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FFHD
Functional Foods in Health and Disease

# A review of the health benefits of *Strychnos decussata* (Pappe) Gilg (Loganiaceae): a potential functional food

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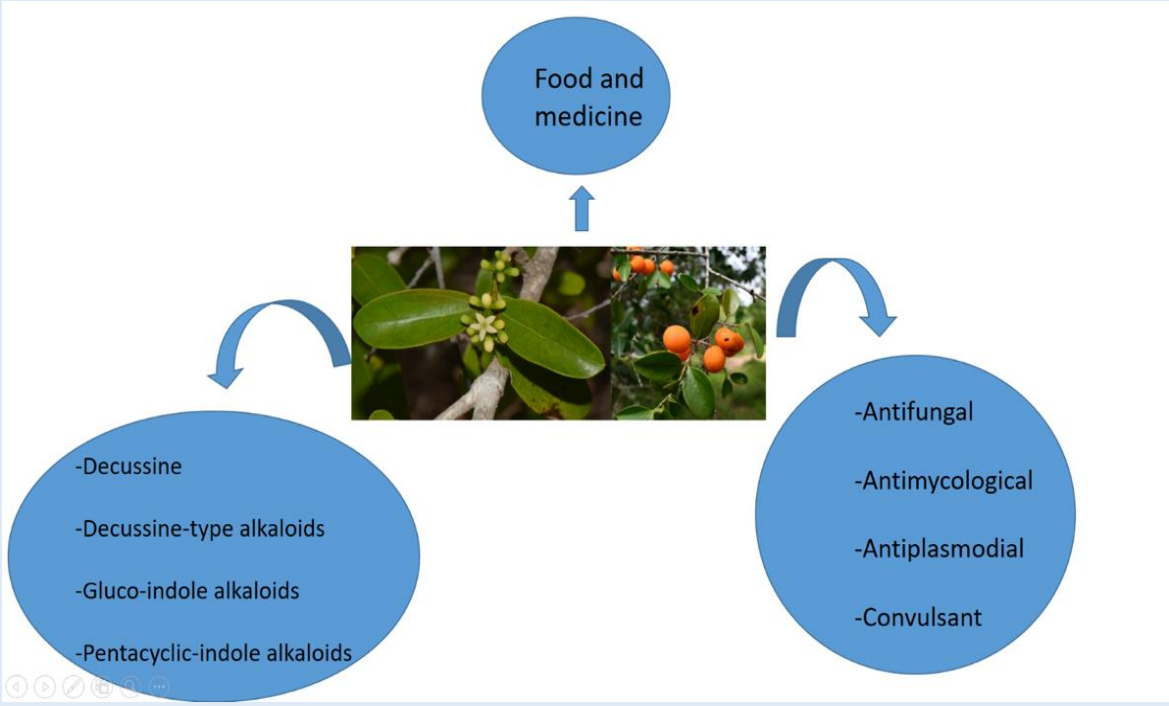
**Submission date**: April 30th, 2022; **Acceptance date**: May 30th, 2022; **Publication date**: August 5th, 2022

**Please cite this article as:** Maroyi A. A review of the health benefits of *Strychnos decussata* (Pappe) Gilg (Loganiaceae): A potential functional food. Functional Foods in Health and Disease. 2022; 12(8): 427-441 DOI: 10.31989/ffhd.v12i8.984

**ABSTRACT**

*Strychnos decussata* is a small to medium sized tree which naturally occurs in open-wooded and thickets in tropical Africa. A critical appraisal of the medicinal, pharmacological and socio-economic properties of *S. decussata* are provided. Research articles focusing on the medicinal, pharmacological and socio-economic properties of *S. decussata* were searched from online databases such as Google Scholar, PubMed, Science Direct, SciELO and SpringerLink. No time limit was set for the search and all research outputs that aligned with the scope of the review were included. *S. decussata* has diverse uses as a food plant and also has medicinal uses such as charm and ritual, scorpion and snake bite antidote, ethnoveterinary medicine, and traditional medicine for fever, gastro-intestinal problems, headache, respiratory infections, wounds, venereal diseases and infections. *S. decussata* exert biological activities such as antifungal, antimycobacterial, antiplasmodial and convulsant activities. Several phytochemical compounds such as decussine and decussine-type alkaloids, gluco-indole alkaloids and pentacyclic indole alkaloids have been isolated from the species. Many applications of *S. decussata* as source of food and herbal medicines as well as its phytochemistry and pharmarcological properties need further investigations.

**Keywords***:* Buddleia family, ethnomedicinal uses, indigenous knowledge, Loganiaceae, *Strychnos decussata*






## INTRODUCTION

*Strychnos decussata* (Pappe) Gilg (Figure 1) is a member of the Loganiaceae family often referred to as the Buddleia family. The best known genus in the family is *Buddleia* L., with its members widely grown in gardens all over the world and prized for their bloom and fragrance [1]. The Loganiaceae family includes 16 genera of herbs, climbers, shrubs and trees recorded throughout the neotropics [1-5]. *S. decussata* is also treated as a member of the Strychnaceae family in several publications [6-9]. Recognition of the family Strychnaceae is based on splitting the Loganiaceae family into four families, namely Antoniaceae, Loganiaceae, Spigeliaceae and Strychnaceae [10-11]. The *Strychnos* L. genus includes approximately 200 species ranging from climber shrubs or lianas, subshrubs or shrubs and trees [12], with some species presenting more than one growth habit depending with the surrounding environment [13-14]. The *Strychnos* species are cosmopolitan and have been recorded under tropical and subtropical conditions in America [14-15,18,20-22], tropical Africa [13], Madagascar [13], South and Southeast Asia [16-17], northern and northeastern Australia [19]. The *Strychnos* species have been recorded in dry or wet forests, savannas and grasslands, from sea level to 2000 m above sea level [12]. Several *Strychnos* species are considered to be functional food plants and these include *S. cocculoides* Baker [23-25], *S. gerrardii* N.E.Br. [25], *S. henningsii* Gilg [26-27], *S. innocua* Delile [23-25], *S. madagascariensis* Poir. [23-24,28-29], *S. mitis* S. Moore [30], *S. nux-vomica* L. [31], *S. potatorum* L.f. [32], *S. pungens* Soler. [23-25] and *S. spinosa* Lam. [23-24,33-34]. A review of the pharmacological studies of *Strychnos* species by Ohiri et al. [35] showed that crude extracts and/or alkaloids isolated from 48 species of the genus exhibited muscle-relaxant, convulsant, anticancer, antimicrobial, cytotoxicity and hypotensive properties. Similarly, *S. decussata* is regarded as an important useful

plant species in Mozambique and South Africa, and the species is included in the monograph "medicinal and magical plants of southern Africa: an annotated checklist [36]. This is a botanical encyclopedia of important ethnomedicinal plants in southern Africa providing basic information about uses, description and ethnopharmacological properties of the species. Within this context, this study was undertaken aimed at reviewing the phytochemical, pharmacological and socio-economic properties of *S. decussata*.


**Figure 1.** *Strychnos decussata*. A: Branch showing flower and leaves (photo: W McCleland) and B: branch showing leaves and fruits (photo: F du Randt)

A systematic review of electronic databases such as Taylor and Francis, Science Direct, Google scholar, Scopus, Web of Science, SpringerLink, SciELO, Pubmed and Elsevier were used. Pre-electronic sources such as national, international journal and other scientific publication, dissertations, theses, books and grey literature with information on the botany, traditional uses, medicinal uses, herbal preparations, phytochemistry and biological activities of *Strychnos decussata* were used. No time limit was set for the search and all literature sources published in English and aligned with the scope of the research were included. The key word *Strychnos decussata* and synonyms of the species such as *Atherstonea decussata, Strychnos atherstonei, Strychnos baculum* and *Strychnos boinensis* were paired with relevant terms such as "biological activities," "ethnomedicinal uses," "food uses," "phytochemicals," "Ethnobotany," "pharmacological properties," and "Traditional uses". Information about definition, classification, and regulation of functional foods was obtained from articles published in journals such as Bioactive Compounds in Health and Disease, Functional Food Science, Functional Foods in Health and Disease [37-47].

