Review of phytochemistry, biological activities and therapeutic potential of *Cleistochlamys kirkii*

Alfred Maroyi

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

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**ABSTRACT**

*Cleistochlamys kirkii* (Benth.) Oliv is a shrub or small tree widely used as a traditional medicine in the east and central Africa. *Cleistochlamys kirkii* is indigenous to Malawi, Mozambique, Tanzania, Zambia and Zimbabwe. This study is aimed at evaluating the phytochemistry, biological activities and therapeutic potential 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. This study revealed that the leaf and root infusion, maceration and decoction of *C. kirkii* are mainly used as traditional medicines for haemorrhoid wounds, rheumatism and tuberculosis. Phytochemical compounds identified from the species include \( \alpha,\beta \)-unsaturated lactone, acetogenin, benzyl benzoate derivatives, \( c \)-benzylated flavanone, heptanolide, an indole alkaloid, phenolics, polyoxygenated cyclohexene and derivatives, sesquiterpene and tetracyclic triterpenes. *In vitro* studies have confirmed the biological activities of *C. kirkii* crude extracts and compounds isolated from the species which include antibacterial, antifungal, antiplasmodial and cytotoxicity. Documentation of the medicinal uses, phytochemistry and pharmacological properties of *C. kirkii* is essential as this information provides baseline data required for future research and development of health-promoting and pharmaceutical products. *Cleistochlamys kirkii* should be subjected to detailed ethnopharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological properties.

*Corresponding Author*
Name: Alfred Maroyi
Phone: +27406022322
Email: amaroyi@ufh.ac.za

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**INTRODUCTION**

*Cleistochlamys kirkii* (Benth.) Oliv is a shrub or small tree belonging to the Annonaceae, commonly known as the custard apple family. Annonaceae is one of the most diverse and primitive plant families consisting of about 108 genera and 2400 species worldwide (Chatrou et al., 2012; Attiq et al., 2017) argued that members of the Annonaceae family are used throughout the world as sources of traditional medicines used against arthritis, gastrointestinal problems, hypertension, inflammation, respiratory infections, rheumatism, skin infections, snake bites, sores and wounds. The extracts and phytochemical compounds isolated from Annonaceae species are characterized by analgesic, anthelmintic, antidiabetic, anti-inflammatory, antimicrobial, antioxidant, antipyretic, antiulcer, antinociceptive, antimalarial, antiprotozoal, antileishmanial, cytotoxicity and hepatoprotective properties (Bhardwaj et al., 2019).
### Table 1: Medicinal uses of Cleistochlamys kirkii

| Medicinal uses         | Plant part used                              | Reference                                  |
|------------------------|----------------------------------------------|--------------------------------------------|
| Cough                  | Leaf and root decoction taken orally         | (Bruschi et al., 2011)                     |
| General weakness       | Leaf and root decoction taken orally         | (Bruschi et al., 2011)                     |
| Haemorrhoid wounds     | Leaf decoction applied topically             | (Nyandoro et al., 2017; Kincses et al., 2018) |
| Hernia                 | Leaf and root decoction taken orally         | (Bruschi et al., 2014; Monjane, 2017)      |
| Muscular pains         | Leaf and root maceration taken orally        | (Bruschi et al., 2011; Monjane, 2017)      |
| Purgative              | Leaf and root decoction taken orally         | (Bruschi et al., 2011)                     |
| Rheumatism             | Leaf decoction applied topically             | (Verzar and Petri, 1987; Nyandoro et al., 2019) |
| Stomach ache           | Leaf and root maceration taken orally        | (Bruschi et al., 2011; Monjane, 2017)      |
| Tuberculosis           | Leaf infusion and/or decoction taken orally   | (Verzar and Petri, 1987; Samwel et al., 2007) |
| Venereal diseases      | Leaf and root decoction taken orally         | (Bruschi et al., 2011; Monjane, 2017)      |

The genus *Cleistochlamys* Oliver is a monotypic genus confined to east and central tropical Africa (Verdcourt and Annonaceae, 1971; Wyk and Wyk, 2013). The genus name “Cleistochlamys” is a contraction of two Greek words “kleistos” or “klistos” meaning “closed” and “chlamys” or “chlamydos” meaning “cloak” (Quattrocchi, 1999). 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 Sena district of Mozambique (Robson and Annonaceae, 1960).

