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Review Article

MEDICINAL USES, PHYTOCHEMICAL AND PHARMACOLOGICAL PROPERTIES OF *TERMINALIA SAMBESIACA* ENGL. AND DIELS (COMBRETACEAE)

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ABSTRACT

Terminalia sambesiaca Engl. and Dielsis a small to large tree widely used as traditional medicine in tropical Africa. This study critically reviewed the medicinal uses, phytochemical and pharmacological properties of *T. sambesiaca*. Literature on medicinal uses, phytochemical and pharmacological properties of *T. sambesiaca* was collected from multiple internet sources such as Web of Science, Scopus®, SpringerLink®, Google Scholar, SciELO, PubMed®, and ScienceDirect®. Complementary information on medicinal uses, phytochemical, and pharmacological properties of *T. sambesiaca* was gathered from pre-electronic sources such as book chapters, books, scientific reports, and journal articles obtained from the University library. This study revealed that *T. sambesiaca* is used as traditional medicine against menstrual problems, infertility in women, stomach ulcers, appendicitis, backache, bilharzia, cancer, cough, diarrhea, earache, infectious diseases, intestinal worms, pneumonia, and syphilis. Phytochemical research identified fatty acids, flavonoids, cardiac glycosides, saponins, triterpenoids, sterols, isochromans, esters, alkylamine, ligands, oxacycle, phenols, polyketides, ceramides, and chromones from the leaves, roots and stem bark of *T. sambesiaca*. Ethnopharmacological research revealed that the phytochemical compounds isolated from *T. sambesiaca* and crude extracts of the species showed antibacterial, anti-*Neisseria gonorrhoeae*, antimycobacterial, antifungal, antioxidant, antiproliferative, and cytotoxicity activities. Since *T. sambesiaca* extracts are widely used as sources of traditional medicines, there is need for extensive phytochemical, pharmacological, toxicological evaluations, *in vivo* and clinical studies.

Keywords: Combretaceae, Indigenous knowledge, *Materia medica, Terminalia sambesiaca*, Traditional medicine

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INTRODUCTION

Terminalia sambesiaca Engl. and Diels has a long history of medicinal use in tropical Africa. Medicinal plants have long been used as sources of pharmaceutical products throughout the world with more than 70–80% of the world's population still relying upon medicinal plants for primary health care [1-4]. Moreover, about 25% of the pharmaceutical prescriptions in use today are directly or indirectly derived from medicinal plants [1-3]. Majority of people in developing countries continue to use traditional medicines for their primary health care needs due to accessibility, affordability, and cultural acceptability of traditional or herbal medicines [2,5,6]. Therefore, medicinal plants represent an important source of natural products offering new opportunities for the development of innovative new pharmaceutical products [7-9]. Medicinal plants are used as crude extracts, poultices, herbal concoctions of different plant species, ointments, infusions of herbal teas or tinctures, component mixtures in porridges or soups, pharmaceutical drugs or prescription medicines [1,10]. However, many medicinal plants are scientifically poorly known and in need of detailed phytochemical and pharmacological research. Several plant species are known to contain active ingredients that have potential in the fight against common diseases and ailments like diabetes [11-14], diarrhea [15,16], malaria [17-19], tuberculosis [20-32], and many other ailments. The future of medicinal plant usage in tropical Africa is determined by recognition and integration of traditional medicine into conventional medicine and advanced ethnopharmacological research of medicinal plants used as phytomedicines, functional foods, and dietary supplements [33]. Recent research shows that the quality of herbal or traditional medicines is often compromised due to their production and also the presence of contaminants emanating from either natural or anthropogenic sources [6]. Therefore, issues about safety and toxicological properties of medicinal plants lead to ethnopharmacological research focusing on phytochemical analyses, pharmacological properties, clinical research, and quality control of medicinal plants [34]. It is therefore, within this context that the current study was undertaken aimed at reviewing the medicinal uses, phytochemical, and pharmacological properties of *T. sambesiaca*.