***Description of Strychnos decussata:*** The genus name *Strychnos* is derived from the Greek word for deadly, in reference to the poisonous properties of the alkaloid strychnine which is associated with several *Strychnos* species [48-49]. The species name "*decussata"* is derived from a Latin reference to the leaf arrangement of the species [49]. The synonyms of S. decussata include Atherstonea decussata Pappe, Strychnos atherstonei Harv., Strychnos baculum Harv. and Strychnos boinensis Jum. & H. Perrier [50-52]. Strychnos decussata is often confused with S. henningsii which has a similar distributional range. The English common names of S.*decussata* include Cape teak, Chaka's wood, king's tree and Panda's walking stick tree. In the 19$^{th}$ century, *S. decussata* stems were often made into ceremonial sticks

for Zulu chiefs in South Africa, hence the plant's local name, "king's tree," which was derived from this practice [7]. S. decussata is a semi-deciduous, small to medium-sized, multi-stemmed, slender tree with waxy branchlets, often with a dense, somewhat drooping crown growing to about 12 m in height [7,9]. The stems of *S.* decussata are often dented and knobby, smooth, leaden-grey, and thornless, while branchlets are conspicuous with pale brown lenticels. The leaves of *S. decussata* are obovate to elliptic in shape, broadest at or above the middle, leathery, glossy green above, hairless with net-veining not visible, apex rounded, and base broadly tapering. The flowers of *S. decussata* are white to cream in colour, axillary, racemose cymes; they often appear before the leaves, occurring in small, loose, branched heads. The fruits are small, globose in shape, rind thin and soft, with very short hairs, turning orange to red when mature. The leaves and shoots of *S. decussata* are consumed by game and livestock [9,53]. *S. decussata* has been recorded in Kenya, Madagascar, Malawi, Mozambique, Somalia, Tanzania, Zambia and Zimbabwe [52,54-55] (Figure 2). The species has been recorded in lowland coastal thickets, bushveld, often along dry watercourses or on termitaria, on hill slopes or rocky watercourses on deep sands at an altitude ranging from 15 m to 1000 m above sea level [7,56].


**Figure 2.** Distribution of *Strychnos decussata* in sub-Saharan Africa (https://www.gbif.org/occurrence/map)

### *Food uses*

The fruits of *S. decussata* are edible [30,57-60] and are used as a snack particularly by children [61-62]. People eat the juicy pulp and fleshy appendages surrounding the seed. The fruits of species such as *S. decussata* have potential to produce various food products which include porridge, non-alcoholic and alcoholic beverages [63]. Indigenous fruit trees such as *S. decussata* provide a major part of the food and nutritional requirements of people living in rural areas and some marginalized areas in sub-Saharan Africa. Moreover, fruits of large-fruited *Strychnos* species such as *S. cocculoides, S. madagascariensis, S. pungens* and *S. spinosa* are considered to be delicious and their fruit pulp sometimes dried and stored for later use [64], thereby extending the

shelf-life and availability of the edible fruits. Research by Nhukarume et al. [63] showed that indigenous fruits contribute significantly to the diets of many rural families in sub-Saharan Africa in times of famine and the fruits also provide some essential micronutrients. The fruits of *Strychnos* species are a source of energy and important nutrients such as carbohydrates, sugars, proteins, vitamins, essential minerals and fibres [25,33-34,65], and therefore, may alleviate nutritional insecurity for local communities. There is evidence that daily consumption of fresh fruits reduces the risk of diseases such as cancer and this is linked to organic compounds such as phenols [66] and flavonoids [67] which contribute to the nutritional value and antioxidant and venotonic effects. However, fruits have a high water content and a relatively low food value with calories ranging from 30 to 70 kcal per 100g, and therefore, should be combined with other foods in order to create a balanced diet [68].

The Functional Food Center defines functional food as "natural or processed foods that contain biologically-active compounds, which, in defined, effective, non-toxic amounts, provide a clinically proven and documented health benefit utilizing specific biomarkers, to promote optimal health and reduce the risk of chronic or viral diseases and manage their symptoms'' [41,45]. The Functional Food Center has created a classification system categorizing functional foods as A, B or C based on research on their epidemiological and after market studies and the quality of evidence for the functional food product [45]. A classification of A shows that aftermarket research, epidemiological studies and certification of the functional food status has been completed, B indicates completion of epidemiological studies and certification while C indicates that the product has only been certified as functional [45]. Current research focusing on functional foods is emphasizing the importance of international regulatory framework for health-related claims associated with functional foods, particularly the use of these claims in the labelling of functional products [69]. Furthermore, Adany et al. [38] and Martirosyan et al. [45] argue that functional foods should undergo a thorough evaluation process, including publishing such findings in peer reviewed journals to ensure that only safe and effective products will be released to the market. Based on the Functional Food Center's classification system, *S. decussata* can be accorded a C classification category as there are numerous gaps in aftermarket research, epidemiological studies and certification of the functional food status of the species. Therefore, there is a need for detailed studies aimed at elucidating the micronutrients and phytochemical compounds associated with *S. decussata* that are important for human nutrition and health.

***Medicinal uses of Strychnos decussata:*** The bark and roots of *S. decussata* are sold in informal herbal medicine markets as traditional medicines in Mozambique [70] and in the Eastern Cape and Gauteng provinces in South Africa [71-72]. The ground root bark of *S. decussata* is used as snuff in South Africa [7,73,74]. The bark, leaf, roots, root bark, root powder and stem bark infusions and/or decoctions of *S. decussata* are mainly used as charm and ritual, scorpion and snake bite antidote, and ethnoveterinary medicine, and traditional medicine for fever, gastro-intestinal problems, headache, respiratory infections, wounds, venereal diseases and infections in Kenya, Madagascar, Mozambique and South Africa (Table 1; Figure 3). Other medicinal applications of *S. decussata* which are supported by at least two literature records include the use of roots as anthelmintic in Mozambique [70,75] and the use of stem bark against ulcers in Kenya [57,76]. Research by Famewo et al. [77,78] revealed that *S. decussata* is an ingredient of a polyherbal medicine mixed with *Agathosma betulina* (P.J. Bergius) Pillans, *Allium sativum* L. (bulb), *Daucus carota* L. (roots),

*Glycyrrhiza glabra* L. (roots), *Gunnera perpensa* L. (rhizome), *Hypoxis argentea* Harv. ex Baker (corms) and *Menta x piperita* L. (leaves) used as traditional medicine against tuberculosis. The bark of *S. decussata* is also mixed with the corms of *H. argentea*, *Centella eriantha* (A. Rich.) Drude (rhizome), *Kniphofia drepanophylla* Baker (roots), *Myrsine melanophloeos* (L.) R.Br. ex Sweet (bark) and *Pentanisia prunelloides* (Klotzsch) Walp (rhizome) as traditional medicine for tuberculosis [77-79]. Similarly, the bark of *S. decussata* is also mixed with the roots of *Hermannia* spp. and *Lauridia tetragona* (L.f.) R.H. Archer as traditional medicine for tuberculosis [77,78]. Research by Famewo et al. [77] showed that the polyherb remedies including the bark of *S. decussata* contain anti-tubercular activities against *Mycobacterium tuberculosis*, a bacterium which causes tuberculosis.