*C. kirkii* (Figure 1) is a much-branched shrub or small straggling tree, seldom taller than 10 metres (Palgrave and Keith, 2002). The bark of *C. kirkii* is smooth, tough, pale grey to light brown in colour and flaking. The leaves are simple, alternate, narrowly oblong to obovate and thinly textured (Burrows et al., 2018). The leaves are dark to bright shiny green above, blue-green and slightly paler below, apex rounded, often notched with a broadly tapering to the rounded base with entire and waxy margins (Strugnell, 2006). The flowers are axillary, sessile, with a heavy sweet scent, creamy-white with reddish-brown bracts below, appearing when trees are leafless. The fruit is a cluster of fleshy oval berries which are purple-black when ripe (Figure 1). *Cleistochlamys kirkii* has been recorded in alluvium soils in hot and dry bushveld, thickets and river valleys in Malawi, Mozambique, Tanzania, Zambia and Zimbabwe up to an altitude of 900 m above sea level (Drummond, 1975; Silva et al., 2004). The fruit of *C. kirkii* is eaten fresh or left to stand in water to make a pleasant fruit drink (Tredgold, 1986; Chikuni, 1996). *Cleistochlamys kirkii* is an important medicinal plant species in southern Africa (Verzar and Petri, 1987; Bruschi et al., 2011). Thus, this review aims to provide an integrated and detailed appraisal of the existing knowledge on the phytochemistry, biological activities and therapeutic potential of *C. kirkii*.

**Medicinal uses of Cleistochlamys kirkii**

The leaf and root infusion, maceration and decoction of *C. kirkii* are mainly used as traditional medicines for haemorrhoid wounds, rheumatism and tuberculosis (Samwel et al., 2007; Pereira et al., 2016) (Table 1). Other medicinal applications of *C. kirkii* supported by at least two literature records include the use of leaf and root decoction against hernia, muscular pains, stomach ache and venereal diseases (Bruschi et al., 2011; Monjane, 2017).

**Phytochemical composition and pharmacological properties of Cleistochlamys kirkii**

Phytochemical compounds such as α,β-unsaturated lactone, acetogenin, benzyl benzoate derivatives,
Table 2: Phytochemical composition of Cleistochlamys kirkii