METHODS

The literature search for medicinal uses, phytochemistry, and pharmacological properties of *T. sambesiaca* was conducted from August to December 2024 using online search databases used included Web of Science (https://www.webofknowledge.com), Scopus® (http://www.scopus.com/), SpringerLink® (https://link.springer.com/), Google Scholar (https://scholar.google.com/), SciELO (https://search.scielo.org/), PubMed® (https://pubmed.ncbi.nlm.nih.gov/), and ScienceDirect® (https://www.sciencedirect.com/search). The pre-electronic sources of literature used in this study, which included books, book chapters, journal articles, dissertations, and thesis were obtained from the University library. The keywords used in the search included "*Terminalia sambesiaca*," the synonyms of the species, "*Terminalia aemula*," "*Terminalia foetens*," "*Terminalia obovata*," "*Terminalia riparia*," and "*Terminalia thomasii*," and English common names "river cluster-leaf" and "river terminalia." An additional search was also conducted using the keywords "biological activities of *Terminalia sambesiaca*," "pharmacological properties of *Terminalia sambesiaca*," "ethnobotany of *Terminalia sambesiaca*," "medicinal uses of *Terminalia sambesiaca*," "phytochemistry of *Terminalia sambesiaca,*" and "traditional uses of *Terminalia sambesiaca.*"

RESULTS AND DISCUSSION

Taxonomy and morphological description of *T. sambesiaca*

The genus *Terminalia* consists of approximately 190 species and is fairly cosmopolitan in distribution, recorded across the tropical areas of Asia, Africa, America, and extending into the subtropical regions of the Pacific Islands and Australia [35-41]. The genus *Terminalia* comprises trees, shrubs, and lianas, characterized by the leaves which are simple, without

scales, that are alternate, spirally arranged, or sometimes opposite or nearly opposite, and are usually terminal or crowded toward the ends of the branches and sometimes on short shoots [36,37,42]. The leaves of some *Terminalia* species are petiolate or subsessile, usually entire but occasionally subcrenate, often with some pellucid dots or glands on either side of the leaf near the base or on the petiole [43]. The flowers are bisexual or male or female on the same or different trees, usually borne in lax spikes [42]. The flowers are small, lacking petals, and the fruit is one-seeded with two wings which are joined at the top and bottom [42]. The bark, leaf and fruit characters are widely used to differentiate and identify the *Terminalia* species [41,44-46]. The genus name *Terminalia* is derived from the Latin word "*terminus*" which means "end," in reference to the leaves that are borne in whorls close to ends of the shoots, branchlets, and branches [47]. The specific name "*sambesiaca*" means "of the Zambezi region" in reference to the geographical area where the species has been collected from [47]. The synonyms of *T. sambesiaca* include *Terminalia aemula* Diels, *Terminalia foetens* Engl., *Terminalia obovata* Sim, *Terminalia riparia* Engl. and Diels and *Terminalia thomasii* Engl. and Diels [44,48,49]. The English common names of *T. sambesiaca* include "river cluster-leaf" and "river terminalia" [50,51].

T. sambesiaca is a small to large evergreen tree with height ranging from 4 m to 40 m [50]. *T. sambesiaca* has a dense crown that is layered with horizontal branches. The bole is usually straight reaching 90 cm in diameter, slightly buttressed, old trees often with bottle-shaped buttresses up to 4 m high [50]. The bark is grey in color, smooth with dark patches giving a mottled appearance, becoming roughish in large specimens. The leaves are simple, crowded or occur in whorls at the ends of the branches, elliptic to broadly obovate in shape, dark green in color, thinly textured, with soft hairs with net venation which is visible below. The leaf apex is rounded, ending in a short point, base tapering, margin entire or sometimes obscurely scalloped. *T. sambesiaca* usually flowers in December to January and the flowers are in axillary or terminal spikes, bisexual or regular male. The flowers arecreamy white in color, sometimes tinged with pink, have a strong and unpleasant smell and are probably pollinated by flies. The fruits are elliptic in shape, green in color flushed with pink, drying to red-brown at maturity [50]. *T. sambesiaca* been recorded in Kenya, Tanzania, Malawi, Mozambique, Zambia and Zimbabwe [52] (Fig. 1). *T. sambesiaca* has been recorded in riverine fringes, rainforest, dry evergreen forest, riverine forest, savanna woodland and rocky hills recorded from sea level up to 850 m above sea level [47]. *T. sambesiaca* is often confused with *Terminalia kilimandscharica* Engl., a species that is often much smaller, characterized by small and less distinctly acuminate and more permanently hairy leaves [50].