**Table 1:** Medicinal uses of *Strychnos decussata*.

| Medicinal uses | Parts used | Country | Reference |
|---|---|---|---|
| Abscesses | Root infusion applied topically | Madagascar | 80 |
| Anthelmintic | Root decoction taken orally | Mozambique | 70,75 |
| Blood purification, cleansing or detoxification | Bark infusion taken orally | South Africa | 81 |
| Charm and ritual (lightning and protection) | Bark and roots used | South Africa | 1,7,9,36,73,81-91 |
| Fever | Bark decoction taken orally | South Africa | 92-95 |
| Gastro-intestinal problems (diarrhoea, stomach ache, stomach gripes and cramps) | Leaf, root, root bark and stem bark decoction or infusion taken orally | Kenya, Madagascar and South Africa | 1,7,25,30,36,48,57,73,76,80,84,85,96-98 |
| Headache | Bark infusion taken orally | South Africa | 92-94,99 |
| Anti-inflammation | Root infusion applied topically | Madagascar | 80 |
| Antimalarial | Leaf infusion taken orally | Madagascar | 80 |
| Rheumatic pain | Leaf decoction applied topically | Madagascar | 100 |
| Scorpion and snake bite antidote | Root decoction or infusion taken orally or root powder applied externally | South Africa | 30,41,81-82,84,101-106 |
| Respiratory infections (sore throat and tuberculosis) | Bark decoction taken orally | South Africa | 77-78,92-95,107 |
| Anti-tuberculosis | Bark mixed with leaves of *Agathosma betulina* (P.J. Bergius) Pillans, *Allium sativum* L. (bulb), *Daucus carota* L. (roots), *Glycyrrhiza glabra* L. (roots), *Gunnera perpensa* L. (rhizome), *Hypoxis argentea* Harv. ex Baker (corms) and *Menta x piperita* L. (leaves) | South Africa | 77-78 |
| Anti-tuberculosis | Bark mixed with the corms of *H. argentea*, *Centella eriantha* (A. Rich.) Drude (rhizome), *Kniphofia drepanophylla* Baker (roots), *Myrsine melanophloeos* (L.) R.Br. ex Sweet (Bark) and *Pentanisia prunelloides* (Klotzsch) Walp (rhizome) | South Africa | 77-79 |
| Anti-tuberculosis | Bark mixed with roots of *Hermannia* spp. and *Lauridia tetragona* (L.f.) R.H. Archer | South Africa | 77-78 |
| Anti-ulcer | Stem bark decoction taken orally | Kenya | 57,76 |
| Venereal diseases and infections | Bark decoction taken orally | Madagascar and South Africa | 92-94,100,108 |
| Wounds | Bark and roots infusion applied topically | Madagascar and South Africa | 80,92-94 |
| Ethnoveterinary medicine (helminthiases and roundworms in cows) | Bark and roots | Mozambique and South Africa | 70,109-114 |

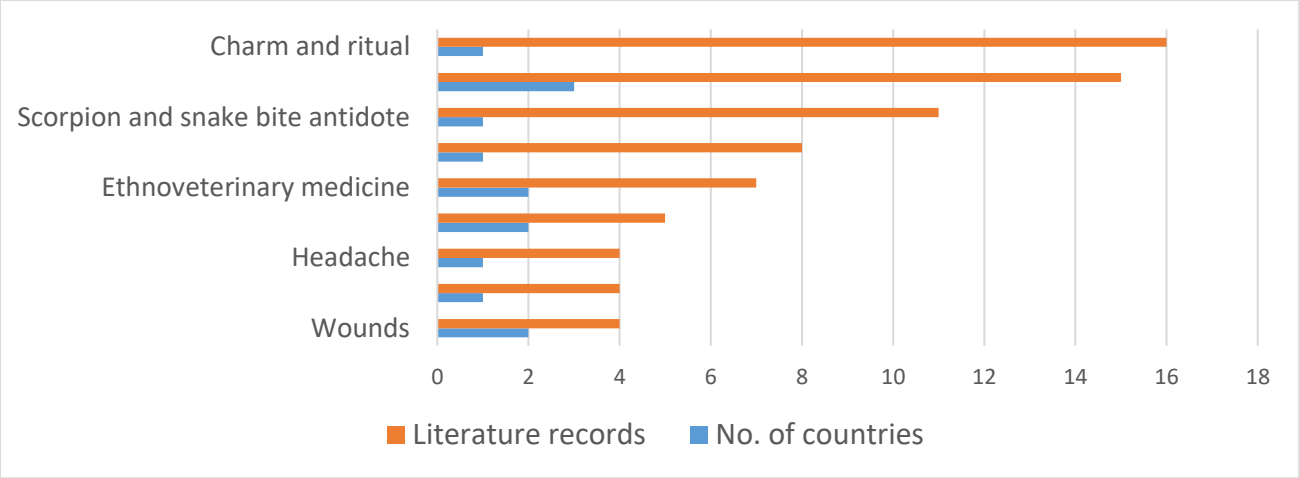



**Figure 3.** Medicinal uses of *Strychnos decussata* in sub-Saharan Africa.

***Phytochemical composition of Strychnos decussata:*** Several phytochemical compounds such as decussine and decussine-type alkaloids, gluco-indole alkaloids and pentacyclic indole alkaloids have been isolated from the leaves and stem bark of *S. decussata* [115-119]. Some of the medicinal properties exhibited by *S. decussata* could be linked to the different alkaloids identified from the species as alkaloids are known to exhibit antibacterial, anticholinesterase, antifungal, antioxidant, antiviral, antimalarial, hepatoprotective, hypoglycemic, antispasmodic, oxytocic, antipyretic, anxiolytic, anticancer, anti-inflammatory, analgesic, cytotoxicity and antidepressant properties [120-122]. Moreover, alkaloids are known to be useful as diet ingredients, supplements and stimulants [121

**Table 2.** Phytochemical composition of *Strychnos decussata.*

| Phytochemical compound | Chemical formula | Plant part | Reference |
|---|---|---|---|
| **Gluco-alkaloid** | - | Leaves | 115 |
| **Akagerine** | $C_{20}H_{24}N_2O_2$ | Stem bark | 117 |
| **17-O-Methyl-akagerine** | $C_{21}H_{26}N_2O_2$ | Stem bark | 117 |
| **10-Hydroxy-17-O-methyl-akagerine** | $C_{21}H_{26}N_2O_3$ | Stem bark | 117 |
| **10-Hydroxy-21-O-methyl-kribine** | $C_{21}H_{26}N_2O_3$ | Stem bark | 117 |
| **10-Hydroxy-epi 21-O-methyl-kribine** | $C_{21}H_{26}N_2O_3$ | Stem bark | 117 |
| **10-Hydroxy-akagerine** | $C_{20}H_{24}N_2O_3$ | Stem bark | 116 |
| **Akagerine lactone** | $C_{20}H_{24}N_2O_3$ | Stem bark | 116 |
| **Decussine** | $C_{20}H_{19}N_3$ | Stem bark | 119 |
| **3,14-Dihydro-decussine** | $C_{20}H_{20}N_3$ | Stem bark | 119 |
| **10-Hydroxy-3,14-dihydro-decussine** | $C_{20}H_{21}N_3$ | Stem bark | 119 |
| **Rouhamine** | $C_{20}H_{17}N_3$ | Stem bark | 119 |
| **Bisnordihydrotoxiferine** | $C_{38}H_{40}N_4$ | Stem bark | 119 |
| **Macusine A** | $C_{22}H_{27}N_2O_3$ | Stem bark | 118 |
| **Macusine B** | $C_{20}H_{25}N_2O^+$ | Stem bark | 118 |
| **Macusine C** | $C_{22}H_{27}N_2O_3$ | Stem bark | 118 |
| **Malindine** | $C_{20}H_{21}N_3$ | Stem bark | 118 |
| **O-Methyl-macusine** | $C_{22}H_{27}N_2O_3^+$ | Stem bark | 118 |

***Pharmacological properties of Strychnos decussata:*** The following biological activities have been reported from the stem bark of *S. decussata* and alkaloids isolated from the species: antifungal [92,94], antimycobacterial [77], antiplasmodial [80] and convulsant [117-118] activities.