| Phytochemical compound                      | Plant part                        | Reference                                      |
|--------------------------------------------|-----------------------------------|------------------------------------------------|
| (-)-1,6-desoxy-β-senepeoxide               | Fruits, leaves, roots and stems   | (Samwel et al., 2007)                         |
| (1S,4S,5S,6R)-5-[(benzyloxy)methyl]-5,6-dihydroxycyclohex-2-ene-1,4-diyl diacetate | Leaves                            | (Nyandoro et al., 2017)                      |
| 2-Methoxybenzylbenzoate                    | Root bark                         | (Nyandoro et al., 2019)                      |
| 3-hydroxybenzaldehyde                      | Leaves                            | (Nyandoro et al., 2017)                      |
| 7-Methoxyisochamanetin                     | Root bark                         | (Nyandoro et al., 2019)                      |
| Acetylmelodorin                            | Bark, fruits, leaves, roots and stems | (Samwel et al., 2007; Pereira et al., 2016) |
| (E)-Acetylmelodorin                        | Root bark                         | (Nyandoro et al., 2019)                      |
| Benzophenone                               | Root bark                         | (Pereira et al., 2016)                       |
| Benzoylmelodorin                           | Fruits, leaves, roots and stems   | (Samwel et al., 2007)                         |
| Benzylbenzoate                             | Root bark                         | (Nyandoro et al., 2019)                      |
| Butenolide cleistanolate                   | Leaves                            | (Nyandoro et al., 2017)                      |
| Chamanetin                                 | Root bark                         | (Pereira et al., 2016; Nyandoro et al., 2019)|
| cis-solamin                                | Root bark                         | (Pereira et al., 2016)                       |
| Cleistonol                                 | Root bark                         | (Nyandoro et al., 2019)                      |
| Cleistenonol                               | Leaves                            | (Nyandoro et al., 2017)                      |
| Cleistenolide                              | Bark, fruits, leaves, roots and stems | (Samwel et al., 2007; Pereira et al., 2016) |
| Cleistodienol                              | Fruits, leaves, roots and stems   | (Samwel et al., 2007)                         |
| Cleistodienuil                             | Leaves                            | (Nyandoro et al., 2017)                      |
| Cleistenediols A - F                       | Leaves                            | (Nyandoro et al., 2017)                      |
| Cleistenechlorohydrins A - B               | Leaves                            | (Nyandoro et al., 2017)                      |
| Cleistophenolide                           | Leaves                            | (Nyandoro et al., 2017)                      |
| Cleistodienol A - B                        | Leaves                            | (Nyandoro et al., 2017)                      |
| Dichamanetin                               | Root bark                         | (Pereira et al., 2016; Nyandoro et al., 2019)|
| Echinulin                                  | Root bark                         | (Pereira et al., 2016)                       |
| ent-subglain C                             | Leaves                            | (Nyandoro et al., 2017)                      |
| Guaiol                                     | Root bark                         | (Nyandoro et al., 2019)                      |
| Iso-acetyl melodorin                       | Fruits, leaves roots and stems    | (Samwel et al., 2007)                         |
| Isochamanetin                              | Root bark                         | (Pereira et al., 2016; Nyandoro et al., 2019)|
| Melodorin                                 | Fruits, leaves roots and stems    | (Samwel et al., 2007)                         |
| Pinocembrin                                | Bark, fruits, leaves, roots and stems | (Samwel et al., 2007; Nyandoro et al., 2019)|
| Pinostrobin                                | Root bark                         | (Nyandoro et al., 2019)                      |
| Polycarpol                                 | Bark, fruits, leaves, roots and stems | (Pereira et al., 2016; Nyandoro et al., 2019)|
| Sootepenol B                               | Leaves                            | (Nyandoro et al., 2017)                      |
| Tetramethylscutellarein                    | Leaves                            | (Nyandoro et al., 2017)                      |
| (Z)-(+-)-5-(2,3-dihydroxy-propylidene)-5H-furan-2-one| Fruits, leaves, roots and stems | (Samwel et al., 2007)                         |
| Z-acetylmelodorin                          | Leaves                            | (Nyandoro et al., 2017)                      |
| Z-melodorin                                | Leaves                            | (Nyandoro et al., 2017)                      |
c-benzylated flavanone, heptanolide, an indole alkaloid, phenolics, polyoxygenated cyclohexene and derivatives, sesquiterpene and tetracyclic triterpenes have been identified from the bark, fruits, leaves, roots and stems of *C. kirkii* (Table 2). The following pharmacological activities have been documented from the crude extracts and phytochemical compounds isolated from *C. kirkii*: antibacterial, antifungal, antiplasmodial and cytotoxicity.

