles published between 1960 and 2019 were used in this study. This study revealed that the bark, leaf, root and stem infusion and/or decoction of *C. kirkii* are mainly used as traditional medicines for boils, colds, gastro-intestinal problems, hypertension, ophthalmia, rheumatism, sexual dysfunction, abdominal pains, sexually transmitted infections, sores and wounds. Phytochemical compounds identified from the species include meamsitrin, myricitrin, kaempferol-5-rhamnoside, kaempferin, kaempferol 3-gluco-7-rhamnoside, quercetin 3,7-dirhamnoside, quercetin 3-gluco-7-rhamnoside, choline, 3-hydroxyprolinebetaine and tetramethylammonium. *Cladostemon kirkii* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological properties.

Keywords: Capparaceae, *Cladostemon kirkii*, indigenous pharmacopeia, traditional medicine.

INTRODUCTION

Cladostemon kirkii (Oliv.) Pax & Gilg is a shrub or a small tree belonging to the Capparaceae or caper family. Over the years, there has been confusion concerning the delimitation of Brassicaceae, Capparaceae and Cleomaceae families. Some researchers such as Glen [1] placed *C. kirkii* in Brassicaceae family, following an all-inclusive Brassicaceae family concept proposed by Angiosperm Phylogeny Group [2,3] and Judd *et al.* [4,5]. Thus, phylogenetic relationships of Brassicaceae, Capparaceae and Cleomaceae families using the chloroplast regions *ndhF*, *trnL-trnF*, *matK*, and *rbcl* supported the monophyly of the three closely related families [6-12]. Hall *et al.* [6] and Hall [10] argued that species habit, fruit characteristics, floral symmetry, stamen number, leaf type and fruit type are important morphological characteristics which can be used to place different species into the three families. The genus *Cladostemon* A. Braun & Vatke is a monotypic genus confined to tropical Africa [13,14]. The genus name "*Cladostemon*" is a contraction of two Greek words "*klados*" and "*stemon*", which translate to "branch" and "stamen", respectively, in reference to branched stamens that branch off a long and conspicuous androphore which, holds the gynophore with the ovary at its tip [15]. The specific name "*kirkii*" honours Sir John Kirk (1832 – 1922), a Scottish

physician, naturalist and companion of the explorer David Livingstone, a British administrator in Zanzibar who recorded and collected the tree species in the Tete district of Mozambique [1]. The English common names of *C. kirkii* are "three-finger bush" and "Tongakieri". The synonyms associated with the name *C. kirkii* include *Cladostemon paxianus* Gilg and *Euadenia kirkii* Oliv. [16-18].

Cladostemon kirkii is a shrub or small deciduous tree, seldom taller than 10 metres [19-21]. *Cladostemon kirkii* has smooth, rather soft branches and a brittle trunk with yellow-grey bark furrowed horizontally. The leaves of *C. kirkii* are shiny, trifoliate, elliptic to obovate in shape, leathery to almost succulent with minute and inconspicuous stipules. The leaf margins are untoothed but in young leaves they are frequently undulating. The flowers are axillary and solitary, borne in terminal spikes or clusters and sweetly scented, with a turf of spreading whitish stamens. The fruits are pendulous, globose with a hard, pale brown shell, borne on thick, jointed stalk with a pervasive unpleasant odour when picked. The seeds of *C. kirkii* are slightly compressed, pear-shaped to kidney-shaped. *Cladostemon kirkii* has been recorded in sandy soils in hot areas, bushveld, dry open sandy woodland, secondary scrub, thicket, coastal and sand forest. *Cladostemon kirkii* has been recorded in the Democratic Republic of Congo (DRC), Eswatini, Kenya, Malawi, Mozambique, South Africa, Tanzania, Zambia and Zimbabwe at an altitude ranging from 15 m to 800 m above sea level [22-30]. The leaves of *C.*

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kirkii are browsed by game and livestock [21]. Within its geographical distributional range, *C. kirkii* is cultivated as shade, an ornamental and decorative garden plant for frost-free areas [31] while the species is also occasionally cultivated in European gardens as a garden curiosity [32]. The roots of *C. kirkii* are eaten during times of famine in Tanzania [33]. The roots of *C. kirkii* are traded as herbal medicine in informal herbal medicine markets in the KwaZulu-Natal and Mpumalanga provinces in South Africa [34-37]. *Cladostemon kirkii* is cultivated in home gardens in the KwaZulu-Natal province in South Africa as a source of traditional medicines [38]. *Cladostemon kirkii* is one of the important medicinal plants in tropical Africa and the species is included in the book "Plant resources of tropical Africa 11(2): Medicinal plants 2", a

photographic guide to the most commonly used medicinal plants in tropical Africa [39]. Thus, the aim of this review is to provide an integrated and detailed appraisal of the existing knowledge on the chemical properties, biological activities and ethnomedicinal uses of *C. kirkii*.