***Antifungal activities:*** Samie et al. [92] evaluated the antifungal activities of acetone and hexane extracts of *S. decussata* stem bark against *Candida albicans, Cryptococcus neoformans* and *Candida krusei* using the agar diffusion and the microdilution methods with nystatin and flucytosine as positive controls. The extracts exhibited activities against the tested pathogens with the minimum inhibitory concentration (MIC) values ranging from 1.9 mg/ml to >7.5 mg/ml [92]. Samie and Mashau [94] evaluated the antifungal activities of hexane extracts of *S. decussata* stem bark against *Fusarium verticillioides, Fusarium oxysporum, Fusarium nygamai, Fusarium graminearum* and *Fusarium proliferatum* using the hole plate diffusion and the microdilution methods with nystatin as positive control. The extract exhibited activities against the tested pathogens with MIC values ranging from 3.8 mg/ml to >7.5 mg/ml [94]. The antifungal activities exhibited by *S. decussata* stem bark extracts corroborate the medicinal uses of the species against opportunistic diseases and infections such as abscesses [80], gastro-intestinal problems [1,7,25,30,36,48,57,73,76,80,84,85,96-98], inflammation [80], respiratory infections [77-78, 92-95,107], venereal diseases and wounds [80, 92-94,100,108].

***Antimycobacterial activities:*** Traditional medicines are widely used against tuberculosis [123-129], a life-threatening disease in animals and humans caused by various *Mycobacterium* species. *S. decussata* is one of the medicinal plants used to treat and manage tuberculosis-related symptoms [77] and *in vitro* activity testing against target pathogenic microorganisms such as *Mycobacterium tuberculosis* is important. Research by Kabongo-Kayoka et al. [130] showed that substances or natural products that can either inhibit the growth of *M. tuberculosis* or kill it while having little or no toxicity to host cells are considered good candidates for developing new anti-tubercular drugs. Famewo et al. [77] evaluated the antimycobacterial activities of ethanol herbal mixture of *S. decussata* with *Agathosma betulina, Allium sativum, Centella eriantha, Daucus carota, Glycyrrhiza glabra, Gunnera perpensa, Hermannia* spp., *Hypoxis argentea, Kniphofia drepanophylla, Lauridia tetragonia, Menta piperita, Pentanisia prunelloides* and *Rapanea melanophloeos* against *Mycobacterium tuberculosis* with isoniazid (0.05 µg/ml) as a positive control. The mixture showed activities with MIC values ranging from <1.6 µg/ml to 25.0 µg/ml while the positive control exhibited MIC value of 0.05 µg/ml [77].

***Antiplasmodial activities:*** Malaria is caused by single-celled parasites of the genus *Plasmodium*, particularly *P. falciparum, P. knowlesi, P. malariae, P. ovale* and *P. vivax* [131]. Therefore, traditional medicines, other therapeutic and preventative drugs against malaria usually interfere with different phases of the *Plasmodium* species life cycle [132-133]. Rasoanaivo et al. [80] evaluated the antiplasmodial activities of the crude alkaloid extracts isolated from *S. decussata* against a chloroquine-resistant *Plasmodium falciparum* strain using the [$^3$H]-hypoxanthine incorporation assay with chloroquine as a positive control. The crude alkaloid extracts exhibited antiplasmodial activities in the *in vitro* experimental model with half maximal inhibitory concentration ($IC_{50}$) value of 19.7 µg/ml in comparison with $IC_{50}$ values ranging from 0.01 µg/ml to 0.1 µg/ml exhibited by the positive control [80]. The antiplasmodial activities exhibited by the crude alkaloid extracts of *S. decussata* corroborate the medicinal applications of the species against malaria in Madagascar. Moreover, six

*Strychnos* species are used as traditional medicines against malaria in Madagascar and such species include *S. decussata, S. diplotricha* Leeuwenb., *S. henningsii, S. madagascariensis, S. mostueoides* Leeuwenb. and *S. myrtoides* Gilg & Busse [80].

***Convulsant activities:*** Rolfsen et al. [117] evaluated the convulsant activities of the alkaloids, akagerine, 17-O-methyl-akagerine, 10-hydroxy-17-O-methyl-akagerine, 10-hydroxy-21-O-methyl-kribine and 10-hydroxy-epi 21-O-methyl-kribine isolated from the stem bark of *S. decussata* using strychnine as the standard drug. The alkaloids exhibited potent convulsant activities with half maximal curative dose ($CD_{50}$) ranging from 45.3 mg/kg to 84.0 and half maximal lethal dose ($LD_{50}$) ranging from 47.5 mg/kg to 90.0 mg/kg. The alkaloids exhibited typical extension component of the tonic convulsions, although they were less active than strychnine [117]. Similarly, Olaniyi et al. [118] evaluated the convulsant activities of the alkaloid malindine obtained from the water-soluble fraction of the stem bark of *S. decussata*. The alkaloid malindine exhibited muscle-relaxant activities when injected intraperitoneally in mice and also produced a 50.0% reduction in the amplitude of the concentration of a diaphragm-muscle preparation at a dose of 0.5 mg/ml [118]. Recent research by Setubal et al. [12] attributed convulsant activities exhibited by *Strychnos* species to alkaloids, particularly strychnine which is known to exhibit the convulsant effects when ingested [12]. The indole alkaloid strychnine is a central nervous system stimulant, inhibits a glycine receptor, increases excitability of all parts of the central nervous system causing symmetric muscular spasms, convulsions, salivation, irreversible contraction of the bronchial muscles and sometimes death from respiratory arrest or cardiac arrest [134-135]. Similarly, Tits et al. [136] evaluated the antispasmodic activities of the alkaloids such as brucine, holstiine, isoretuline, O-acetylisoretuline and retuline isolated from a closely related species *S. henningsii* using the myostimulating effect of histamine and bradykinin on guinea-pig ileum. The alkaloid isoretuline exhibited moderate activities [136].

## CONCLUSION

This review established the food value and medicinal uses of *S. decussata. S. decussata* contains several alkaloid compounds that are pharmacologically and pharmaceutically valuable. The species also demonstrated some pharmacological activities which need further investigation, such as antifungal, antimycobacterial, antiplasmodial and convulsant activities. Further research should focus on detailed pharmacological research, in vivo and clinical studies, as well as toxicological evaluations. The results obtained are promising and this species should be explored further to decipher its true ethnobotanical values and pharmacological worth.

**List of abbreviations:** $CD_{50}$: half maximal curative dose, $IC_{50}$: half maximal inhibitory concentration, $LD_{50}$: half maximal lethal dose, MIC: minimum inhibitory concentration

**Competing interests:** There are no competing interests associated with this research.

**Authors' contributions:** The author conceived the research and wrote the manuscript.

**Acknowledgments:** I thank the reviewers for their careful reading of the manuscript and constructive remarks.

## REFERENCES

1. Palmer E, Pitman N. Trees of southern Africa covering all known indigenous species in the Republic of South Africa, South-West Africa, Botswana, Lesotho and Swaziland. AA Balkema, Cape Town, South Africa; 1972.
2. Backlund M, Oxelman B, Bremer B. Phylogenetic relationships within the Gentianales based on ndhF and rbcL sequences, with particular reference to the Loganiaceae. Amer J Bot 2000,87:1029–1043. DOI: https://doi.org/10.2307/2657003.