**Antibacterial activities**

(Odebode et al., 2004a) evaluated the antibacterial activities of crude dichloromethane extract of *C. kirkii* stem bark and the compounds cleistenolide and pinocembrin isolated from the stem bark of the species against *Pseudomonas phaseolicola* and *Staphylococcus aureus* using the disc method. The crude extract exhibited activities at all concentrations, while the compounds showed moderate to weak activities at concentrations above 200.0 ppm (Odebode et al., 2004b). Similarly, Odebode et al. (2004a) evaluated the antibacterial activities of crude dichloromethane extract of *C. kirkii* stem bark and the compounds cleistenolide and pinocembrin isolated from the stem bark of the species against *Pseudomonas syringae PV. phaseolicola* using the disc method with streptomycin as a positive control. The crude extract and the compounds exhibited activities against the tested pathogen with a diameter of inhibition zones ranging from 5.3 mm to 15.0 mm in comparison to the width of inhibition zone of 17.5 mm exhibited by the positive control (Odebode et al., 2004b; Samwel et al., 2007) evaluated the antibacterial activities of the compounds cleistenolide, cleistodienol, (Z)(+)-5-(2,3-dihydroxy-propyldiene)-5H-furan-2-one, melodorinol, acetyl melodorinol, iso-acetyl melodorinol and pinocembrin isolated from the fruits, leaves, roots and stems of *C. kirkii* against *Staphylococcus aureus* and *Bacillus anthracis* using the hole plate method with chloramphenicol (10.0 μg/mL) as a positive control. The compounds exhibited activities (Samwel et al., 2007; Pereira et al., 2014, 2015) evaluated the antibacterial activities of n-hexane, dichloromethane, ethyl acetate and methanol extracts and fractions of *C. kirkii* root bark and the compounds chamanetin, isochamanetin, dichamanetin, echinulin, cis-solam, cleistenolide, acetylmelodorinol, polycarpol and benzophenone isolated from the species against *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Bacillus subtilis* and *Staphylococcus aureus* using broth microdilution method with amoxicillin, oxacillin and vancomycin as positive controls. The authors also evaluated the type of interaction of the compounds with the β-lactam antibiotics amoxicillin and oxacillin using a chemosensitization assay performed on the checkerboard method against *Staphylococcus aureus* resistant and susceptible strains. The best results were obtained for apolar and polar extracts with minimum inhibitory concentration (MIC) values of 7.5 μg/mL to 62.μg/mL against Gram-positive strains. The compounds chamanetin, isochamanetin, dichamanetin and cleistenolide exhibited activities against the tested pathogens. The compound polycarpol, in combination with antibiotics, exhibited substantial synergistic activities (Pereira et al., 2014, 2016; Kincses et al., 2018). The authors also assessed the combined effects of antibiotics ciprofloxacin and tetracycline and the compounds chamanetin and dichamanetin by using the checkerboard microdilution method in *Staphylococcus aureus* strains. The compounds chamanetin and dichamanetin exhibited activities against *Staphylococcus aureus* with MIC values ranging from 0.8 μM to 25 μM. The combined effect of the antibiotics and the compounds chamanetin and dichamanetin on *Staphylococcus aureus* resulted in synergism (Kincses et al., 2018).

**Antifungal activities**

(Odebode et al., 2004a) evaluated the antifungal activities of crude dichloromethane extract of *C. kirkii* stem bark and the compounds cleistenolide and pinocembrin isolated from the stem bark of the species against *Fusarium solani*, *Botryodiplodia theobromae*, *Aspergillus niger* and *Aspergillus flavus* using the disc method with benomyl as a positive control. The crude extract and the compounds exhibited activities against *Botryodiplodia theobromae*, *Aspergillus niger* and *Aspergillus flavus* with a diameter of inhibition zones ranging from 10.0% to 48.5% in comparison to the diameter of inhibition zone of 100% exhibited by the positive control (Odebode et al., 2004a). Similarly, (Samwel et al., 2007) evaluated the antifungal activities of the compounds cleistenolide, cleistodienol, (Z)(+)-5-(2,3-dihydroxy-propyldiene)-5H-furan-2-one, melodorinol, acetyl melodorinol, iso-acetyl melodorinol and benzoyl melodorinol isolated from the fruits, leaves, roots and stems of *C. kirkii* against *Candida albicans* using the disk diffusion method with ketoconazole as a positive control. The compounds exhibited activities against the tested pathogen (Samwel et al.,
Antiplasmodial activities