Medicinal uses of *T. sambesiaca*

The traditional medicines prepared from the bark, leaves, roots, or stem bark of *T. sambesiaca* are used to treat and manage 18 human diseases and ailments (Table 1). The main ailments and diseases treated by *T. sambesiaca* extracts (Fig. 2) include menstrual problems, infertility in women, stomach ulcers, appendicitis, backache, bilharzia, cancer, cough, diarrhea, earache, infectious diseases, intestinal worms, pneumonia, and syphilis. Other medicinal applications of *T. sambesiaca* that are supported by at least two references include its uses as traditional medicine for colds [47,53], fever [47,53], sexually transmitted diseases [54], and stomach ache [47,53].

Phytochemical and pharmacological properties of *T. sambesiaca*

The leaves, roots, and stem bark of *T. sambesiaca* are characterized by fatty acids, flavonoids, cardiac glycosides, saponins, triterpenoids, sterols, isochromans, esters, alkylamine, ligands, oxacycle, phenols, polyketides, ceramides, and chromones [57,58,62,63,67] (Table 2).

Fig. 1: Distribution of *Terminalia sambesiaca* in tropical Africa

Table 1: Medicinal uses of *Terminalia sambesiaca*

Medicinal use	Part used	References
Appendicitis	Leaf, root or stem bark decoction taken orally	[47,55-58]
Backache	Not specified	[59-61]
Bilharzia	Not specified	[59-61]
Cancer	Bark, leaf, root or stem bark decoction taken orally	[55-58]
Colds	Bark or leaf decoction taken orally	[47,53]
Cough	Leaf, root or stem bark decoction taken orally	[55,62,63]
Diarrhea	Leaf, root, or stem bark decoction taken orally	[47,55,58,62,63]
Earache	Not specified	[59-61]
Fever	Bark or leaf decoction taken orally	[47,53]
Infectious diseases	Leaf, root, or stem bark decoction taken orally	[55,62-64]
Infertility in women	Leaf decoction taken orally	[54,65,66]
Intestinal worms	Not specified	[59-61]
Menstrual problems	Not specified	[59-61]
Pneumonia	Not specified	[59-61]
Sexually transmitted diseases	Not specified	[54]
Stomach ache	Leaf decoction taken orally	[47,53]
Stomach ulcers	Brak, leaf, root, or stem bark decoction taken orally	[47,55-58]
Syphilis	Not specified	[59-61]

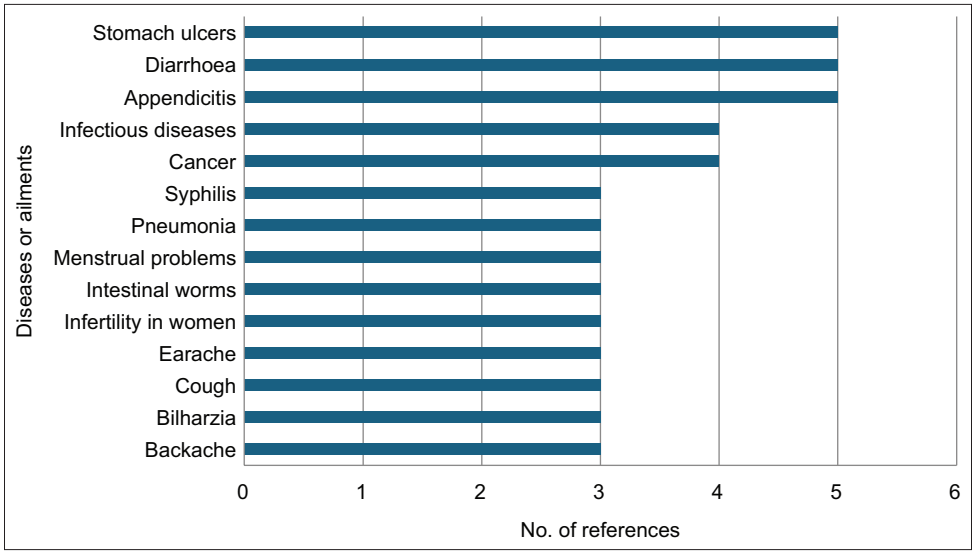

Fig. 2: Main ethnomedicinal applications of *Terminalia sambesiaca* in tropical Africa