3. APG III: An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. Bot J Linnean Soc 2009,161:105–121. DOI: https://doi.org/10.1111/j.1095-8339.2009.00996.x
4. Gibbons KL, Henwood MJ, Conn BJ. Phylogenetic relationships in Loganieae (Loganiaceae) inferred from nuclear ribosomal and chloroplast DNA sequence data. Australian Syst Bot 2012,25:331–340. DOI: https://doi.org/10.1071/SB12002.
5. Struwe L, Gibbons KL, Conn B, Motley T. Loganiaceae (including Antoniaceae, Geniostomaceae, Spigeliaceae, and Strychnaceae). IN: The families and genera of flowering plants, volume 15. Edited by Kadereit JW, Bittrich V. Springer Verlag, Berlin, Germany; 2019, pp. 511-526.
6. Leistner OA. Seed plants of southern Africa: Families and genera. Strelitzia 10, National Botanical Institute, Pretoria, South Africa; 2000.
7. Palgrave MC. Keith Coates Palgrave trees of southern Africa. Struik Nature, Cape Town, South Africa; 2002.
8. Van Wyk B-E, Van Heerden F, Van Oudtshoorn B. Poisonous plants of South Africa. Briza Publications, Pretoria, South Africa; 2005.
9. Van Wyk B, Van Wyk P. Field guide to trees of southern Africa. Struik Nature, Cape Town, South Africa; 2013.
10. Takhtajan A. Diversity and classification of flowering plants. Columbia University Press, New York, USA; 1996.
11. Takhtajan A. Flowering plants. Springer, New York, USA; 2009.
12. Setubal RB, Frasier CL, Molina J, Torke BM, Forzza RC, Struwe L. A toxic story: Phylogeny and classification of *Strychnos* L. (Loganiaceae). Syst Bot 2021,46:639–655. DOI: https://doi.org/10.1600/036364421X16312067913444.
13. Leeuwenberg AJM. The Loganiaceae of Africa VIII, *Strychnos* III: Revision of the African species with notes on the extra-African. Medelingen Landbouwhogeschool 1969,69:1–316.
14. Krukoff BA. American species of *Strychnos*. Lloydia 1972;35:193–271.
15. Krukoff BA, Monachino J. The American species of *Strychnos*. Brittonia 1942;4:248–322.
16. Leenhouts PW. Loganiaceae. IN: Flora Malesiana, series 1, volume 6. Edited by van Steenis CGGJ. Noordhoff Kolff NV, Djakarta, Indonesia; 1962, pp 293-387.
17. Bisset NG, Leenhouts PW, Leeuwenberg AJM, Philcox D, Tirel-Roudet C, Vidal JE. The Asian species of *Strychnos*. Part II. Typification, miscellaneous notes, synoptic key, and sectional classification. Lloydia 1973,36:179–201.
18. Huft MJ. A new species of *Strychnos* (Loganiaceae) from Nicaragua. Annals Missouri Bot Garden 1988,75:383–384. DOI: https://doi.org/10.2307/2399481.
19. Conn BJ, Brown EA, Dunlop CR. Loganiaceae. IN: Flora of Australia, volume 28, Gentianales. Edited by Orchard AE. CSIRO Publishing, Melbourne, Australia; 1996, pp 1-71
20. Brant AE, Davidse G. Strychnos. IN: Flora Mesoamericana, volume 4. Edited by Davidse B, Souza M, Knapp S, Chiang F. Missouri Botanical Garden Press, St. Louis, USA; 2009, pp 637-640.
21. McPherson G. *Strychnos puberula* (Loganiaceae), a new species from Panama. Novon 2011,21:472–474. DOI: https://doi.org/10.3417/2010095
22. Brandão EKS, Rapini A. Novelties in *Strychnos* sect. Breviflorae (Loganiaceae). Phytotaxa 2017,329:262–268. DOI: https://doi.org/10.11646/phytotaxa.329.3.7
23. Ngadze RT, Linnemann AR, Nyanga LK, Fogliano V, Verkerk R. Local processing and nutritional composition of indigenous fruits: The case of monkey orange (*Strychnos* spp.) from southern Africa. Food Rev Int 2017,33:123–142. DOI: https://doi.org/10.1080/87559129.2016.1149862.
24. Ngadze RT, Verkerk R, Nyanga LK, Fogliano V, Linnemann AR. Improvement of traditional processing of local monkey orange (*Strychnos* spp.) fruits to enhance nutrition security in Zimbabwe. Food Secur 2017,9:621–633. DOI: https://doi.org/10.1007/s12571-017-0679-x.
25. Van Rayne KK, Adebo OA, Wokadala OC, Ngobese NZ. The potential of *Strychnos* spp L. utilization in food insecurity alleviation: A review. Food Reviews Int 2021. DOI: https://doi.org/10.1080/87559129.2021.2012791.
26. de Ruijter A. *Strychnos henningsii* Gilg. IN: Plant resources of tropical Africa 11: Medicinal plants 1. Edited by Schmelzer GH, Gurib-Fakim A. Backhuys Publishers, Leiden, the Netherlands; 2008, pp 570-571.
27. Maroyi A. Evaluation of medicinal uses, phytochemistry and pharmacological properties of *Strychnos henningsii* Gilg (Strychnaceae). Int J Sci Technol Res 2021,10:10-18.
28. Van Rayne KK, Adebo OA, Ngobese NZ. Nutritional and physicochemical characterization of *Strychnos madagascariensis* Poir (Black monkey orange) seeds as a potential food source. Foods 2020,9:1060. DOI: https://doi.org/10.3390/foods9081060..
29. Maroyi A. Evaluation of medicinal uses, phytochemistry and pharmacological properties of *Strychnos madagascariensis* Poir. Medicinal Plants Int J Phytomed Related Industries 2021,12:369-377. DOI: https://doi.org/10.5958/0975-6892.2021.00043.5.