(Nyandoro et al., 2017) evaluated the antiplasmodial activities of the ethanolic crude extract of C. kirkii leaves. The compounds cleistodienediol, cleistodienol A, cleistodienol B, cleistenechlorohydrin A, cleistenechlorohydrin B, cleistenediol F, cleistenonal, cleistophenolide, ent-subglain C, melodorinol, acetylmelodorinol, tetramethylscutellarein and 2-hydroxybenzaldehyde isolated from the species against the chloroquine-sensitive strain of *Plasmodium falciparum* 3D7 and Dd2 using an imaging-based assay method. The compounds cleistodienediol, cleistodienol A, cleistodienol B and acetylmelodorinol exhibited activities against both 3D7 and Dd2 with half-maximal inhibitory concentration (IC$_{50}$) values ranging from 0.2 $\mu$M to 40.0 $\mu$M (Nyandoro et al., 2017). Similarly, (Nyandoro et al., 2019) evaluated the antiplasmodial activities of the ethanolic crude extract of *C. kirkii* root bark and the compounds cleistodienediol, cleistodienol A, cleistodienol B, cleistenechlorohydrin A, cleistenechlorohydrin B, cleistenediol F, cleistenonal, cleistophenolide, ent-subglain C, melodorinol, acetylmelodorinol, tetramethylscutellarein and 2-hydroxybenzaldehyde isolated from the species against the chloroquine-sensitive strain of *Plasmodium falciparum* 3D7 using an imaging-based assay method with artemisinin as the reference drug. The crude extract gave 72.0% inhibition against the 3D7 strain at 0.01 $\mu$g/mL, while the compounds dichamanetin, (E)-acetylmelodorinol and cleistenediol exhibited activities with IC$_{50}$ values ranging from 0.03 $\mu$M to 8.2 $\mu$M (Nyandoro et al., 2019). (Nyandoro et al., 2019) also evaluated the cytotoxicity activities of the ethanolic crude extract of *C. kirkii* root bark and the compounds cleistodienediol, cleistodienol A, cleistodienol B, cleistenechlorohydrin A, cleistenechlorohydrin B, cleistenediol F, cleistenonal, cleistophenolide, ent-subglain C, melodorinol, acetylmelodorinol, tetramethylscutellarein and 2-hydroxybenzaldehyde isolated from the species against the chloroquine-sensitive strain of *Plasmodium falciparum* 3D7 using an imaging-based assay method with artemisinin as the reference drug. The crude extract gave 72.0% inhibition against the 3D7 strain at 0.01 $\mu$g/mL, while the compounds dichamanetin, (E)-acetylmelodorinol and cleistenediol exhibited activities with IC$_{50}$ values ranging from 0.03 $\mu$M to 8.2 $\mu$M (Nyandoro et al., 2019).

Cytotoxicity activities

(Samwel et al., 2007) evaluated the cytotoxicity activities of the compounds cleistodienol, (Z)-(+)-(2,3-dihydroxy-propylidene)-5H-furan-2-one, melodorinol, acetylmelodorinol, iso-acetylmelodorinol and benzoyl melodorinol isolated from the fruits, leaves, roots and stems of *C. kirkii* using the brine shrimp assay. The compounds exhibited activities with half-maximal lethal dose (LD$_{50}$) value of 0.09 $\mu$g/mL (Samwel et al., 2007). Similarly, (Nyandoro et al., 2019) evaluated the cytotoxicity activities of the ethanolic crude extract of *C. kirkii* leaves. The compounds cleistodienediol, cleistodienol A, cleistodienol B, cleistenechlorohydrin A, cleistenechlorohydrin B, cleistenediol F, cleistenonal, cleistophenolide, ent-subglain C, melodorinol, acetylmelodorinol, tetramethylscutellarein and 2-hydroxybenzaldehyde isolated from the species against HEK-293 cells and MDA-MB-231, triple-negative, aggressive breast cancer cell line. All the compounds exhibited activities with IC$_{50}$ values ranging from 0.03 $\mu$M to 8.2 $\mu$M (Nyandoro et al., 2019). (Nyandoro et al., 2019) also evaluated the cytotoxicity activities of the ethanolic crude extract of *C. kirkii* root bark and the compounds cleistodienediol, cleistodienol A, cleistodienol B, cleistenechlorohydrin A, cleistenechlorohydrin B, cleistenediol F, cleistenonal, cleistophenolide, ent-subglain C, melodorinol, acetylmelodorinol, tetramethylscutellarein and 2-hydroxybenzaldehyde isolated from the species against the triple-negative aggressive breast cancer cell line MDA-MB-231 using Alamar Blue assay with lupeol as the reference drug. The crude extract exhibited activities with an IC$_{50}$ value of 42.0 $\mu$g/mL. In contrast, the compounds chamanetin, isochamanetin, dichamanetin, 7-methoxyisochamanetin, pinostrobin, pinocembrin, benzyl benzoate, 2-methoxybenzyl benzoate, guaiol, polycarpol, (E)-acetylmelodorinol and cleistenolide isolated from the species against the chloroquine-sensitive strain of *Plasmodium falciparum* 3D7 using an imaging-based assay method with artemisinin as the reference drug. The crude extract gave 72.0% inhibition against the 3D7 strain at 0.01 $\mu$g/mL, while the compounds dichamanetin, (E)-acetylmelodorinol and cleistenediol exhibited activities with IC$_{50}$ values ranging from 0.03 $\mu$M to 8.2 $\mu$M (Nyandoro et al., 2019).
CONCLUSIONS