Medicinal uses

The bark, leaf, root and stem infusion and/or decoction of *C. kirkii* are mainly used as traditional medicines for boils, colds, gastro-intestinal problems, hypertension, ophthalmia, rheumatism, sexual dysfunction, abdominal pains, sexually transmitted infections, sores and wounds (Table 1; Figure 1). In South Africa, the roots of *C. kirkii* are mixed with those

Table 1: Medicinal uses of *Cladostemon kirkii*

Medicinal use	Parts used	Country	Reference
Abdominal pains	Root infusion and/or decoction taken orally	Mozambique	[45-47]
Abscesses	Leaf infusion applied topically	Tanzania	[48]
Blood purifier	Root decoction taken orally	Eswatini	[49]
Boils	Roots mixed with those of <i>Commiphora zanzibarica</i> (Baill.) Engl. and applied topically	South Africa	[24,40]
Cancer	Root infusion taken orally	Eswatini	[50]
Ceremonial use	Whole plant	Mozambique	[1]
Colds	Root infusion and/or decoction taken orally	Mozambique	[45,47]
Gastro-intestinal problems (diarrhoea and stomachache)	Root maceration taken orally	Mozambique	[47,51]
Hernia	Leaf infusion taken orally	Tanzania	[52]
Hypertension	Bark, root and stem maceration taken orally	South Africa	[41,53]
Hypertension	Roots mixed with leaves of <i>Aloe marlothii</i> A. Berger and stems of <i>Sarcophyte sanguinea</i> Sparrm., and taken orally	South Africa	[41]
Menstrual problems	Leaf decoction taken orally	Tanzania	[52]
Ophthalmia	Leaf infusion applied topically	Mozambique	[1,33]
Rheumatism	Leaf and root infusion and/or maceration applied topically	Mozambique	[33,54]
Sexual dysfunction	Root infusion and/or decoction taken orally	Mozambique	[45,47]
Sexually transmitted infections	Root infusion and/or decoction taken orally	Mozambique and South Africa	[45,47,55,56]
Sores and wounds	Leaf and root infusion and/or decoction applied topically	Eswatini, Kenya, South Africa and Tanzania	[33,38,48,49]
Sores	Roots mixed with those of <i>Elephantorrhiza elephantina</i> (Burch.) Skeels and <i>Sarcophyte sanguinea</i> , bulb of <i>Drimia delagoensis</i> (Baker) Jessop and whole plant parts of <i>Ranunculus multifidus</i> Forssk., and applied topically	South Africa	[33,42,43]
Sores	Roots mixed with those of <i>Elephantorrhiza elephantina</i> , <i>Sarcophyte piriiei</i> Hutch., bark of <i>Ficus sur</i> Forssk., leaves of <i>Senecio serratuloides</i> DC., bulb of <i>Drimia delagoensis</i> and whole plant parts of <i>Ranunculus multifidus</i> , and applied topically	South Africa	[43,44]
Sores	Roots mixed with those of <i>Elephantorrhiza elephantina</i> , <i>Sarcophyte piriiei</i> , bulb of <i>Drimia delagoensis</i> and whole plant parts of <i>Ranunculus multifidus</i>	South Africa	[43,44]
Swellings	Leaf infusion applied topically	Tanzania	[52]

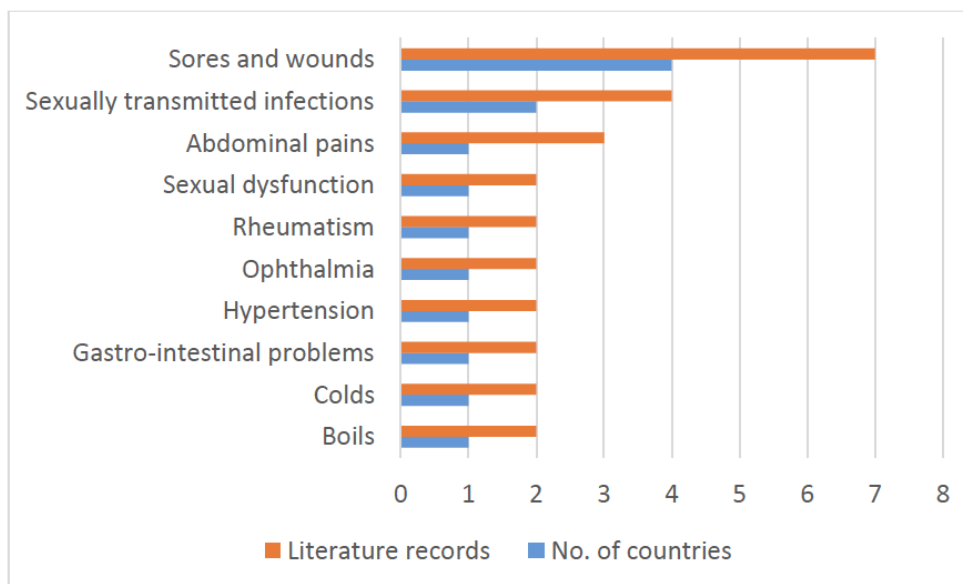


Figure 1: Medicinal applications of *Cladostemon kirkii* derived from literature records.