30. Oyen LPA. *Strychnos mitis* S. Moore. IN: Plant resources of tropical Africa 7: Timbers 2. Edited by Lemmens RHMJ, Louppe D, Oteng-Amoako AA. PROTA Foundation, Backhuys Publishers, Leiden, the Netherlands; 2012, pp 613-616.
31. de Ruijter A. *Strychnos nux-vomica* L. IN: Plant resources of tropical Africa 11: Medicinal plants 1. Edited by Schmelzer GH, Gurib-Fakim A. Backhuys Publishers, Leiden, the Netherlands; 2008, pp 575-577.
32. de Ruijter A. *Strychnos potatorum* L. f. IN: Plant resources of tropical Africa 11: Medicinal plants 1. Edited by Schmelzer GH, Gurib-Fakim A. Backhuys Publishers, Leiden, the Netherlands; 2008, pp 577-579.
33. Tittikpina NK, Atakpama W, Hoekou Y, Diop YM, Batawila K, Akapagana K. *Strychnos spinosa* Lam.: Comprehensive review on its medicinal and nutritional uses. Afr J Compl Alt Med 2020,17:8-21. DOI: https://doi.org/10.21010/ajtcan.v17i2.2.
34. Omotayo AO, Aremu AO. Undervalued spiny monkey orange (*Strychnos spinosa* Lam.): An indigenous fruit for sustainable food-nutrition and economic prosperity. Plants 2021,10:2785. DOI: https://doi.org/10.3390/plants10122785.
35. Ohiri FC, Verpoorte R, Svendsen AB. The African *Strychnos* species and their alkaloids: A review._J Ethnopharmacol 1983,9:167-223. DOI: https://www.doi.org/10.1016/0378-8741(83)90032-6.
36. Arnold TH, Prentice CA, Hawker LC, Snyman EE, Tomalin M, Crouch NR, Pottas-Bircher C. Medicinal and magical plants of southern Africa: An annotated checklist. National Botanical Institute, Pretoria, South Africa; 2002.
37. Olatunya AM. Bioactive components of two species of locally grown nuts: Their potential health benefits and implications for healthy living. Bioactive Comp Health Dis 2021,4:301-310. DOI: https://www.doi.org/10.31989/bchd.v4i12.869.
38. Adany A, Kanya H, Martirosyan D. Japan's health food industry: An analysis of the efficacy of the FOSHU system. Funct Foods Health Dis 2021,4:63-78. DOI: https://www.doi.org/10.31989/bchd.v4i4.795.
39. Agarwal P, Rutter E, Martirosyan DM. Analysis of contemporary epidemiological study research. Funct Food Sci 2021,1:97-116. DOI: https://www.doi.org/10.31989/ffs.v1i12.882.
40. Iriti M, Varoni EM, Vitalini S. Phytochemical diversity behind health-promoting effects of traditional Mediterranean foods. Funct Food Sci 2021,1:67-81. DOI: https://www.doi.org/10.31989/ffs.v1i11.849.
41. Martirosyan D, Kanya H, Nadalet C. Can functional foods reduce the risk of disease? Advancement of functional food definition and steps to create functional food products. Funct Foods Health Dis 2021,11:213-221. DOI: https://www.doi.org/10.31989/ffhd.v11i5.788.
42. Soumya NPP, Mini S, Sivan SK, Mondal S. Bioactive compounds in functional food and their role as therapeutics. Bioactive Comp Health Dis 2021,4:24-39. DOI: https://www.doi.org/10.31989/bchd.v4i3.786.
43. Bhattarai S, Janaswamy S. The nexus of gut microbiota, diet and health. Funct Food Sci 2022,2:47-63. DOI: https://www.doi.org/10.31989/ffs.v2i2.885
44. Martirosyan DM, Sanchez SS. Establishment of dosage of bioactive compounds in functional food products. Funct Food Sci 2022,3:79-93. DOI: https://doi.org/10.31989/ffs.v2i3.915.
45. Martirosyan D, Lampert T, Ekblad M. Classification and regulation of functional food proposed by the Functional Food Center. Funct Food Sci 2022,2:25-46. DOI: https://www.doi.org/10.31989/ ffs.v2i2.890.
46. Martirosyan DM, Lampert T, Lee M. A comprehensive review on the role of food bioactive compounds in functional food science. Funct Food Sci 2022,3:64-79. DOI: https://www.doi.org/10.31989/ffs.v2i3.906
47. Kayode AAA, Okumede GF, Alabi GO. Mode of action of some bioactive compounds with anticancer activity. Bioactive Comp Health Dis 2022,5:67-83. DOI: https://www.doi.org/10.31989/bchd.v5i2.901.
48. Venter E. Trees of the Garden Route: Mossel Bay to Storms River. Briza Publications, Pretoria, South Africa; 2012.
49. Schmidt E, Lotter M, McCleland W. Trees and shrubs of Mpumalanga and Kruger National Park. Jacana Media, Johannesburg, South Africa; 2017.
50. Bruce EA, Lewis J. Loganiaceae. Flora of tropical East Africa, Crown Agents for Overseas Governments and Administrations, London, UK; 1960.
51. Leeuwenberg AJM. Loganiaceae. IN: Flora Zambesiaca volume 7, part 1. Edited by Launert E. Flora Zambesiaca Managing Committee, London, UK; 1983, pp 327–374.
52. Thulin M. Loganiaceae. IN: Flora of Somalia volume 3. Edited by Thulin M. The Trustees of the Royal Botanic Gardens, Kew., Richmond, Surrey, UK; 2006, pp 110-117
53. Van Wyk P. Field Guide to the trees of the Kruger National Park. Struik Publishers, Cape Town, South Africa; 2008.
54. Verdoorn IC. Loganiaceae. IN: Flora of southern Africa. Volume 26. Edited by Dyer RA, Codd LE. Botanical Research

Institute, Department of Agricultural Technical Services, Pretoria, South Africa; 1963, pp 134–171

55. Manning JC, Goldblatt P. Plants of the Greater Cape Floristic Region I: The core Cape flora. Strelitzia 29. South African National Biodiversity Institute, Pretoria, South Africa; 2012.
56. Germishuizen G, Meyer NL. Plants of southern Africa: An annotated checklist. Strelitzia 14. National Botanical Institute, Pretoria, South Africa; 2003.
57. Wanjiru MG. The investigation of the alkaloids of *Strychnos decussata*. BSc Dissertation, University of Nairobi, Nairobi, Kenya; 1986.
58. Beentje H, Adamson J, Bhanderi D. Kenya trees, shrubs, and lianas. National Museums of Kenya, Nairobi, Kenya; 1994.
59. Simitu PJ. Consumption and conservation of drylands' indigenous fruit trees for rural livelihood improvement in Mwingi District, Kenya. MSc Dissertation, Kenyatta University, Nairobi, Kenya; 2011.
60. Mutie FM, Rono PC, Kathambi V, Hu G-W, Wang Q-F. Conservation of wild food plants and their potential for combatting food insecurity in Kenya as exemplified by the drylands of Kitui County. Plants 2020,9:1017. DOI: https://doi.org/10.3390/plants9081017.
61. Fox FW, Norwood Young ME. Food from the Veld. Delta Books, Johannesburg, South Africa; 1982.
62. Welcome AK, Van Wyk B-E. An inventory and analysis of the food plants of southern Africa. S Afr J Bot 2019,122:136–179. DOI: https://doi.org/10.1016/j.sajb.2018.11.003.
63. Nhukarume L, Chikwambi Z, Muchuweti M, Chipurura B. Phenolic content and antioxidant capacities of *Parinari curatelifolia, Strychnos spinosa* and *Adansonia digitata*. J Food Biochem 2010,34:207–221. DOI: https://doi.org/10.1111/j.1745-4514.2009.00325.x.
64. Van Wyk B-E, Gericke N. People's plants: A guide to useful plants of southern Africa. Briza Publications, Pretoria, South Africa; 2018.
65. Aremu AO, Moyo M. Health benefits and biological activities of spiny monkey orange (*Strychnos spinosa* Lam.): An African indigenous fruit tree. J Ethnopharmacol 2022,283:114704. DOI: https://doi.org/10.1016/j.jep.2021.114704.
66. Ávila-Gálvez MÁ, Giménez-Bastida JA, Espín JC, González-Sarrías A. Dietary phenolics against breast cancer: A critical evidence-based review and future perspectives. Int J Mol Sci 2020,21:5718. DOI: https://doi.org/10.3390/ijms21165718.
67. Rodríguez-García C, Sánchez-Quesada C, Gaforio J. Dietary flavonoids as cancer chemopreventive agents: An updated review of human studies. Antioxidants 2019,8:137. DOI: https://doi.org/10.3390/antiox8050137.
68. Van Wyk B-E. Food plants of the world: Identification, culinary uses and nutritional value. Briza Publications, Pretoria, South Africa; 2005.
69. Domínguez Díaz L, Fernández-Ruiz V, Cámara M. An international regulatory review of food health-related claims in functional food products labeling. J Funct Foods 2020,68:103896. DOI: https://doi.org/10.1016/j.jff.2020.103896.
70. Barbosa F, Hlashwayo D, Sevastyanov V, Chichava V, Mataveia A, Boane E, Cala A. Medicinal plants sold for treatment of bacterial and parasitic diseases in humans in Maputo city markets, Mozambique. BMC Compl Med Ther 2020,20:19. DOI: https://doi.org/10.1186/s12906-019-2809-9.
71. Williams VL, Balkwill K, Witkowski ETF. A lexicon of plants traded in the Witwatersrand *umuthi* shops, South Africa. Bothalia 2001,31:71-98. DOI: https://doi.org/10.4102/abc.v31i1.508.
72. Dold AP, Cocks ML. The trade in medicinal plants in the Eastern Cape Province, South Africa. S Afr J Sci 2002,98:589-597. DOI: https://hdl.handle.net/10520/EJC97419.
73. Mbambezeli G. *Strychnos decussata* (Pappe) Gilg; 2008. Available from: http://pza.sanbi.org/strychnos-decussata, accessed on 11 February 2022.
74. Stafford GI. Southern African plants used to treat central nervous system related disorders. PhD Thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa; 2009.
75. Sitoe E. Medicinal ethnobotany of Mozambique: A review and analysis. MSc Dissertation, University of Johannesburg, Johannesburg, South Africa; 2020.
76. Njume C. Phytochemical analysis and bioactivity of selected South African medicinal plants on clinical isolates of *Helicobacter pylori*. PhD Thesis, University of Fort Hare, Alice, South Africa; 2012.
77. Famewo EB, Clarke AM, Wiid I, Ngwane A, Van Helden P, Afolayan AJ. Anti-mycobacterium tuberculosis activity of polyherbal medicines used for the treatment of tuberculosis in Eastern Cape, South Africa. Afr Health Sci 2017,17:780-789. DOI: https://doi.org/10.4314/ahs.v17i3.21.
78. Famewo EB, Clarke AM, Afolayan AJ. Ethno-medicinal documentation of polyherbal medicines used for the treatment of tuberculosis in Amathole district municipality of the Eastern Cape province, South Africa. Pharm Biol 2017,55:696-700. DOI: https://doi.org/10.1080/13880209.2016.1266670.