The phytochemical compounds isolated from *T. sambesiaca* and crude extracts of the species exhibited antibacterial, anti-*Neisseria gonorrhoeae*, antimycobacterial, antifungal, antioxidant, antiproliferative, and cytotoxicity activities.

Antibacterial activities

Chhabra *et al.* [55] assessed the antibacterial properties of aqueous extracts of the stem bark of *T. sambesiaca* against *Salmonella typhi, Staphylococcus aureus, Pseudomonas aeruginosa,* and *Shigella boydii* using the agar diffusion assay. The extract demonstrated activities against the tested pathogens [55]. Fyhrquist *et al.* [69] assessed the antibacterial activities of methanol extracts of the roots and stem bark of *T. sambesiaca* against *Klebsiella aerogenes, Staphylococcus epidermidis*, *S. aureus*, *Bacillus subtilis*, *Micrococcus luteus,* and *Sarcina* spp. using the agar diffusion method with ampicillin and streptomycin as positive controls. The extracts demonstrated activities against the tested pathogens exhibiting zone of inhibition ranging from 25.0 mm to 40.0 mm and minimum inhibitory concentration (MIC) values ranging from 0.9 mg/mL to 1.8 mg/mL [69]. Shai *et al.* [61] assessed the antibacterial activities of dichloromethane, n-hexane, and acetone extracts of *T. sambesiaca* leaves against *Escherichia coli, P. aeruginosa, S. aureus,* and *Enterococcus faecalis* using the microplate dilution assay with gentamicin as a positive control. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 0.08 mg/mL to 2.5 mg/mL [61]. Fyhrquist *et al.* [62] evaluated the antibacterial properties of aqueous, methanol, and butanol extracts of *T. sambesiaca* roots against *S. aureus* using the microdilution assay. The extracts demonstrated activities against the tested pathogen exhibiting MIC values ranging from 156.0 µg/mL to 312.0 µg/mL [62]. Anokwuru *et al.* [70] evaluated the antibacterial properties of methanol extracts of *T. sambesiaca* leaves against *S. aureus, S. epidermidis, Bacillus cereus, Klebsiella pneumoniae, P. aeruginosa, E. faecalis, E. coli, Salmonella typhimurium,* and *Shigella sonnei* using the microdilution assay with ciprofloxacin as a positive control. The extracts exhibited activities against the tested pathogens with MIC values ranging from 0.38 mg/mL to >3.0 mg/mL [60]. Anokwuru *et al.* [71] evaluated the antibacterial properties of methanol extracts of *T. sambesiaca* leaves against *S. aureus, B. cereus, E. coli,* and *S. typhimurium* using the microdilution assay with ciprofloxacin as a positive control. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 0.38 mg/mL to 2.0 mg/mL [71]. Florenca *et al.* [67] assessed the antibacterial properties of aqueous and methanol extracts of *T. sambesiaca* leaves against *E. coli, S. aureus, K. pneumoniae,* and their resistant counterparts Methicillin-resistant *S. aureus* and extended-spectrum Beta-Lactamase *E. coli* using the microdilution broth method with penicillin, erythromycin, tetracycline, chloramphenicol, and ciprofloxacin as positive controls. The extracts