The current scientific evidence, as illustrated by biological activities demonstrated by *C. kirkii*, indicates its potential as traditional medicine. The biological activities exhibited by the extracts and compounds isolated from the species directly or indirectly support a wide range of physiological processes, which offers protection against the growth of undesirable microbes and cytotoxicity properties which could trigger antitumor activities. The present study showed that there are still some research gaps in the phytochemistry, pharmacological and toxicological properties of the species. Therefore, further rigorous research is required aimed at evaluating the phytochemical properties of the different plant parts used as sources of traditional medicines as well as clinical trials and in vivo experiments.

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Conflict of Interest

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REFERENCES

Attiq, A., Jalil, J., Husain, K. 2017. Annonaceae: Breaking the Wall of Inflammation. *Frontiers in Pharmacology*, 8:752–752.

Bhardwaj, R., Pareek, S., Sagar, N. A., Vyas, N. 2019. Bioactive compounds of Annona. In Murthy, H., Bapat, V., editors, *Bioactive compounds in underutilized fruits and nuts*, pages 1–26. Springer.

Bruschi, P., Mancini, M., Mattioli, E., Morganti, M., Signorini, M. 2014. Traditional uses of plants in a rural community of Mozambique and possible links with Miombo degradation and harvesting sustainability. *Journal of Ethnobiology and Ethnomedicine*, 10(1):59–59.

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.

Burrows, J. E., Burrows, S. M., Lötter, M. C., Schmidt, E. 2018. *Trees and shrubs of Mozambique*. Pty, Cape Town.

Chatrou, L. W., Pirie, M. D., Erkens, R. H. J., Couvreur, T. L. P., Neubig, K. M., Abbott, J. R., Mols, J. B., Maas, J. W., Saunders, R. M. K., Chase, M. W. 2012. A new subfamilial and tribal classification of the pantropical flowering plant family Annonaceae informed by molecular phylogenetics. *Botanical Journal of the Linnean Society*, 169(1):5–40.

Chikuni, A. C. 1996. Conservation status of mopane woodlands in Malawi: A case study of Mua-Tsanya Forest Reserve. In Maesen, V. D. G., L. J. Burgt, V. D., M., X., Rooy, V. M. D., M., J., editors, *The biodiversity of African plants*, pages 250–258. Kluwer Academic Publishers.

Drummond, R. B. 1975. A list of trees, shrubs and woody climbers indigenous or naturalised in. *Rhodesia. Kirkia*, 10:229–285.

Kincses, A., Varga, B., Ákos Csonka, Sancho, S., Mulhovo, S., Madureira, A. M., Ferreira, M.-J. U., Spengler, G. 2018. Bioactive compounds from the African medicinal plant Cleistochlamys kirkii as resistance modifiers in bacteria. *Phytotherapy Research*, 32(6):1039–1046.

Monjane, J. 2017. Secondary metabolites from Mozambican plants. Lund.

Nugraha, A. S., Damayanti, Y. D., Wangchuk, P., Keller, P. A. 2019. Anti-Infective and Anti-Cancer Properties of the Annona Species: Their Ethnomedical Uses, Alkaloid Diversity, and Pharmacological Activities. *Molecules*, 24(23):4419–4419.