79. Maroyi A. A review of botany, medicinal uses and biological activities of *Pentanisia prunelloides* (Rubiaceae). Asian J Pharmaceut Clinical Res 2019,12:4-9. DOI: https://doi.org/10.22159/ajpcr.2019.v12i18.34190.
80. Rasoanaivo P, Martin M-T, Guittet E, Frappier F. New contributions to the structure elucidation and pharmacology of *Strychnos* alkaloids. IN: Studies in natural products chemistry, volume 26, bioactive natural products, part G. Edited by Rahman A. Elsevier, London, UK; 2002, pp. 1029-1072.
81. Cocks ML, Dold AP. Cultural significance of biodiversity: the role of medicinal plants in urban African cultural practices in the Eastern Cape, South Africa. J Ethnobiol 2006,26: 60–81. DOI: https://doi.org/10.2993/0278-0771(2006)26[60:csobtr]2.0.co;2
82. Mabogo DEN. The ethnobotany of the Vhavenda. MSc Dissertation, University of Pretoria, Pretoria, South Africa; 1990.
83. Pooley E. The complete field guide to trees of Natal, Zululand and the eastern region. Natal Flora Publications Trust, Durban, South Africa; 1993
84. Hutchings A, Scott AH, Lewis G, Cunningham AB. Zulu medicinal plants: An inventory. University of Natal, Pietermaritzburg, South Africa; 1996.
85. Corrigan BM, Van Wyk B-E, Geldenhuys CJ, Jardine JM. Ethnobotanical plant uses in the KwaNibela Peninsula, St Lucia, South Africa. S Afr J Bot 2011,77:346–359. DOI: https://doi.org/10.1016/j.sajb.2010.09.017.
86. Koopman A. The interface between magic, plants and language. Southern Afr Humanities 2013,25:87-103. DOI: https://hdl.handle.net/10520/EJC149101
87. Coetzee H, Nell W, Van Rensburg L. An intervention program based on plant surrogates as alternatives to the use of southern ground-hornbills in cultural practices. Ethnobot Res Appl 2014,12:155–164.
88. Moteetee A. A review of plants used for magic by Basotho people in comparison with other cultural groups in southern Africa. Indian J Trad Knowl 2017,16:229-234. DOI: http://nopr.niscair.res.in/handle/123456789/40124
89. Magwede K. A quantitative survey of plant use of the Vhavenḓa, Limpopo province, South Africa. PhD Thesis, University of Johannesburg, Johannesburg, South Africa; 2018.
90. Magwede K, Van Wyk B-E, Van Wyk AE. An inventory of Vhavenḓa useful plants. S Afr J Bot 2019,122:57–89. DOI: https://doi.org/10.1016/j.sajb.2017.12.013.
91. Van Vuuren SF, Motlhatlego KE, Netshia V. Traditionally used polyherbals in a southern African therapeutic context. J Ethnopharmacol 2022,288:114977. DOI: https://doi.org/10.1016/j.jep.2022.114977.
92. Samie A, Tambani T, Harshfield E, Green E, Ramalivhana JN, Bessong PO. Antifungal activities of selected Venda medicinal plants against *Candida albicans*, *Candida krusei* and *Cryptococcus neoformans* isolated from South African AIDS patients. Afr J Biotechnol 2010,9:2965-2976.
93. Dzoyem JP, Kuete V. Review of the antifungal potential of African medicinal plants. IN: Antifungal Metabolites from Plants. Edited by Razzaghi-Abyaneh M, Rai M. Springer-Verlag, Berlin, Germany; 2013, pp. 78-153.
94. Samie A, Mashau F. Antifungal activities of fifteen Southern African medicinal plants against five *Fusarium* species. J Med Plants Res 2013,7:1839-1848.
95. Semenya SS, Maroyi A. Data on medicinal plants used to treat respiratory infections and related symptoms in South Africa. Data Brief 2018,21:419-423. DOI: https://doi.org/10.1016/j.dib.2018.10.012.
96. Hutchings A. A survey and analysis of traditional medicinal plants as used by the Zulu, Xhosa and Sotho. Bothalia 1989,19:111–123. DOI: https://doi.org/10.4102/abc.v19i1.947.
97. Grace OM, Prendergast HDV, Jäger AK, Van Staden J. Bark medicines used in traditional healthcare in KwaZulu-Natal, South Africa: An inventory. S Afr J Bot 2003,69:301–363. DOI: https://doi.org/10.1016/S0254-6299(15)30318-5.
98. Njume C, Afolayan AJ, Ndip RN. Diversity of plants used in the treatment of *Helicobacter pylori* associated morbidities in the Nkonkobe municipality of the Eastern Cape province of South Africa. J Med Plants Res 2011,5:3146-3151. DOI: https://doi.org/10.5897/JMPR.9000455.
99. Frimpong EK, Asong JA, Aremu AO. A review on medicinal plants used in the management of headache in Africa. Plants 2021,10:2038. DOI: https://doi.org/10.3390/plants10102038.
100. Norscia I, Borgognini-Tarli SM. Ethnobotanical reputation of plant species from two forests of Madagascar: A preliminary investigation. S Afr J Bot 2006,72:656–660. DOI: https://doi.org/10.1016/j.sajb.2006.04.004.
101. Arnold H-J, Gulumian M. Pharmacopoeia of traditional medicine in Venda. J Ethnopharmacol 1984,12:35-74. DOI: https://doi.org/10.1016/0378-8741(84)90086-2.
102. Mors WB, do Nascimento MC, Pereira BMR, Pereira N.A. Plant natural products active against snake bite: The

molecular approach. Phytochem 2000,55:627-642. DOI: https://doi.org/10.1016/s0031-9422(00)00229-6.