Table 2: Phytochemical composition of *Terminalia sambesiaca*

Phytochemical compound	Formula	Plant part	References
1-[(2-Hydroxyethyl) amino]-2-dodecanol	$C_{14}H_{31}NO_2$	Leaves	[67]
1-Linoleoyl glycerol	$C_{21}H_{38}O_4$	Leaves	[67]
1-Tetradecylamine	$C_{14}H_{31}N$	Leaves	[67]
2-Amino-1,3,4-octadecanetriol	$C_{18}H_{39}NO_3$	Leaves	[67]
2-(Hydroxymethyl)-2-(octylamino)-1,3-propanediol	$C_{12}H_{27}NO_3$	Leaves	[67]
(2S,3R)-2-Amino-1,3-dodecanediol	$C_{12}H_{27}NO_2$	Leaves	[67]
2,5-Furandicarboxylic acid	$C_6H_4O_5$	Leaves	[67]
2,6-Diacetylpyridine	$C_{21}H_{37}N$	Leaves	[67]
3,5-di-tert-Butyl-4-hydroxybenzaldehyde	$C_{15}H_{22}O_2$	Leaves	[67]
5-Hydroxymethylfurfural	$C_6H_6O_3$	Leaves	[67]
6,6'-Oxybis (2,2-dimethyl-1-hexanol)	$C_{16}H_{34}O_3$	Leaves	[67]
(8aR,12S,12aR)-12-Hydroxy-4-methyl-4,5,6,7,8,8a, 12,12a-octahydro-2H-3-benzoxecine-2,9 (1H)-dione	$C_{14}H_{20}O_4$	Leaves	[67]
12-Aminolauric acid	$C_{12}H_{25}NO_2$	Leaves	[67]
Anofinic acid	$C_{12}H_{12}O_3$	Leaves	[67]
Azelaic acid	$C_9H_{16}O_4$	Leaves	[67]
Chaetomellic acid B	$C_{21}H_{34}O_3$	Leaves	[67]
(+)-Clavaminol	$C_{15}H_{31}NO_2$	Leaves	[67]
Corchorifatty acid	$C_{18}H_{32}O_5$	Leaves	[67]
Corilagin	$C_{27}H_{22}O_{18}$	Roots	[62,63]
α-Eleostearic acid	$C_{18}H_{30}O_2$	Leaves	[67]
Ellagic acid	$C_{14}H_6O_8$	Leaves, roots, and stem bark	[58,67]
Ellagic acid glycosides	$C_{20}H_{16}O_{13}$	Roots	[57,62,63]
Ellagitannins	$C_{44}H_{32}O_{27}$	Roots	[57,63]
Ethyl oleate	$C_{20}H_{38}O_2$	Leaves	[67]
Gallic acid	$C_7H_6O_5$	Roots and stem bark	[58]
Koninginin	$C_{16}H_{28}O_4$	Leaves	[67]
Lauramide	$C_{12}H_{25}NO$	Leaves	[67]
Lauryldimethylamine oxide	$C_{14}H_{31}NO$	Leaves	[67]
Monasnicotinate A	$C_{23}H_{31}NO_4$	Leaves	[67]
N-(1,3-Dihydroxyoctadec-4-en-2-yl) acetamide	$C_{20}H_{39}NO_3$	Leaves	[67]
Naringenin	$C_{15}H_{12}O_5$	Leaves	[67]
Orsellide C	$C_{15}H_{18}O_7$	Leaves	[67]
Palmitelaidic acid methyl ester	$C_{17}H_{32}O_2$	Leaves	[67]
Palmitoyl alanine	$C_{19}H_{37}NO_3$	Leaves	[67]
Phloionolic acid	$C_{18}H_{36}O_5$	Leaves	[67]
Phomochromone B	$C_{12}H_{14}O_4$	Leaves	[67]
Pseudoanguillosporin B	$C_{17}H_{26}O_4$	Leaves	[67]
D(-)-Quinic acid	$C_7H_{12}O_6$	Leaves	[67]
β-sitosterol	$C_{29}H_{50}O$	Leaves	[68]
Terchebulin	$C_{48}H_{28}O_{30}$	Roots	[62,63]
Tetradecaphytosphingosine	$C_{14}H_{31}NO_3$	Leaves	[67]

demonstrated activities against the tested pathogens exhibiting MIC values ranging from 133.0 μg/mL to 1500.0 μg/mL [67].

Anti-*N. gonorrhoeae* activities

Da Silva *et al.* [72] evaluated the anti-*N. gonorrhoeae* properties of ethanol extracts of *T. sambesiaca* leaves and roots against nine *N. gonorrhoeae* penicillin and tetracycline-sensitive and resistant strains using the agar dilution assay. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 100.0 μg/mL to 400.0 μg/mL [72].