Nyandoro, S. S., Maeda, G., Munissi, J. J., Gruhonjic, A., Fitzpatrick, P. A., Lindblad, S., Duffy, S., Pelletier, J., Pan, F., Puttreddy, R., Avery, V. M., Erdélyi, M. 2019. A New Benzopyranyl Cadenane Sesquiterpene and Other Antiplasmodial and Cytotoxic Metabolites from Cleistochlamys kirkii. *Molecules*, 24(15):2746–2746.

Nyandoro, S. S., Munissi, J. J. E., Gruhonjic, A., Duffy, S., Puttreddy, R., Holleran, J. P., Fitzpatrick, P. A., Pelletier, J., Avery, V. M., Rissannen, K., Erdélyi, M. 2017. Polyoxgenated Cyclohexenes and Other Constituents of Cleistochlamys kirkii Leaves. *Journal of Natural Products*, 80(1):114–125.

Odebode, A. C., Madachi, S. J. M., Joseph, C. C., Irungu, B. N. 2004a. Antimicrobial activities of constituents from isolona cauliflora verd and cleistochlamys krikii benth, oliv.: Annonaceae. *Journal of Agricultural Sciences, Belgrade*, 49(1):109–116.

Odebode, A. C., Mdachi, S. J. M., Joseph, C. C., Irungu, B. N. 2004b. Antibacterial activities of constituents from Isolona cauliflora and Cleistochlamys kirkii. *Tanzania Journal of Science*, 29(2):19–26.

Palgrave, M. C., Keith 2002. *Coates Palgrave trees of southern Africa*. Struik Publishers, Cape Town.
Pereira, F., Feliciano, D., Sancha, S., Mulhovo, S., Luo, X., Duarte, A., Madureira, A. M., Ferreira, M. J. U. 2014. Cleistochlamys kirkii constituents with antibacterial activity. *Planta Medica*, 80(16):43–43.

Pereira, F., Madureira, A. M., Sancha, S., Mulhovo, S., Luo, X., Duarte, A., Ferreira, M. J. U. 2016. Cleistochlamys kirkii chemical constituents: Antibacterial activity and synergistic effects against resistant *Staphylococcus aureus* strains. *Journal of Ethnopharmacology*, 178:180–187.

Pereira, F., Sancha, S., Feliciano, D., Luo, X., Mulhovo, S., Duarte, A., Madureira, A. M., Ferreira, M. J. U. 2015. Evaluation of the antibacterial activity of some African medicinal plants. *Planta Medica*, 81(16):108–108.

Quattrocchi, U. 1999. *CRC world dictionary of palms: common names, scientific names, eponyms, synonyms, and etymology volume i A-C*. CRC Press, Washington DC.

Robson, N. K. B., Annonaceae 1960. *Flora Zambesiaca vol 1, part 1. Crown Agents for Oversea Governments and Administrations*. London.

Samwel, S., Mdachi, S. J., Nkunya, M. H., Irungu, B. N., Moshi, M. J., Moulton, B., Luisi, B. S. 2007. Cleistenolide and Cleistodienol: Novel Bioactive Constituents of Cleistochlamys kirkii. *Natural Product Communications*, 2(7):1934578X0700200–1934578X0700200.

Silva, D., Izidine, M. C., Amude, S., B, A. 2004. *A preliminary checklist of the vascular plants of Mozambique*. Southern African Botanical Diversity Network Report No. 30. Pretoria.

Strugnell, A. M. 2006. *A checklist of the Spermatophytes of Mount Mulanje, Malawi*. Scripta Botanica Belgica 34. National Botanic Garden, Belgium, Meise.

Tredgold, M. H. 1986. *Food Plants of Zimbabwe*. Mambo Press, Gweru.

Verdcourt, B., Annonaceae 1971. *Flora of tropical east africa. crown agents for overseas governments and administrations*. pages 1–132.

Verzar, R., Petri, G. 1987. Medicinal-plants in Mozambique and their popular use. *Journal of Ethnopharmacology*, 19:67–80.

Wyk, B. V., Wyk, P. V. 2013. *Field guide to trees of southern Africa*. Struik Nature. Cape Town.