103. Molander M, Nielsen L, Søgaard S, Staerk D, Rønsted N, Diallo D, Chifundera KZ, Van Staden J, Jäger AK. Hyaluronidase, phospholipase $A_2$ and protease inhibitory activity of plants used in traditional treatment of snakebite-induced tissue necrosis in Mali, DR Congo and South Africa. J Ethnopharmacol 2014,157:171–180. DOI: https://doi.org/10.1016/j.jep.2014.09.027.
104. Félix-Silva J, Silva-Junior AA, Zucolotto SM, Fernandes-Pedrosa MF. Medicinal plants for the treatment of local tissue damage induced by snake venoms: An overview from traditional use to pharmacological evidence. Evidence-Based Compl Alt Med 2017, Volume 2017, Article ID 5748256. DOI: https://doi.org/10.1155/2017/5748256.
105. Mhlongo LS. The medicinal ethnobotany of the Amandawe Area in KwaCele, KwaZulu-Natal, South Africa. BSc Dissertation, University of Johannesburg, Johannesburg, South Africa; 2019.
106. Mhlongo LS, Van Wyk B-E. Zulu medicinal ethnobotany: new records from the Amandawe area of KwaZulu-Natal, South Africa. S Afr J Bot 2019,122:266–290. DOI: https://doi.org/10.1016/j.sajb.2019.02.012
107. Amaral AXB, Adi MS. The influence of knowledge, lifestyle and culture on the incidence of tuberculosis a literature review. Indian J Forensic Med Toxicol 2021,15:1936-1943. DOI: https://doi.org/10.37506/ijfmt.v15i2.14630
108. Fernandes L, Van Rensburg EJ, Hoosen AA, Steenkamp V. *In vitro* activity of medicinal plants of the Venda region, South Africa, against *Trichomonas vaginalis*. Southern Afr J Epidemiol Infection 2008,23:26-28. DOI: https://doi.org/10.1080/10158782.2008.11441310.
109. Dold AP, Cocks ML. Traditional veterinary medicine in the Alice district of the Eastern Cape province, South Africa. S Afr J Sci 2001,97:375–379. DOI: https://hdl.handle.net/10520/EJC97371
110. McGaw LJ, Eloff JN. Ethnoveterinary use of southern African plants and scientific evaluation of their medicinal properties. J Ethnopharmacol 2008,119:559–574. DOI: https://doi.org/10.1016/j.jep.2008.06.013.
111. Mphahlele M. The *in vitro* anthelmintic effects of ethnoveterinary medicinal plant extracts used in Blouberg District, Limpopo province, South Africa. MSc Dissertation, Tshwane University of Technology, Pretoria, South Africa; 2015.
112. Khunoana ET, McGaw LJ. Ethnoveterinary medicinal plants used in South Africa. IN: Ethnoveterinary medicine: Present and future concepts. Edited by McGaw LJ, Abdalla MA. Springer, Cham, Switzerland; 2020, pp 208-250.
113. Suroowan S, Mahomoodally MF. Alternative antimicrobials: Medicinal plants and their influences on animal infectious diseases. IN: Ethnoveterinary medicine: Present and future concepts. Edited by McGaw LJ, Abdalla MA. Springer, Cham, Switzerland; 2020, pp 23-56.
114. Selogatwe KM, Asong JA, Struwig M, Ndou RV, Aremu AO. A review of ethnoveterinary knowledge, biological activities and secondary metabolites of medicinal woody plants used for managing animal health in South Africa. Vet Sci 2021,8:228. DOI: https://doi.org/10.3390/vetsci8100228.
115. Petitjean A, Rasquanairo P, Razafintsalama J. A new gluco-alkaloid from *Strychnos decussata*. Phytochem 1977,16:154-155. DOI: https://doi.org/10.1016/0031-9422(77)83050-1
116. Olaniyi AA, Rolfsen W. Two new tertiary indole alkaloids from *Strychnos decussata.* J Nat Prod 1980,43:595-597. DOI: https://doi.org/10.1021/np50011a012
117. Rolfsen W, Olaniyi A, Hylands P. New tertiary alkaloids of *Strychnos decussata.* J Nat Prod 1980,43:97-101. DOI: https://doi.org/10.1021/np50007a007
118. Olaniyi AA, Rolfsen W, Verpoorte R. Quaternary indole alkaloids of *Strychnos decussata.* Planta Med 1981,43:353-359. DOI: https://doi.org/10.1055/s-2007-971523
119. Rolfsen W, Olaniyi A, Verpoorte R, Bohlin L. Some new decussine-type alkaloids from *Strychnos decussata, Strychnos dale* and *Strychnos elaeocarpa.* J Nat Prod 1981,44:415-421. DOI: https://doi.org/10.1021/np50016a004.
120. Chaves SK, Feitosa CM, da Araújo SL. Alkaloids pharmacological activities: Prospects for the development of phytopharmaceuticals for neurodegenerative diseases. Curr Pharm Biotechnol 2016,17:629-635. DOI: https://doi.org/10.2174/1389201017071605032015 41.
121. Kurek J. Introductory chapter: Alkaloids: Their importance in nature and for human life. IN: Alkaloids: Their importance in nature and human life. Edited by Kurek J. IntechOpen, London, UK; 2019, pp 1–7.
122. Peng J, Zheng T-T, Li X, Liang Y, Wang L-J, Huang Y-C, Xiao H-T. Plant-derived alkaloids: The promising disease-modifying agents for inflammatory bowel disease. Front Pharmacol 2019,10:351. DOI: https://doi.org/10.3389/fphar.2019.00351.
123. Semenya SS, Maroyi A. Medicinal plants used for the treatment of tuberculosis by Bapedi traditional healers in

the Limpopo province, South Africa. Afr J Trad Compl Alt Med 2012,10:316-323. DOI: https://doi.org/10.4314/ajtcam.v10i2.17.

124. Semenya SS, Maroyi A. Exotics plants used therapeutically by Bapedi traditional healers for respiratory infections and related symptoms in the Limpopo province, South Africa. Indian J Trad Knowl 2018,17:663-671. DOI: http://nopr.niscpr.res.in/handle/123456789/45068.
125. Semenya SS, Maroyi A. Respiratory infections treated by Bapedi traditional healers in the Limpopo Province, South Africa: Extent of treatments and diagnosis techniques. Indian J Trad Knowl 2018,17:672-681. DOI: http://nopr.niscair.res.in/handle/123456789/45067
126. Semenya SS, Maroyi A. Data on medicinal plants used to treat respiratory infections and related symptoms in South Africa. Data Brief 2018,21:419-423. DOI: https://doi.org/10.1016/j.dib.2018.10.012
127. Semenya SS, Maroyi A. Ethnobotanical survey of plants used by Bapedi traditional healers to treat tuberculosis and its opportunistic infections in the Limpopo Province, South Africa. S Afr J Bot 2019,122:401-421. DOI: https://doi.org/10.1016/j.sajb.2018.10.010.
128. Semenya SS, Maroyi A. Source, harvesting, conservation status, threats and management of indigenous plant used for respiratory infections and related symptoms in the Limpopo province, South Africa. Biodiversitas 2019,20(3):790-811. DOI: https://doi.org/10.13057/biodiv/d200325.
129. Semenya SS, Maroyi A. Ethnobotanical survey of plants used to treat respiratory infections and related symptoms in the Limpopo province, South Africa. J Herbal Med 24:100390. DOI: https://doi.org/10.1016/j.hermed.2020.100390.
130. Kabongo-Kayoka PN, Eloff JN, Obi CL, McGaw LJ. Antimycobacterial activity and low cytotoxicity of leaf extracts of Some African Anacardiaceae tree species. Phytother Res 2016,30:2001–2011. DOI: https://doi.org/10.1002/ptr.5706.
131. Ashley EA, Phyo AP, Woodrow CJ. Malaria. Lancet 2018,391:1608–1621. DOI: https://doi.org/10.1016/S0140-6736(18)30324-6.
132. Lelièvre J, Almela MJ, Lozano S, Miguel C, Franco V, Leroy D, Herreros E. Activity of clinically relevant antimalarial drugs on *Plasmodium falciparum* mature gametocytes in an ATP bioluminescence "transmission blocking" assay. PLoS One 2012,7(4):e35019. DOI: https://doi.org/10.1371/journal.pone.0035019.
133. Peatey CL, Skinner-Adams TS, Dixon MW, McCarthy JS, Gardiner DL, Trenholme KR. Effect of antimalarial drugs on *Plasmodium falciparum* gametocytes. J Infect Dis 2009,200(10):1518-1521. DOI: https://doi.org/10.1086/644645.
134. Wink M, Van Wyk B-E. Mind-altering and poisonous plants of the world: An illustrated scientific guide. Briza Publications, Pretoria, South Africa; 2008.
135. Van Wyk B-E, Wink M. Phytomedicines, herbal drugs and plant poisons. Briza Publications, Pretoria, South Africa; 2015.
136. Tits M, Damas J, Quetin-Leclercq J, Angenot L. From ethnobotanical uses of *Strychnos henningsii* to antiinflammatories, analgesics and antispasmodics. J Ethnopharmacol 1991,34(2-3):261-267. DOI: https://doi.org/10.1016/0378-8741(91)90045-f.