Antimycobacterial activities

Fyhrquist *et al.* [57] evaluated the antimycobacterial properties of water and methanol extracts of *T. sambesiaca* roots and stem bark against *Mycobacterium smegmatis* using the agar diffusion and microdilution assays with rifampicin as a positive control. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 1250.0 μg/mL to 2500.0 μg/mL [57].

Antifungal activities

Fyhrquist *et al.* [69] assessed the antifungal properties of methanol extracts of the roots and stem bark of *T. sambesiaca* against using the agar diffusion method with amphotericin B as the positive control. The extract demonstrated activities against the tested *Candida albicans* pathogen exhibiting zone of inhibition ranging from 24.0 mm to 34.0 mm [69]. Fyhrquist *et al.* [56] evaluated the antifungal activities of methanol extracts of *T. sambesiaca* roots against *Candida glabrata* and *Cryptococcus neoformans* using the agar diffusion method with amphotericin B and itraconazol as positive controls. The extracts exhibited activities against *C. neoformans* and *C. glabrata* exhibiting MIC values of 1.6 mg/mL and 3.1 mg/mL, respectively [56]. Masoko *et al.* [73] evaluated the antifungal activities of acetone, hexane, dichloromethane, and methanol extracts of *T. sambesiaca* leaves against *C. albicans, Aspergillus fumigatus, C. neoformans, Microsporum canis,* and *Sporothrix schenckii* using the microdilution assay with amphotericin B as a positive control. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 0.02 mg/mL to 1.3 mg/mL [73]. Shai *et al.* [61] evaluated the antifungal properties of dichloromethane, n-hexane, and acetone extracts of *T. sambesiaca* leaves against *Micrococcus canis, A. fumigatus, C. neoformans, C. albicans,* and *Sporothrix schenckii* using the microplate dilution assay with amphotericin B as a positive control. The extracts demonstrated activities against the tested pathogens exhibiting MIC values ranging from 0.02 mg/mL to 0.6 mg/mL [61].

Antioxidant activities

Masoko and Eloff [74] evaluated the antioxidant properties of methanol and acetone extracts of *T. sambesiaca* leaves using 2,2-diphenyl-1-picryl hydrazyl (DPPH) free radical scavenging assay. The methanol and acetone extracts exhibited weak and strong antioxidant activities, respectively [74]. Masuku *et al.* [75] assessed the antioxidant activities

of aqueous, acetone, and methanol extracts of *T. sambesiaca* leaves using the DPPH free radical scavenging assay with Vitamin C as a positive control. The extracts demonstrated properties by exhibiting half maximal inhibitory concentration (IC_{50}) values ranging from 500.5 µg/mL to 685.5 µg/mL [75].

Antiproliferative activities

Fyhrquist *et al.* [76] evaluated the antiproliferative properties of methanolic extract of *T. sambesiaca* roots against HeLa (cervical carcinoma) and T 24 (bladder carcinoma) cancer cell lines using the Alamar Blue assay. The extract exhibited activities against HeLa and T 24 cancer cells, exhibiting inhibition of 18.0% and 29.5%, respectively [76].

Cytotoxicity activities

Masuku *et al.* [75] assessed the cytotoxicity properties of aqueous, acetone, and methanol extracts of *T. sambesiaca* leaves on TM3 Leydig cells using 3-(4,5-dimethylthiazol-2-yl)-2,5- diphenyltetrazolium assay. The extracts demonstrated activities by exhibiting IC_{50} values ranging from 451.0 µg/mL to 905.0 µg/mL [75].

CONCLUSION

The present review provides a summary of the medicinal and ethnopharmacological properties of *T. sambesiaca* in tropical Africa. To realize the full potential of *T. sambesiaca* as a medicinal plant species, there is a need for detailed evaluations of the phytochemical, pharmacological, and toxicological properties of the species, as well as *in vivo* and clinical studies involving the species.

AUTHOR CONTRIBUTION

AM conceptualized the research and wrote the manuscript.

CONFLICTS OF INTEREST

No conflicts of interest is associated with this research.

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