of *Commiphora zanzibarica* (Baill.) Engl. as traditional medicine for boils [24,40]. The roots of *C. kirkii* are mixed with leaves of *Aloe marlothii* A. Berger and stems of *Sarcophyte sanguinea* Sparrm. are used as traditional medicine for hypertension [41]. The roots of *C. kirkii* are mixed with those of *Elephantorrhiza elephantina* (Burch.) Skeels and *Sarcophyte sanguinea*, bulb of *Drimia delagoensis* (Baker) Jessop and whole plant parts of *Ranunculus multifidus* Forssk. and applied topically on sores [42,43]. Alternatively, the roots of *C. kirkii* are mixed with those of *Elephantorrhiza elephantina*, *Sarcophyte piri* Hutch., bark of *Ficus sur* Forssk., leaves of *Senecio serratuloides* DC., bulb of *Drimia delagoensis* and whole plant parts of *Ranunculus multifidus*, and applied topically on sores [43,44]. The roots of *C. kirkii* are also mixed with those of *Elephantorrhiza elephantina*, *Sarcophyte piri*, bulb of *Drimia delagoensis* and whole plant parts of *Ranunculus multifidus* and used as traditional medicine for sores [43,44].

Phytochemical Composition and Pharmacological Properties

From an extract of the leaves of *C. kirkii*, Bombardelli *et al.* [57] isolated flavonoids such as mearnsitrin, myricitrin, kaempferol-5-rhamnoside, kaempferin, kaempferol 3-gluco-7-rhamnoside, quercetin 3,7-dirhamnoside and quercetin 3-gluco-7-rhamnoside (Table 2). Flavonoids possess antiallergic, antibacterial, anticancer, antidiabetic, antifungal, anti-inflammatory, antileukemic, anti-mutagenic, antioxidant, antiulcer, antiviral, cardioprotective, hepatoprotective, immune system promoting, skin

protective and vasodilator effects [58-64]. McLean *et al.* [65] identified choline, 3-hydroxyprolinebetaine and tetramethylammonium from the aerial parts and branches of *C. kirkii*. Loontjens [66] argued that quaternary ammonium compounds are potent biocides widely used in medical applications, cosmetics, disinfectants, surfactants and solvents. The leaves of *C. kirkii* also yielded 6.8% proteins and 3.8% lipids [67,68].

De Wet *et al.* [38] evaluated the antibacterial activities of crude extracts of *C. kirkii* roots against *Escherichia coli* and *Staphylococcus aureus* using the micro dilution method. The extract exhibited activities against tested pathogens [38]. Similarly, Pereira *et al.* [69] evaluated the antibacterial activities of methanol extracts of *C. kirkii* roots against *Staphylococcus aureus*, *Enterococcus faecalis*, *Bacillus subtilis*, *Salmonella typhimurium* and *Pseudomonas aeruginosa* using the micro dilution method. The extract exhibited activities against tested pathogens [69]. Ramulondi [70] and Ramulondi *et al.* [71] evaluated the toxicity activities of dichloromethane: methanol and aqueous extract of *C. kirkii* roots using the brine shrimp assay and the Ames test. The authors also assessed the cytotoxicity activities of aqueous and organic extracts of *C. kirkii* in combinations with *Aloe marlothii* leaves and *Sarcostemma sanguinea* stems using the sum of the fractional inhibitory concentration (Σ FIC), which allowed the classification of the type of the cytotoxicity. Both extracts were categorized as non-toxic as the mortality rate was less than 50% [72]. Both extracts were also categorized as non-mutagenic against *Salmonella typhimurium* bacterial strains, TA98 and

Table 2: Phytochemical Composition of *Cladostemon kirkii*

Phytochemical compound	Plant part	Reference
Mearnsitrin	Leaves	[57]
Myricitrin	Leaves	[57]
Kaempferol-5-rhamnoside	Leaves	[57]
Kaempferin	Leaves	[57]
Kaempferol 3-gluco-7-rhamnoside	Leaves	[57]
Quercetin 3,7-dirhamnoside	Leaves	[57]
Quercetin 3-gluco-7-rhamnoside	Leaves	[57]
Choline	Aerial parts and branches	[65]
3-hydroxyprolinebetaine	Aerial parts and branches	[65]
Tetramethylammonium	Aerial parts and branches	[65]
Proteins (%)	Leaves	[67,68]
Lipids (%)	Leaves	[67,68]

TA100. Plant combinations resulted in additive, antagonistic and non-interactive effects. The plant combinations tested in the Ames test resulted in non-interactive effects towards both *Salmonella typhimurium* strains [70,71].

CONCLUSION

Cladostemon kirkii is widely used as herbal medicine throughout its distributional range in tropical Africa. Documentation of its ethnopharmacological properties is important as this information is required for further research on the species. The present study showed that there are still some research gaps in the phytochemistry, pharmacological and toxicological properties of the species. Further rigorous research is required aimed at evaluating the phytochemical properties of the different plant parts used as sources of traditional medicines.

CONFLICT OF INTEREST

No conflict of interest is associated with this work.

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